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TEKNOLOGI DAN INOVASI**
MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

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2020



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EXECUTIVE SUMMARY

Science, Technology and Innovation (STI) are increasingly viewed by governments – in both developed and developing countries – as a major driving force of national socio-economic development. Malaysia's STI competency and capacity have witnessed impressive successes over the past three decades that have transformed the economy from one that is entirely dependent on primary commodities to become a multi-sector economy with manufacturing and services propelling its growth to its current emphasis on innovation. Despite these achievements, our STI proficiency can be best described as mixed as reported in the series of National STI Indicators Report published by MASTIC, Ministry of Science, Technology and Innovation since 1994. The 2020 Report – the 10th edition in this series of reports – presents Malaysia's performance in STI across a broad spectrum of activities. This report was prepared at a time when the corona virus disease (COVID-19) continues to severely impact the economies of almost every country in the world including Malaysia. The events of recent months have starkly reminded us that mastery of STI remains our most potent weapon in facing the challenges posed by the pandemic as well as meeting our national aspirational targets as documented in the shared prosperity vision 2030. We are confident that given commitment and conviction Malaysia can continue to build and mobilize its STI proficiency to secure its socio-economic goals despite a future fraught with uncertainties.

WHAT IS THIS REPORT ALL ABOUT?

This report, the tenth since 1994, describes the findings aimed at assessing the overall performance of STI in Malaysia through an examination of eleven related themes pertaining to:

- Education Advancement;
- Society & STI;
- Digital Infrastructure;
- Research Investment and Workforce;
- Public Research and Development (R&D) Investment: Major Grants and Programmes;
- Manufacturing and Services Sectors Innovation;
- Knowledge and Technology Intensive Industries;
- Energy and Green Technology;
- Bibliometrics: Publications and Citations;
- Intellectual Capital; and
- Commercialisation.

The main focus of this report is to ascertain where we are in the above items particularly our strengths and deficiencies in relation to the levels as contained in the previous report as well as to compare our achievements with selected countries. More importantly, the findings would

assist policy makers in the identification of areas of strengths that should be maintained and developed and weaknesses and gaps that need to be addressed and remedied. Such constant monitoring and evaluation of our STI system is crucial given the changing nature and increasing capital intensity of knowledge creation and diffusion. This report is structured according to a framework of four important pillars of STI by utilising the concept of National Innovation System to better understand the STI ecosystem as follows:

Pillar 1 (Basic Supporting Environment) – Education, public awareness and digital infrastructure are considered as the enablers that serve as the foundation to promote and support STI development.

Pillar 2 (Public and Private Investments) – Includes investments by both the government and industry in funding R&D and other innovation-related activities.

Pillar 3 (Industrial Development) - evaluates the innovation, knowledge and technological content of STI within the industrial sector.

Pillar 4 (Scientific Capabilities) - highlights the national scientific knowledge progress specifically through the bibliometric, intellectual property (IP) and commercialisation indicators assessment.

All the four pillars are inextricably interlinked to capture the dynamics of the country's National Innovation System. Based on this framework, the Study Team has employed a series of indicators following Organisation for Economic Co-operation and Development (OECD) Main Science and Technology Indicators and National Science Foundation (NSF) to ensure comparability.

MAIN FINDINGS

The key findings of the four main pillars are as follows:

PILLAR 1: BASIC SUPPORTING ENVIRONMENT

THEME 1: EDUCATION ADVANCEMENT

Positive Trends

- Although the number of enrolments in Information and Communication Technologies (ICT) at STPM is relatively small compared to other Pure Science subjects, ICT continues to gain traction over the years with more than 40% increased enrolment in 2019 compared to that of 2015.
- In terms of percentages, the performance of students in STPM Mathematics (M), Physics, Chemistry and Biology has remained almost unchanged over the period of 2016-2019. Mathematics (T), however, recorded improvements in band A (21% in 2016 to 24% in 2019) with reduced Fs (12% in 2016 to 9% in 2019).
- At the Sijil Pelajaran Malaysia (SPM) level, the performance of students in Mathematics, Physics, Chemistry and Biology has remained almost unchanged, in terms of percent grades achieved over the period of 2016-2020.
- The performance achievement for grades A to C among all Science subjects at SPM, displayed some improvements over the period 2016 to 2019.
- At the tertiary level, enrolment at the twenty public universities has increased slightly at the undergraduate (first degree) level. Among the Science-based programmes, Engineering, Manufacturing and Construction has the highest share in enrolment especially at the Malaysian Comprehensive (average 20%) and Technical Universities (average 72%) followed by Science, Mathematics and Computing (average 16% of all enrolment).
- The enrolment of undergraduates at private universities has increased from 207,816 in 2014 to 281,395 in 2019 with a high percentage of enrolment in Social Sciences, Business and Law.
- Enrolment in Science-based programmes at private universities is approximately 38% of the annual enrolment, almost half of which are in Engineering, Manufacturing and Construction. Similar trend is observed at the Masters and Doctoral programmes with fewer enrolment in Science-based programmes (19% and 32%, respectively in 2019)

Reality Check - Gaps

- There is a significant declining trend in the percentages of students registering for Additional Mathematics, Physics, Chemistry and Biology in 2019 compared to 2011 at SPM level. Similar trend is also observed for technical subjects except ICT.
- In terms of performance in Pure Science subjects, rural students' achievements are lower than their peers in the urban areas. Similarly, there is a gender disparity in terms of subject and grade achievement.
- In public Higher Learning Institutions (HLIs), the number of enrolments for Science courses is consistently less than for non-Science courses at the undergraduate levels – at a ratio of 45:55.
- At Masters level, the percentage of Science-based enrolment is 44% with a declining trend for engineering, manufacturing and construction (broad subject by National Education Code (NEC)) from 21% in 2011 to 16% in 2020. A similar trend is observed at Doctoral level.

International Comparisons

- 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.
- A comparison of scores shows that 15-year-olds in Singapore, South Korea, Hong Kong and Shanghai are performing as though they have had three or more years of schooling than 15-year-olds in Malaysia.
- For both Mathematics and Science achievement in Malaysia, socio-economic status explains 17% of the respective total variation in performance, slightly more than that of the OECD.

THEME 2: SOCIETY & STI

Positive Trends

- Interest in STI topics (79.6% in 2019) has been on the upward trend since 2008 with environmental pollution issues registering highest level of interest (85.2%).
- Since 2000, Malaysians are consistent in rejecting the idea that the harm of science is greater than its benefits.
- Malaysians view the impacts of STI as positive rather than negative, especially when it comes to health (75.5%) and quality of life (82.0%).
- More than 40% of respondents are aware of all the government STI-related programmes with a commendable 20% or more (less than 2% in 2014) respondent participation in 6 of these programmes.

Reality Check - Gaps

- Based on selected statements, there is an overall positive acceptance of STI and scientific research among Malaysians although the percentages in agreement with the selected statements are lower (59%) than those registered in the 2014 survey (79%).
- The average public knowledge of STI (45.9% in 2019) in Malaysia has been below 50% for the past 19 years. Malaysians are less knowledgeable about more challenging science ideas.
- The 2019 survey findings recorded the lowest percentage (38.2%) of Malaysians since 2000 saying the benefits of STI are greater than its harmful effects.
- There is a marked difference of public interest and perceived knowledge in STI topics amongst rural and urban dwellers.
- Most Malaysians (> 34%) are unaware of government spending on STI-related matters.

International Comparisons

- Public interest in STI in Malaysia (79.6%) is comparable to the level displayed in China (75.3%) and in the USA (85.0%).
- Overall, knowledge and understanding of STI concepts and ideas among the public in Malaysia (46%) is below that of developed nations such as USA (66%), European Union (EU) (65%), South Korea (63%), Japan (53%) and Singapore (66%).
- Fewer Malaysian respondents (38%) – compared to American (74%) and Singaporean (62%) respondents – are convinced that the benefits of scientific research outweigh any harmful effects.
- Generally, majority of respondents from Malaysia (79%) – like those from USA, Singapore, China and EU – are in agreement that STI improves the quality of their lives.
- More than 40% of Malaysian respondents – like their counterparts in USA and Europe – consider climate change and environmental pollution as serious problems.

THEME 3: DIGITAL INFRASTRUCTURE

Positive Trends

- The ICT industry contributed 19.1% to the national economy in 2019.
- As of 2018, the Multimedia Super Corridor (MSC) programme has led businesses in Malaysia to generate RM473 billion. The programme has created 99,590 jobs in 2009, 147,568 jobs in 2014 and, 182,538 jobs as of 2018.

- Adoption rates of broadband for internet access and cellular telephone have reached above 100 per 100 inhabitants.

Reality Check - Gaps

- In term of share of household computer access, underdeveloped states such as Kelantan, Kedah, Pahang and Sabah achieved 58.2%, 59.6%, 59.7% and 59.8% in 2019 respectively.
- It is noted that the size of the innovation-related fund for ICT had been reduced in the 10th Malaysia Plan (MP).

International Comparison

- A significant improvement is needed in internet bandwidth per internet user.
- Many of the ICT related indicators imply that Malaysia has been capitalising on the technologies for growth.

PILLAR 2: PUBLIC AND PRIVATE INVESTMENT

THEME 4: R&D INVESTMENT & RESEARCH WORKFORCE

Positive Trends

- An equal distribution of R&D expenditure among the three types of R&D – 39.3% for Basic Research, 36.2% for Applied Research and 24.5% for Experimental Development.
- In 2018, BE contributed the largest share (43.9%) of R&D expenditure.
- Business Expenditure on R&D (BERD) in Malaysia in 2018 was mainly contributed by in-house R&D by majority foreign owned large BEs.
- The ratio of male to female researchers is almost equal.

Reality Check - Gaps

- In 2018, Gross Expenditure on R&D (GERD) (14.8%) and its ratio to Gross Domestic Product (GDP) (27.8%) growth decreased significantly. Malaysia's GERD was at RM15,060 million whereas GERD/GDP ratio was recorded at 1.04%.
- A significant decrease in BERD contribution from 70.5% in 2008 to 43.9% in 2018.
- A 15.4% decrease in total number of R&D personnel from 145,741 persons in 2016 to 123,362 persons in 2018; and 20.4% decrease in the researchers per 10,000 labour force from 74.0 in 2016 to 58.9 in 2018.

- Full-time Equivalent (FTE) of R&D personnel experienced a 6.1% decline in 2018, that is, from 89,178 in 2016 to 83,763 in 2018.

International Comparisons

- In terms of GERD, Malaysia is currently ranked 19th while USA, Japan and Germany claim the top three places in the list. For percentage of GERD/GDP, Malaysia is ranked 31st while South Korea, Switzerland and Sweden are the leading nations. Malaysia's research intensity (1.04%) is below the world average (1.72%).
- Malaysia's investment in higher education expenditure on R&D as percentage of GERD was 42.6%. This placed Malaysia fifth relative to OECD countries. Malaysia was just behind of Latvia, Mexico, Chile and Estonia.

THEME 5: PUBLIC R&D INVESTMENT: MAJOR GRANTS AND PROGRAMMES

Positive Trends

- An extensive range of R&D grants, programmes and incentives are made available to promote and support R,D&C activities in the country. Various ministries and their agencies are given mandates and responsibilities in managing the designated funding facilities for targeted researchers, firms, non-governmental organizations (NGOs) and individuals in national priority areas.
- Revisions to the funding mechanisms have been undertaken frequently to make sure the grants and programmes are relevant to the needs of researchers and firms. New grants have been introduced by several ministries such as MOSTI and Ministry of Higher Education (MOHE).
- A number of successful public funded projects have created significant impacts to the society.

Reality Check - Gaps

- BEs faced issues on the lack of information on R&D incentives, the definition of R&D incentives is not clear, and the application procedures are not clear. HLIs, Government Research Institutes (GRIs) and NGOs reported that they suffered from insufficient government funding.
- There was a significant decrease in terms of number and amount of R,D&C projects approved in the 11th MP in comparison to 10th MP. This was particularly obvious in the grants and programmes provided by MOSTI, and performance of BioNexus companies and MSC Malaysia Status.

International Comparisons

- Leading countries have only one or two agencies disbursing funds and incentives – for example, VINNOVA (Sweden); Ministry of Economic Affairs (Taiwan).

PILLAR 3: INDUSTRIAL DEVELOPMENT

THEME 6: MANUFACTURING AND SERVICES SECTORS INNOVATION

Positive Trends

- More (>22%) companies expended more than RM4 million on innovation-related activities compared to less than 2% in National Survey of Innovation 2015 (NSI-2018).
- More firms indicated spending a minimum amount of RM25,000 on innovation than in NSI-2018.
- More companies (> 16%) have indicated that their product innovations are new to the world – far more than the 1% reported in NSI-2018 for the same item.
- Main source of funding is from own sources.

Reality Check - Gaps

- Uptake on government incentives and support measures is minimal (< 10%).
- Lack of awareness (75%) on incentives.
- Universities and GRIs are considered one of the least important partners for collaboration although they are important sources of information.
- Adoption rate of intellectual property rights (IPRs) by enterprises from both sectors is minimal (< 10%).
- High cost and lack of funding continue to be main constraints.
- Poor adoption (< 10%) of Fourth Industrial Revolution (IR 4.0) technologies.

International Comparisons

- After Singapore, Malaysia is the best performing country in the region for both Global Competitiveness Index (GCI) (27th, 2019) and Global Innovation Index (GII) (33rd, 2020) rankings.
- Malaysia is placed 5th in the Community Innovation Survey (CIS) ranking of countries with innovative enterprises with a score of 65% (we were ranked 31st in NSI-2018).

THEME 7: KNOWLEDGE AND TECHNOLOGY INTENSIVE INDUSTRIES (KTI)***Positive Trends***

- The overall Malaysia's KTI value added has grown steadily between 2011 and 2018.
- Among the KTI industries in Malaysia, Computer, Electronic, and Optical Products; Chemicals and Chemical Products; and Motor Vehicles are among the top three sectors in terms of value-added between 2011 and 2018.
- In terms of KTI industries trade performance, export shares increased by 26.94% between 2011 and 2018. Likewise, the overall export of commercial services have grown by 3.42% during the period.

Reality Check - Gaps

- The insurance and financial services export share are extremely small, contributing 1% - 2% to the overall commercial services.
- Import shares of KTI industries increased by 15.63% between 2011 and 2018 indicating that the country needs to engage in much higher value-added activities in order to reap from these industries.
- Malaysia's commercial services sector imports increased gradually between 2011 and 2018 and grew by 16.35%.

International Comparisons

- In 2018, Malaysia's KTI industries value added share of GDP at 11.13% surpassed the world's share. However, as a share of world value added, Malaysia's contribution is still low given its size of the industry.
- Malaysia's medium-high R&D intensive industries contribution is lower than other ASEAN peers like Singapore, Thailand and Indonesia.
- However, Malaysia's high R&D intensive industries have dominated other ASEAN counterparts (Indonesia, Philippines, Singapore and Thailand) by gaining significant trade surplus.

THEME 8: ENERGY AND GREEN TECHNOLOGY***Positive Trends***

- Since 2006, Malaysia experienced a drastic decline in greenhouse gas (GHG) emissions declining from the peak of 374 tonnes in 2005 to 161 tonnes of CO₂ equivalent of GHG emissions in 2016 due to sound management of land-use and forestry.

- The exports of photosensitive semiconductor devices products have significantly increased from USD2,599 million in 2010 to USD4,677 million in 2019.
- Malaysia's knowledge content in areas of energy and sustainable science and technology (S&T), measured by publication counts, indicates an increasing trend over the years with share of publication being nearly more than three-fold in 2019 compared to 2011.
- The largest amount of green financing goes to solar farm and solar technologies.
- Malaysia has the potential to become regional hub for green sukuk financing. Since 2017, 12 green financing (bond and sukuk) deals have been issued amounting to RM5,245 million.

Reality Check - Gaps

- Targets in achieving the renewable energy mix to total energy supply is falling short.
- Malaysia needs to strategize the demand side management and adoption of green technology in critical sectors namely energy, transportation and industrial sectors.
- The demand side management of the electricity consumption intensity is crucial in improving energy efficiency especially demand from the industry.
- Low carbon energy related technology capabilities, measured by international patenting activities, remained low.

International Comparisons

- On average, the international scientific collaboration in related green technologies stands at 37% between 2008 and 2016.
- Malaysia's energy intensity is relatively lower than Indonesia, Thailand and Vietnam.
- Despite Malaysia recording lower energy intensity (per GDP), Malaysia's final energy consumption per capita is higher than many other ASEAN countries.

PILLAR 4: SCIENTIFIC CAPABILITIES

THEME 9: BIBLIOMETRICS: PUBLICATIONS AND CITATIONS

Positive Trends

- A total of 136,124 articles is recorded between period of 2001 and 2019 – an increase from 53,954 in 10th MP to 55,418 in 11th MP (2016-2019).
- The top 5 research universities – Universiti Malaya (UM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM), Universiti Kebangsaan Malaysia (UKM)

and Universiti Teknologi Malaysia (UTM) - produced a total of 105,641 articles (or 77.6% of total published articles) from 2001 to 2019.

- Top multidisciplinary fields are “Materials Science-Multidisciplinary”, “Engineering Electrical Electronic” and “Multidisciplinary Sciences”.
- For citations count, Malaysia witnessed an increasing trend since 2001.
- Malaysia’s vast diverse networks for publication implies its interest in pursuing advanced scientific knowledge with those from both advanced and developing countries.

Reality Check - Gaps

- A low growth rate of publication between 2016 and 2018.
- Malaysia’s commitment towards appropriating science to learn and control COVID-19 is commendable. However, we are lacking in terms of capacity in COVID-19 related research results.
- Citation is still relatively low.

International Comparisons

- In the ASEAN region, Malaysia with 112,663 articles and 1,338,623 citations leads many countries in publishing performance. However, it is well behind the publishing performance of Singapore (136,336 articles and 2,998,455 citations).

THEME 10: INTELLECTUAL CAPITAL

Positive Trends

- Public research institutions (e.g. MIMOS) and universities (UTM, UPM and UM) emerged to be among the top organizations in domestic patenting.
- Malaysia has a total of 265 AI-related Patent Cooperation Treaty (PCT) patents between 2001-Aug 20th 2020. MIMOS (52 patents), Continental AG (11 patents) and INTEL (8 patents) are among the top assignees in Malaysia.

Reality Check - Gaps

- The efforts of Malaysia in trying to boost the counts for local applications between 2008 and 2018 has yet to see significant progress.
- There are 4,539 foreign applications in 2008 - about 6 times compared to the local applications. In 2018, the count for foreign applications increased to 6,245. The foreign applications remained the key driver for patenting growth.

International Comparisons

- Malaysia is performing at a moderate pace in PCT patenting compared to that of advanced countries.
- Malaysia is performing well below that of the advanced countries in AI-related PCT patenting.

THEME 11: COMMERCIALISATION

Positive Trends

- Overall commercialisation rate has improved slightly from 8% to 9% during the 10th MP.
- Highest revenue generation of the publicly funded research was during the 9th MP amounting RM3,431.98 million.
- At institutional level, Malaysian Palm Oil Board (MPOB) and MIMOS have actively and successfully commercialise and monetise their research outputs.
- Between 2011-2015, Commercialisation of R&D Fund (CRDF) and Biotechnology Commercialisation Grant (BCG) generated the highest revenue by commercialising the potentially viable projects.

Reality Check - Gaps

- The income generation is declining over the years due to limited funding.
- Royalties and Licensing fee remains in deficit indicating that Malaysia should also improve its technology licensing abroad.
- Key challenges in commercialisation remains and efforts to improve the commercialisation ecosystem is needed.

International Comparisons

- Malaysia is an active user of foreign technology recording deficit in royalties licensing payments and receipts.

WAY FORWARD

The findings of this report have revealed that Malaysia's present proficiency in STI needs to be further enhanced in order to ensure that the nation is not seriously disadvantaged by the exponential pace in scientific and technological developments that we are witnessing today. Our present inadequacies cannot remain unresolved. Instead, we need to adopt bold and creative solutions to confront our STI shortcomings holistically. Accordingly, this report has

identified six key takeaways and recommendations for consolidating the four pillars of STI which are in alignment with the thrusts of the recently launched National Science, Technology and Innovation Policy (NSTIP) 2021-2030.

PILLAR 1: BASIC SUPPORTING ENVIRONMENT

KEY TAKEAWAY 1: *Elevate quality of Science, Technology, Engineering and Mathematics (STEM) education and STEM career pathways in order to enhance STEM proficiency levels as well as ensuring sustainability of STI talent pipeline.*

Despite impressive achievements at all levels of education, STEM enrolment continues to exhibit a declining trend of enrolment in particular Science-based subjects at the school level as well as greater proportion of enrolment in non-Science-based courses at the tertiary level. Additionally, there are disparities in performance in Pure Science subjects between rural and urban students. At the international level, Malaysia's performance in the OECD's PISA and TIMSS surveys has been less than satisfactory. These issues suggest, among others, a pressing need for the improvement of the teaching of Science in schools at all levels as well as ensuring that STEM career pathways are as rewarding as non-STEM jobs.

Actions:

- (i) Establish task force to review all relevant initiatives and recommendations pertaining to enhancing quality of STEM education in schools, colleges, universities including addressing associated gender and locational disparities.
- (ii) Introduce improved and continuous career development pathways to attract and retain STEM talent as detailed in ASM's 2017 Science Outlook document.
- (iii) Implement all recommendations pertaining to nurturing and retention of STEM talent as detailed in Strategic Thrust 4 of the NSTIP 2021-2030 Action Plan.

KEY TAKEAWAY 2: *Promote STI awareness and elevate digital infrastructure and skills for industry transformation and an inclusive Malaysia.*

Malaysians have shown much interest and acceptance of STI. Nevertheless, there are many shortcomings that require attention. Similarly, despite Malaysia being a highly digitally networked nation, with 90% of households using the internet, to-date, it has not been able to narrow the gap between underserved areas and the rest of the country due to structural connectivity problems. Digitalizing Small and Medium-sized Enterprises (SMEs) will enhance their competitiveness, and productivity but only less than 10% have adopted IR 4.0 technologies.

Actions:

- (i) Review existing STI enculturation programmes to enhance their effectiveness to raise Malaysians' knowledge of STI.
- (ii) Mobilize and leverage partnerships with various stakeholders in popularising science to society including using various platforms and STI-based content development.
- (iii) Strengthen the governance framework for enculturation of science to streamline programmes and resources.
- (iv) Implement the strategies and programmes for enhancing enculturation and application of STI as detailed in Strategic Trust 5 of the NSTIP 2021-2030 Action Plan.
- (v) Promote demand-side initiatives (such as incentives for skills enhancement) to foster greater adoption of digital and other IR 4.0 technologies by SMEs.
- (vi) Support collaborative ventures between industry and universities/research organisations to experiment with new approaches to enhance connectivity in underserved areas.
- (vii) Support initiatives to drive upgrading of digital infrastructure and skills provision to SMEs as detailed in Malaysia Digital Economy Blueprint and action plans of Jalinan Digital Negara (JENDELA).
- (viii) Intensify efforts to narrow the digital divide between developed and underdeveloped states.
- (ix) Improve funding support and its access to re-energise industry and human workforce in ICT.

PILLAR 2: PUBLIC AND PRIVATE INVESTMENT

KEY TAKEAWAY 3: *Ensure sustained investments in R&D through alternative funding mechanisms and greater international funding.*

Recent years have witnessed a decline in government R&D funding as well as reduced expenditure by industry in R&D due to the global economic downturn. This recession is exacerbated by the COVID-19 pandemic and will severely impact the capacity of several nations to invest in risky activities such as R&D in the coming years. Indeed, given the weak prevailing conditions, the STI agenda should focus on sustainability issues. New funding mechanisms are also needed to promote a smarter mix of funding that embraces the participation of several stakeholders.

Actions:

- (i) Increase public and private sector R&D investments targeting for gross national R&D expenditure levels of at least 2.5% of GDP by 2025 and 3.5% by

2030 as documented in Strategic Thrust 2 of the NSTIP 2021-2030 Action Plan.

- (ii) Initiate evaluation of following alternative financing mechanisms – such as consortium funding; crowdfunding; angel funding; philanthropy; co-investment; debt financing instrument; innovation bonds; Islamic sustainable financing (waqf), Malaysia Science Endowment - for possible adoption.
- (iii) Attract International and matching funding collaboration focusing on sustainability.
- (iv) Establish appropriate metrics for all RUs to achieve in terms of international funding of their R&D effort.

KEY TAKEAWAY 4: *Restructure STI funding system to be more streamlined, responsive, results-driven and strategy-linked to advance nation's STI agenda.*

An inordinate number of schemes characterise our public funding support system for STI. Our funding system needs to be rationalised and results driven. A recent initiative to promote a more focused and collaborative approach towards research and technology development is the identification of 30 niche areas by the Academy of Sciences Malaysia under its 10-10 MySTIE Framework which has been adopted by the government to support the implementation of the NSTIP 2021-2030. Enhanced management of these schemes is vital to ensure that our limited resources are utilised well to advance industry as well as socio-economic objectives. Additionally, these schemes need to be well publicised and easily accessible by the relevant target groups.

Actions:

- (i) Launch review of public funding system to be, among others, more streamlined, promote development of capabilities in new technologies; achieve balance among fundamental, mission-oriented, near market as well as Social Sciences and Humanities, foster excellence and partnerships and support commercialisation and IPR initiatives of researchers in alignment with Strategic Thrust 2 of the NSTIP 2021-2030.
- (ii) Initiate more targeted strategies to disseminate information on the grants and incentives to firms through collaboration with intermediaries such industry associations and science (or business and industrial) parks.
- (iii) Enhance management of funding system/grant schemes with attention to, among others, monitoring and evaluation, competent assessment of proposals, improved awareness and access to the scheme, guidelines on IPR and royalty sharing.
- (iv) Critically examine the 30 niche areas under the 10-10 MySTIE Framework developed by the Academy of Sciences Malaysia with a view to implementation.

- (v) Conduct specific training workshops for firms to enhance their knowledge and know-how on grants and incentives applications.

PILLAR 3: INDUSTRIAL DEVELOPMENT

KEY TAKEAWAY 5: *Strengthen the Governance Framework for effective management of STI support measures for industry.*

Despite years of bridge-building efforts by the government, universities and GRIs are still considered one of the least important partners by industry in innovation cooperation. New forms of partnerships such as open innovation and co-innovation should be explored to promote sharing of risks and resources with industry. Another distinctive feature of our innovation ecosystem is that far too many organisations and schemes have been established by the government to promote STI in industry. It is vital that an effective monitoring and evaluation initiative be undertaken to appraise, among others, all these schemes and rationalise them so that they are more focused, accessible, results-driven and forward-looking. Strengthening the governance framework for industrial development assumes urgency particularly at a time when resources are much reduced. Additionally, efforts to promote the energy and green industry as well as the KTI sectors become critical in our quest to deepen our industrial base as well as expand our export earnings.

Actions:

- (i) Launch comprehensive review of existing STI for industry programmes to enhance their effectiveness.
- (ii) Establish separate inter-agency committees for STI funding for industry to streamline programmes, resources and priorities in addition to recommendations to enhance governance framework for responsive STI as detailed in Strategic Thrust 1 of the NSTIP 2021-2030.
- (iii) Strengthen initiatives for the adoption of IR 4.0 technologies by SMEs.
- (iv) Promote more effective university-industry partnerships.
- (v) Establish close collaborations with foreign counterparts through knowledge and technology transfer in energy and green technologies as well as other technology areas identified in Strategic Thrust 3 of the NSTIP 2021-2030.
- (vi) Strategize development of niche KTI industries to leverage on transformation of Malaysia's manufacturing sector in line with IR 4.0.
- (vii) Strategize and leverage on the private green financing initiatives such as sukuk to propel Malaysia to become the regional hub.
- (viii) Accord emphasis for efforts on demand-side management and adoption of green technologies among the energy, transportation and industrial related sectors.

PILLAR 4: SCIENTIFIC CAPABILITIES

KEY TAKEAWAY 6: *Leverage partnerships for successful management of STI capability development and commercialisation.*

This study has revealed that Malaysian universities have collaborated extensively with their partners abroad in terms of publications. These collaborations have contributed towards the upward trend in publications. However, a worrying trend is the low citation count despite the increase in publications. Similarly, Malaysia needs to forge strategic collaborations with foreign partners in order to enhance its competencies in selected technologies such as AI and COVID-19 related research. There is a wide disparity between foreign and local patenting in the country. Additionally, royalties and licensing fees remain in deficit indicating that Malaysia should improve its technology licensing abroad. While commercialisation rate of public funded research projects has improved marginally during the 10th MP, much remains to be done in terms of enhancing the commercialisation ecosystem in the country.

Actions:

- (i) Redesign approaches and incentives to promote more effective engagement with industry as well as collaborative models for specific STI programmes.
- (ii) Promote strategic approach to developing technological capabilities through forging technology partnerships/knowledge transfer programmes with external partners as detailed in Strategic Thrust 6 of the NSTIP 2021-2030.
- (iii) Prioritise high impact and multidisciplinary research via collaborative activities.
- (iv) Introduce measures to enhance research publication productivity (including citation counts) among researchers in public HLIs.
- (v) Initiate effective approaches to boost local patenting particularly among local firms.
- (vi) Intensify efforts in building local capabilities through R&D in areas such as IoTs, Big Data Analytics and Artificial Intelligence.
- (vii) Critically re-examine the commercialisation ecosystem including the support system at various institutional and programme levels incorporating the recommendations of the National STI Policy 2021-2030 aimed at enhancing the commercial value of locally produced products and STI services.
- (viii) Implement regulatory reforms in areas such as IPR, researcher and student mobility, industrial engagement, and other critical areas.
- (ix) Establish monitoring and evaluation system for better tracking of commercialisation efforts.

CONCLUSION

This report provides a broad overview of how well Malaysia is performing in STI, our current strengths and limitations as well as where we need to go in a world still reeling from the devastation wrought by the COVID-19 pandemic. The findings suggest that the basic foundations of our STI ecosystem as depicted under the 4 pillars in this report is sound but needs to be enhanced if the nation aspires to propel its economy to a higher trajectory. Our present inadequacies in STI are impeding, for example, the ability of our industries to ward off the challenges posed by our lower cost competitors who are closing on us. We need to harness STI to move up the economic value chain as well as make a difference to the lives of all Malaysians. We are confident that the key takeaways and recommendations in this report will help our STI ecosystem to become more robust, resilient and responsive in mobilising STI to achieve the nation's vision of shared prosperity.

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1

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 Future Challenges, STI and Report Objectives

We are in unprecedented times due to the disruptions following the COVID-19 crisis, which has impacted almost all spheres of our lives. These disruptions are likely to continue as the pandemic progresses. In the longer term, STI and other policy responses could shape and steer economic transitions towards more sustainable, resilient and inclusive futures. But these efforts could be frustrated by weaker global demand, tighter public budgets and reduced investments from businesses and investors, all of which can have long-lasting negative effects on countries' scientific production and their capacities to respond to this crisis. Despite these difficult external conditions, efforts to enhance indigenous STI capacity cannot afford to be diminished. On the contrary, these efforts need to be enhanced to ensure that the country will be much stronger to face the uncertainties of the future.

Malaysia's STI capacity building has been on the upward trajectory for more than three decades. This uninterrupted attention to building our capacity and capabilities is manifested in the nation's rise in several STI indicators as reported in the series of National STI Indicators Report published by MASTIC, Ministry of Science, Technology and Innovation since 1994. The 2020 Report – the 10th edition in this series of reports – presents Malaysia's performance in STI across a number of areas including human capital development; public awareness; ICT; R&D investment and research workforce; public sector investment in R&D; innovation in manufacturing and services sectors; energy and green technologies; bibliometrics; IP rights; and commercialisation and returns on R&D. Our latest global rankings are commendable as evident in the international surveys undertaken by CIS, the Global Innovation Index (GII), and the GCI.

Identifying the critical areas of strength and weakness of the STI ecosystem are essential. The compilation of this comprehensive array of STI indicators – covering supply, demand, linkage and output - provides a useful snapshot to policy makers as to how well the country is doing in terms of STI. This Report aims to promote a more systemic approach towards managing and measuring the nation's performance in STI. Such an approach is vital in the coming months and years given the devastating impact of COVID-19 in recent times in almost all spheres of human activity. Indeed, positioning STI for the shared prosperity vision 2030, inclusive development and to attain the targets of the Sustainable Development Goals (SDGs) is vital. Competency in STI remains a potent tool in our arsenal to overcome these challenges. This 2020 Indicators Report will present where we are in terms of STI, some of our challenges and how do we move forward. We are confident that given commitment and conviction Malaysia can continue to build and mobilize its STI proficiency to secure its socio-economic goals despite a future fraught

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with uncertainties. The ultimate aim of this report is to transform the various voluminous reports and indicators to form a single report that aids policy makers.

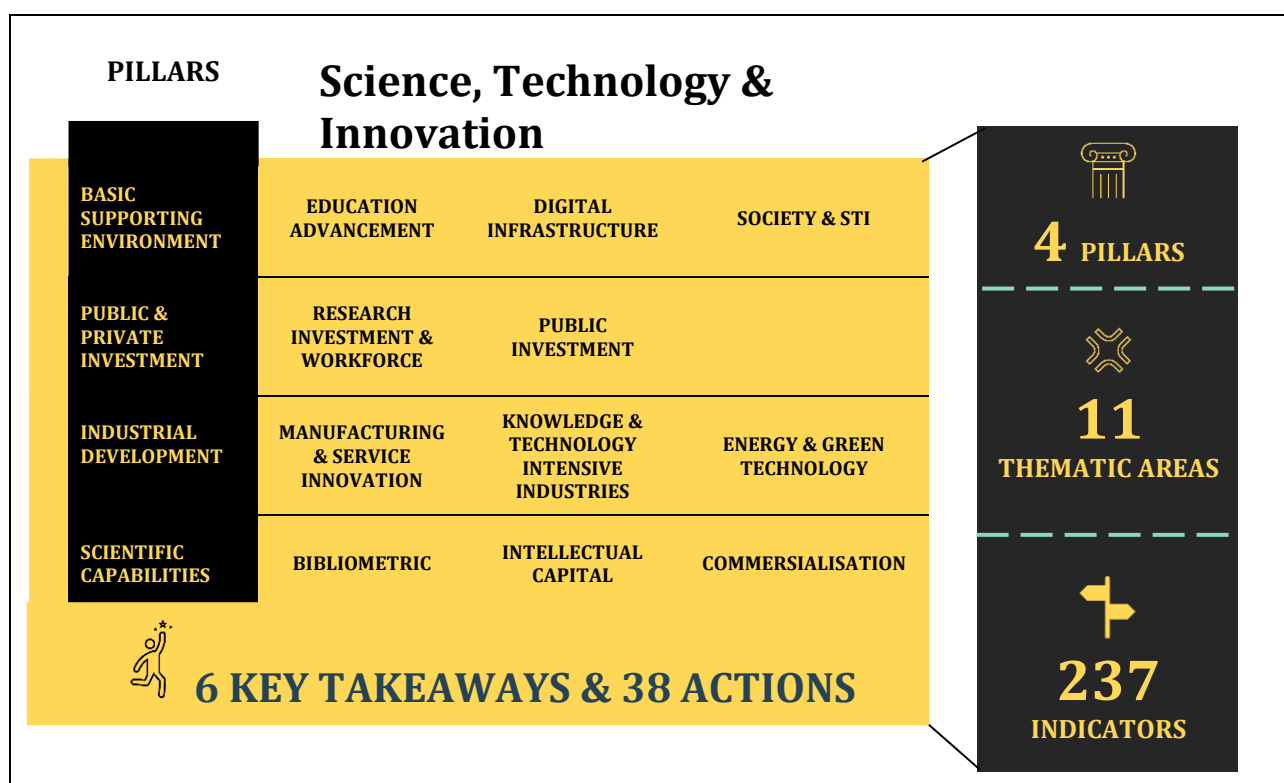
The Malaysian STI Indicators Report 2020 sets its objectives to:



1.2 Framework and Methodology

The report framework focuses on four main pillars of STI and 11 thematic areas of STI as follows: (1) Basic STI Supporting Environment (2) Public and Private Investments (3) Industrial Development and (4) Scientific Capabilities (Figure 1.1). Our approach is anchored by the adoption of standard STI indicators as in OECD S&T Indicators and the Science & Engineering Indicators by the National Science Foundation, United States to ensure comparability. The framework provides policy makers a better understanding on the status of STI and the current position of the nation's STI ecosystem - both public and private sectors STI position - in Malaysia. The analysis provides 6 key takeaways and 38 actions to consider by policy makers. The data collection approaches involve primary and secondary data. Primary data is obtained from earlier studies and surveys commissioned by MASTIC. In drawing international comparisons, comparable secondary data is obtained from various sources such as international agencies and literature search including reports. Secondary data collection – from various ministries and agencies - is facilitated by MASTIC.

Figure 1.1 STI Framework, Pillars and Themes



Source: UPUM

1.3 Scope and Limitations

The STI indicators cover 11 thematic areas and nearly 237 indicators (Appendix 1). While the indicators aim to cover various themes, the time periods reported depends on the data availability. Most recent data are presented and where possible consistency is maintained covering information from 2011 to 2019. Data limitations exist in some areas including data discontinuity where it is not reported. Definitions of terminology used and technical notes are as in Appendix 2.

1.4 What's New in STI 2020 Report

The 2020 STI report adds value to the stakeholders by reporting new developments and improving the presentation style to ease readability. First, where possible, the STI indicators are aligned to SDGs and other current developments to reflect the positioning of STI for inclusive development. Some of these pillars are critical to support, directly or indirectly, the Shared Prosperity Vision, Inclusive Development and attain the targets of SDGs. Second, it highlights the international comparison and includes gap analysis to identify red flags and our strengths. In other words, the report builds on positive progress (Where are we raising?), reality checks (being honest, where we need to improve?) and international standing (How are we doing globally?). Third, it assembles box articles to illustrate supporting evidence and case studies to amplify and clarify the issues raised in the relevant themes. Fourth, it proposes policy directions as the way forward with six major key takeaways and several recommendations.

And, lastly, visualisation (infographics) and improving readability enhances the report's presentation style.

1.5 Snapshot of Past Progress

Tracking the overall progress of the STI indicators (based on the previous STI reports) from 2010 to 2016 shows that Malaysia has been progressing over the years. The key findings of the progress and gaps are self-explanatory in Table 1.1, which does not require further explanation.

While the current trends in R&D are as follows. GERD/GDP ratio decreased to 1.04% in 2018 from 1.4% in 2016 – the percentage is the second lowest since 2008. The decrease is mainly due to the significant reduction in R&D allocation or budgetary cuts among the Business Enterprises (BEs). Nonetheless, HLIs and GRIs showed increment in their R&D expenditures since 2008. Since 2014, Basic Research and Experimental Development continued to increase in their share in the overall national R&D expenditure, while Applied Research has continued to decrease. In 2018, Basic Research and Applied Research recorded almost equal R&D share. Basic Research was mostly contributed by HLIs, while Applied Research and Experimental Development were mainly contributed by BE. In terms of Field of Researches (FORs), Engineering and Technology, and Information, Computer and Communication Technology are constantly the two primary contributors of GERD. With regards to GERD by Socio-Economic Objective (SEOs), Advanced Experimental and Applied Science and Sustainable Economic Development are the top two SEOs that together contributed to about or more than half of the GERD during 2016-2018 period. In 2018, the number of researchers per 10,000 labour force dropped to 59 from 74 in 2016. The drop was caused by the decrease of almost 18,500 researchers from 2016 to 2018. In most cases, the decrease in the number of researchers is due to R&D project cycle and reduction in budget for R&D.

HLI was the primary contributor in the number of researchers. Regarding the proportion of researchers by qualification, the headcount of Doctor of Philosophy (PhD) holders increased to its highest proportion to 42,228 holders in 2018 compared to the previous years. While for Master degree holders there was a decrease in headcount of more than 6,000 between 2016 and 2018. There were lesser number of researchers with Bachelor and other qualifications in 2018 as compared to 2016. Meanwhile, the ratio of female to male researchers in R&D has remained rather steady between 48.2% (2016) and 49.1% (2018).

Table 1.1 Key Findings: Malaysian STI Indicator Reports 2010, 2013, 2016

Aspects	2010	2013	2016
Education in S&T	• Additional Mathematics is the most registered subject among Science stream at SPM between 2005-2009. • A decrease in the number of registered students for Science courses at STPM. • The number of enrolment and graduations in S&T at undergraduate and postgraduate levels in the public universities has remain unchanged over the years. • Female outnumbered male students at the undergraduate level (except in Technical fields) between 2008-2009, but males outnumbered females at PhD level.	• Mathematics is the most registered subject at SPM between 2008-2012. • A decrease in the number of registered students for Science courses in STPM. • Lower enrolments in Science courses compared to non-Science courses at the undergraduate and postgraduate levels.	• The number of enrolments for Science and Mathematics at SPM level has increased since 2008. • At STPM level, the number of registrations in Science, Mathematics and Technology subjects has generally decreased. • At public and private universities, the number of enrolments for Science courses is consistently less than that of non-Science courses at the undergraduate and postgraduate levels.
Public Awareness of S&T	• 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 consistent positive attitude towards S&T. • Malaysia lags behind USA, Europe and South Korea on their understanding of S&T.	• Malaysians viewed S&T as having a positive impact on individual enjoyment of life, public health, standard of living and working conditions. • Malaysians have consistent positive attitude towards S&T. • Malaysia lags behind USA, Europe and South Korea on their understanding of S&T.	• Malaysians are found to be either interested or very interested in the STI issues surveyed in 2014. • The number of Malaysians who are very interested in selected STI issues are much fewer in comparison to the USA and the EU respondents. • The average public knowledge of STI in Malaysia has been below 50%.
Human Resource in S&T	• A decrease in headcount of R&D personnel and FTE for private sector. • An increase in FTE for the HLIs. • An increase in participation of women in R&D.	• 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.	• The number of researchers has significantly increased since 2008. • The total R&D personnel stood at 114,539 persons whereas the ratio of researchers to 10,000 workforces was 60.7 in 2014. • Researchers with Master's degree surged more than two-fold from 31.3% in 2012 to 61.7% in 2014 while the proportion of researchers with PhD degree reduced

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Aspects	2010	2013	2016
			by half from 45.2% in 2012 to 20.2% in 2014.
Public Sector Support for R&D	- Government has provided numerous grants and incentives for R&D in S&T. - Positive response from the public and private institutions reflects their awareness of the existence of these programmes and their keen interest in being involved.	- Government continues to provide various grants and incentives to promote R&D activities. - Positive response continues to be observed from the public and private institutions. - High degree of importance is placed on not just the R&D but also commercialisation of R&D output, especially in the biotechnology area.	- At Pre-R&D stage, Cradle Funds have supported a total of 134 Cradle Investment Programme (CIP) Catalysts projects (RM44.88 million), 7 University 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 MOSTI and several research grants from MOHE. - A total of 1,489 ScienceFund project valued at RM309.27 million were granted in 2011-2015.
R&D	- National GERD dropped drastically in 2006-2008. - The GERD/GDP ratio, a measure of research intensity, dropped in 2006-2008.	- National GERD increased in 2006-2011. - The GERD/GDP ratio increased in 2004-2011. - Malaysia's BERD improved over the years but still considered low compared to developed countries such as Singapore, South Korea and Taiwan.	- Malaysia's GERD reached RM13.97 billion in 2014 which was the best performance since 2000. - The R&D intensity, or the percentage of GERD over Gross Domestic Product (GDP), stood at 1.3% in 2014 – a more than two-fold increment from year 2000. - About 73.5% of the R&D expenditures was classified as current expenditure.
Innovation	- Malaysia ranked 24th on innovation competitiveness and 26th on global competitiveness in the GCI 2010-2011. - Malaysia is ranked 12th on the innovative capacity and 10th on world competitiveness in Competitiveness Yearbook 2010 (WCY 2010).	- Malaysia ranked 23rd on innovation and 25th on competitiveness out of 144 countries in the GCI 2011-2012. - Malaysia is ranked 13th on the innovative capacity of firms in generating new products and processes in WCY 2013, behind developed countries such as Israel (1st), USA (2nd) and Switzerland (3rd).	- The NSI-15 survey indicates that the services sector to be more innovative than the manufacturing sector, with higher percentage of innovative companies. - Innovative companies in both sectors typically records annual sales of more than RM6 million. - Internationally, Malaysia is among the top 20 most competitive economies globally, ranking 18th in GCI 2015-2016. - In Global Innovation Index (GII) 2016, Malaysia is ranked 35th, higher in ranking than Thailand (52nd) and

Aspects	2010	2013	2016
			Indonesia (88 th) but lower than Singapore (6 th).
IP Rights and Balance in Royalties and Licensing Fees	• 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 deficit in the balance of payments for royalties and licensing fees in 2001-2009.	• Promising growth in application of PCT patents by HLIs and Research Institutes (RIs). • 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 IP.	• Malaysia's patent and utility innovation applications trend in MyIPO manifested an increasing capacity from 1,136 patents in 2011 to 1,375 in 2014. • MIMOS Berhad and UTM stand out as the most productive organisations in PCT patenting activities. • For trademark, the applications have more than doubled in 2015 compared to 2001 while the registration increased by fourfold.
ICT in Malaysia	• An increase in penetration rate for cellular telephones and internet access. • Encouraging penetration rate for household's broadband.	• ICT access improved significantly, reflecting continuous improvement in ICT technology adoption by Malaysian population. • An increase in penetration rate for cellular telephones and households' broadband.	• Malaysia witnessed a sharp increase in broadband subscriptions during the period since the end of 2000s. • The MSC program of Malaysia emerged as the catalyst of growth for ICT industry in Malaysia. • Manufacturing stands out as the dominant industry that offers the most employment opportunities in ICT labour market of Malaysia.
Biotechnology / Energy and Green Technology	• Total number of participants in and revenues 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.	• 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.	• Malaysia has shown gradual progress in the green technology diffusion due to the various incentives and programmes. • Nevertheless, the source of energy mix is still predominantly fossil fuel namely coal and natural gas. • Challenges remained in diffusing the renewable technologies given the lower cost of fossil fuels due to subsidisation, high cost of renewable technologies, high investment requirements

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Aspects	2010	2013	2016
			and limited technological know-how. • More effort is needed to decouple the growth from conventional source of energy especially fossil fuel to that of green energy to drive the green economy.
Trade in Technology	• 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 in the world in 2008.	• 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 worlds.	• The annual average growth of KI sector's value added in Malaysia is 37% from 2000 to 2014. • Malaysia's KI industry average growth is lacking behind (28%) from other ASEAN nations like Indonesia (83%), Philippines (48%), Thailand (44%) and Singapore (36%). • Malaysia's documented consistent trade deficit in commercial KI services compared to other ASEAN nations like Singapore and Philippines from 2004 to 2013.
Publications and Citations	• 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.	• Positive growth in number of publications and citations. • Decline in annual growth rate for publications and citations.	• Malaysia witnessed a trend with a consistent increase in publications. It has a capacity of producing 10,499 articles in 2014. • "Material Science" with publication reporting multidisciplinary research findings emerged as the top fields. • UM emerged as the top institution in performing scientific publications with capacity of producing 14,920 articles for a period of 13 years.

Source: Compilation from STI Indicators Report, 2010, 2013, 2016, MASTIC

1.6 Summary

Over the years, Malaysia has made significant progress in various aspects of STI. Currently, new challenges emerge, and it is essential that Malaysia positions its STI ecosystem to support as well as facilitate the transition to a new agenda that would mitigate such challenges. Bridging the gaps through STI on issues related to sustainable development including environment and inclusiveness are critical at this juncture.

2

EDUCATION ADVANCEMENT

CHAPTER 2: EDUCATION ADVANCEMENT IN MALAYSIA

2.1 Introduction

In developing and nurturing talent in STI, Malaysia is committed to ensuring the quality and effectiveness of STEM¹ education. The Malaysia Education Blueprint (MEB) 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 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. The commitment of Malaysia to harnessing 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 initiated since the 1980s; these include the National Science and Technology Policy (1986-1989, 2002-2010) and Industrial Technology Development (1990-2001). The commitment is further enhanced with the MEB which proposes major reforms to Malaysia's higher education system to accelerate the positive upward trajectory of the system. The various initiatives and programmes implemented under these policies have accelerated the progress of the country's STI proficiency, including increasing R&D capabilities and capacity, networking with industry-funded public research organizations and the development of new knowledge-based industries. The newly launched National Policy on Science, Technology and Innovation (NSTIP) 2021-2030 is designed to intensify local technology development and efforts to transform the country from being technology users to technology developers.

As we embark on the Fourth Industrial Revolution (IR 4.0), technology will play a central role in almost all aspects of our lives. The 21st century competencies, in reference to the changing world that the next generation will enter upon leaving school include cognitive skills that go beyond mastery of academic content. Specifically, Thrust 4 of NSTIP, Adaptive STI Talent, aims to develop a competent STI talent group and adaptable to a variety of situations especially in the face of global economic and technological changes. More specifically, under Leading STEM Education (Strategy B), two initiatives will be pursued; (1) developing STEM teaching and learning modules that are transdisciplinary (2) Streamlining the TVET Module in the education system.

This chapter discusses the STEM education in Malaysia from upper secondary school to the university level and the readiness in STI participations. The data presented have been obtained from three main sources, namely: MOHE; the Ministry of Education (MOE) and the STEM Centre

¹ STEM refers to the subjects based on the NEC.

MOE. 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 Science, Mathematics and Technology Education at Secondary and Pre-University Levels

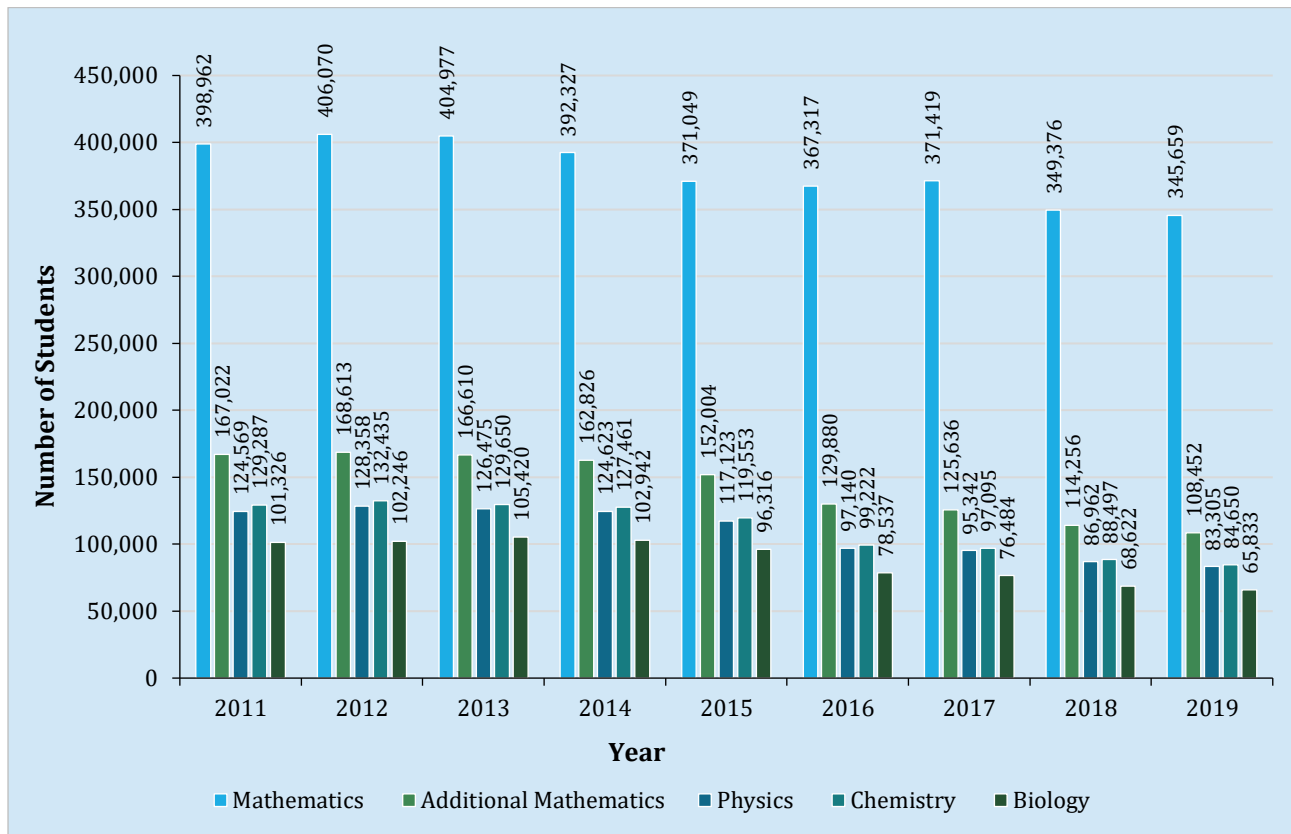
SPM, or the Malaysian Certificate of Education, is a national examination taken by all fifth-year secondary school students in Malaysia, an equivalent to the O-level in the United Kingdom (UK) and the eleventh grade in America's K–12 (education). STPM and Matriculation/ Pre-University programmes are 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 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, and Matriculation levels. The data analysed are limited to those from the Ministry of Education and Ministry of Higher Education.

2.2.1 Science, Mathematics and Technical Subjects at SPM Level

Mathematics 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 as a subject is compulsory for students in the Commerce, Literature and Arts streams only. Figure 2.1 displays the number of registered students² by subject from 2011-2019. Throughout this period, the percentage of students registered for Additional Mathematics, Physics, Chemistry and Biology subjects is relatively constant. However, the total number of registered students for Mathematics has decreased by 7% in 2019 compared to 2015.

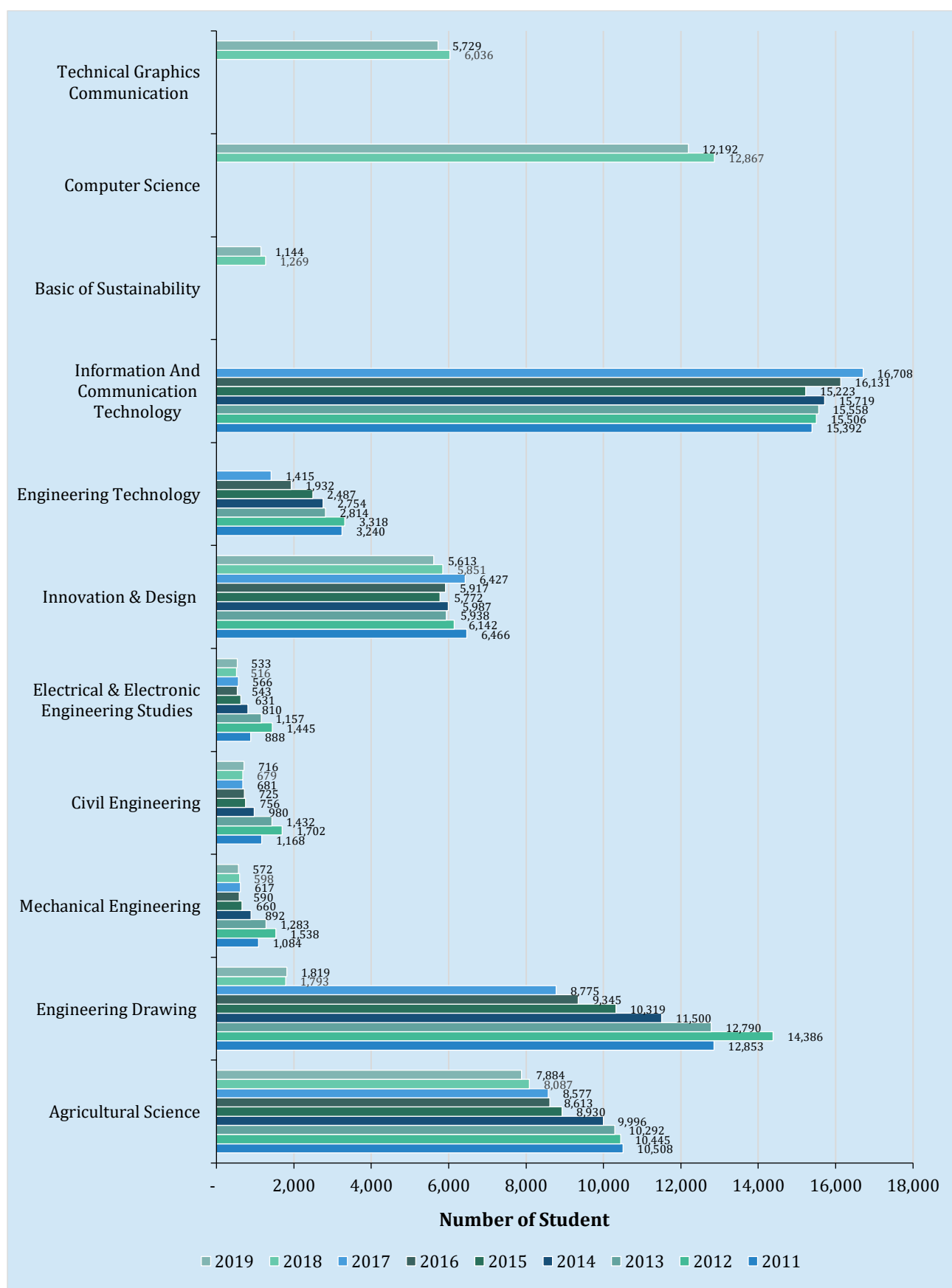
² The data comprises: (i) all school candidates excluding private candidates; and (ii) new candidates/first timers sitting for SPM.

Figure 2.1 Registration for Pure Science Subjects, SPM 2011 – 2019



Source: STEM Centre, MOE

Figure 2.2 shows the number of students registered for technical subjects at the SPM level for 2011 – 2019. The number of students registered for ICT gradually increased from 2011 to 2017 and newer related subjects were introduced in 2018 where Computer Science and Technical Graphic Communication is gaining traction among students. The change in trend towards ICT and computer related courses is largely due to the Government's emphasis on ICT over the years. The number of registrations for Mechanical Engineering, Civil Engineering and Electric & Electronic Engineering Studies remains relatively constant for 2016-2019.

Figure 2.2 Registration for Technical Subjects at SPM, 2011 – 2019

Source: STEM Centre, MOE

2.2.1.1 Grades for Mathematics, Pure Science and Technical Subjects at SPM Level

A similar performance trend is observed over the years 2016-2019, in terms of percentages for band A achievers (that is, A+, A and A-), for all Pure Science subjects (Table 2.1). On the other extreme with lower grade achieved, the percentage of students with grade G in Mathematics has improved from 23% in 2016 to 19% in 2019. While only a very small percentage of grade G is observed for Physics, Chemistry and Biology, Additional Mathematics stood almost unchanged at 23% to 25%. For technical subjects, the performance trends (in terms of percentages) are very similar from 2016 to 2019 with slight improvements for Engineering Drawing and Electric and Electronic Engineering (Table 2.2). The percentage of top performers, that is band A (A+, A and A-), for Innovation and Design has significantly reduced from 40% in 2016 to 12% in 2019.

Table 2.1 Grades Attained for Pure Science Subjects at SPM, 2016 – 2019

Year	2016	2017	2018	2019
Mathematics				
A+	25,293	31,827	22,157	20,434
A	53,258	59,281	64,356	64,939
A-	18,575	20,247	16,896	17,618
B+	19,126	21,195	18,035	18,382
B	19,991	23,078	19,777	19,160
C+	21,234	23,055	22,036	20,937
C	24,013	27,920	28,897	26,320
D	44,643	50,761	43,192	39,356
E	55,188	47,653	50,328	53,861
G	85,996	66,402	63,702	64,652
TOTAL	367,317	371,419	349,376	345,659
Additional Mathematics				
A+	5,915	4,718	3,689	3,247
A	10,418	10,755	11,266	10,150
A-	7,786	6,670	5,058	5,369
B+	9,014	7,995	6,158	6,923
B	10,760	9,967	8,303	7,631
C+	11,104	11,132	10,221	9,994
C	12,262	12,019	11,759	11,893
D	16,073	14,840	14,355	13,687
E	17,057	17,112	14,973	14,608
G	29,491	30,428	28,474	24,950
TOTAL	129,880	125,636	114,256	108,452
Physics				
A+	7,887	8,858	5,616	6,201
A	3,187	1,451	4,778	3,911
A-	10,260	11,910	8,394	8,856
B+	12,128	14,383	10,731	10,744
B	14,151	14,246	12,973	12,198
C+	14,214	14,487	14,054	13,238
C	14,713	13,290	14,461	12,131
D	14,911	12,352	12,204	11,584
E	4,760	3,757	3,299	3,736

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Year	2016	2017	2018	2019
G	929	608	452	706
TOTAL	97,140	95,342	86,962	83,305
Chemistry				
A+	7,657	7,807	5,460	6,509
A	4,785	1,657	4,014	3,599
A-	7,791	8,743	7,292	7,431
B+	8,497	10,227	8,536	8,037
B	9,090	10,254	8,603	8,646
C+	9,300	10,881	9,568	10,012
C	11,128	12,234	10,536	9,668
D	20,854	18,830	18,776	15,648
E	16,326	12,650	12,943	11,895
G	3,794	3,812	2,769	3,205
TOTAL	99,222	97,095	88,497	84,650
Biology				
A+	2,923	2,558	2,658	2,309
A	6,655	6,107	5,954	5,969
A-	8,327	7,712	6,060	6,439
B+	10,736	10,185	7,419	7,955
B	12,129	11,013	9,666	10,304
C+	12,769	11,766	11,182	10,670
C	10,261	12,051	10,522	8,966
D	10,333	10,796	10,563	9,095
E	3,665	3,619	4,009	3,522
G	739	677	589	604
TOTAL	78,537	76,484	68,622	65,833

Source: STEM Centre, MOE

Table 2.2 Grades Attained for Technical Subjects at SPM, 2016 – 2019

Year	2016							
Subject	Agricultural Science	Engineering Drawing	Mechanical Engineering	Civil Engineering	Electric and Electronic Engineering	Innovation and Design	Engineering Technology	Information and Communication Technology
A	1,062	2,130	146	152	154	2,366	163	2,540
B	2,312	3,186	145	274	175	2,419	449	6,461
C	2,223	2,300	139	199	124	845	539	5,171
D	894	698	118	73	53	183	284	1,267
E	745	503	37	21	26	67	253	495
G	1,377	528	5	6	11	37	244	197
TOTAL	8,613	9,345	590	725	543	5,917	1,932	16,131
Year	2017							
A	1,208	2,357	132	127	151	2,791	145	2,349
B	2,316	2,860	163	247	196	2,644	352	5,685
C	2,235	2,023	157	177	122	761	396	6,563
D	817	646	101	76	56	167	212	1,339
E	673	455	47	38	35	44	175	602
G	1,328	434	17	16	6	20	135	170
TOTAL	8,577	8,775	617	681	566	6,427	1,415	16,708
Year	2018							
Subject	Agricultural Science	Engineering Drawing	Mechanical Engineering	Civil Engineering	Electric and Electronic Engineering	Innovation and Design	Computer Science	Information and Communication Technology
A	1,476	446	134	136	156	585	3,439	1,555
B	2,450	645	180	225	186	2,359	4,679	2,003
C	2,392	440	149	183	79	2,180	2,991	1,582
D	1,215	133	76	88	52	585	1,221	708
E	481	84	39	23	26	129	424	172
G	73	45	20	24	17	13	113	16
TOTAL	8,087	1,793	598	679	516	5,851	12,867	6,036
Year	2019							
A	1,654	472	132	124	164	699	3,002	1,620
B	2,613	633	174	243	208	2,423	3,848	2,082
C	2,124	450	140	208	102	1,900	3,539	1,277
D	1,066	131	66	74	38	503	1,390	582
E	362	93	42	47	18	71	378	158
G	65	40	18	20	3	17	35	10
TOTAL	7,884	1,819	572	716	533	5,613	12,192	5,729

Source: STEM Centre, MOE

Table 2.3 shows that the performance for males and females over the years are similar. In terms of proportions, more males are observed in band A for Additional Mathematics, Physics and Chemistry. The percentage of males failing that is in band G is approximately twice that of

females especially in Mathematics and Science. In terms of urban to rural achievements, the gap is visible among those in band A (that is, the proportion of high performer).

Table 2.3 Grades by Gender, Mathematics and Science at SPM, 2016 – 2019

Year	2016	2016	2017	2017	2018	2018	2019	2019
	Mathematics							
	Male	Female	Male	Female	Male	Female	Male	Female
A	40,262	56,864	45,982	65,373	42,172	61,237	42,830	60,161
B	15,127	23,990	17,329	26,944	14,841	22,971	15,006	22,536
C	18,840	26,407	20,973	30,002	21,533	29,400	19,966	27,291
D	20,268	24,375	21,986	28,775	19,987	23,205	17,990	21,366
E	26,594	28,594	23,223	24,430	24,764	25,564	26,657	27,204
G	53,456	32,540	44,038	22,364	41,191	22,511	41,109	23,543
TOTAL	174,547	192,770	173,531	197,888	164,488	184,888	163,558	182,101
	Science							
	Male	Female	Male	Female	Male	Female	Male	Female
A	19,388	32,255	21,176	35,404	20,844	34,619	18,988	34,253
B	25,794	35,214	22,852	31,366	24,209	32,727	22,496	30,138
C	29,796	32,164	30,995	35,071	26,242	29,163	27,041	29,255
D	24,508	17,779	21,702	19,124	18,307	15,978	18,507	16,118
E	19,095	10,648	20,546	13,671	20,170	13,115	21,337	14,539
G	14,671	5,804	16,197	5,499	17,142	6,272	18,927	7,796
TOTAL	133,252	133,864	133,468	140,135	126,914	131,874	127,296	132,099
	Additional Mathematics							
	Male	Female	Male	Female	Male	Female	Male	Female
A	11,421	12,698	10,337	11,806	9,287	10,726	9,127	9,639
B	7,765	12,009	7,072	10,890	5,738	8,723	5,949	8,605
C	8,503	14,863	8,594	14,557	8,166	13,814	8,227	13,660
D	5,747	10,326	5,367	9,473	5,112	9,243	5,036	8,651
E	6,140	10,917	6,027	11,085	5,389	9,584	5,420	9,188
G	12,376	17,115	12,602	17,826	11,865	16,609	10,407	14,543
TOTAL	51,952	77,928	49,999	75,637	45,557	68,699	44,166	64,286
	Physics							
	Male	Female	Male	Female	Male	Female	Male	Female
A	10,807	10,527	11,029	11,190	9,025	9,763	9,386	9,582
B	10,755	15,524	11,811	16,818	9,758	13,946	9,488	13,454
C	10,628	18,299	10,119	17,658	10,818	17,697	9,599	15,770
D	5,364	9,547	4,403	7,949	4,540	7,664	4,448	7,136
E	1,904	2,856	1,483	2,274	1,294	2,005	1,541	2,195
G	517	412	331	277	278	174	395	311
TOTAL	39,975	57,165	39,176	56,166	35,713	51,249	34,857	48,448
	Chemistry							
	Male	Female	Male	Female	Male	Female	Male	Female
A	9,013	11,220	8,090	10,117	7,560	9,206	7,840	9,699
B	6,829	10,758	8,123	12,358	6,702	10,437	6,520	10,163
C	7,602	12,826	8,588	14,527	7,422	12,682	7,418	12,262
D	7,963	12,891	7,220	11,610	7,235	11,541	6,337	9,311
E	7,080	9,246	5,551	7,099	5,609	7,334	5,335	6,560

Year	2016	2016	2017	2017	2018	2018	2019	2019
G	2,155	1,639	2,065	1,747	1,576	1,193	1,738	1,467
TOTAL	40,642	58,580	39,637	57,458	36,104	52,393	35,188	49,462
	Biology							
	Male	Female	Male	Female	Male	Female	Male	Female
A	7,351	10,554	6,853	9,524	6,202	8,470	6,288	8,429
B	8,207	14,658	7,806	13,392	6,293	10,792	6,811	11,448
C	8,165	14,865	8,464	15,353	7,602	14,102	7,104	12,532
D	4,004	6,329	4,199	6,597	3,890	6,673	3,474	5,621
E	1,748	1,917	1,505	2,114	1,678	2,331	1,510	2,012
G	491	248	376	301	348	241	330	274
TOTAL	29,966	48,571	29,203	47,281	26,013	42,609	25,517	40,316

Source: STEM Centre, MOE

2.2.2 Science and Mathematics at STPM Level

At STPM level, Mathematics(T) recorded the highest number of students registered from 2011-2019, followed by Chemistry, Biology and Physics, as displayed in Table 2.4. While Mathematics(T) is taken by most Science students, Mathematics(M) is for the Business and Accounts students. Except for 2019, Mathematics (M), Mathematics(T), Chemistry, Biology and Physics, displayed a decreasing trend in enrolment since 2014. Although the number of annual enrolment for ICT is small, an increasing trend is observed since 2015 with a slight dip in 2018. In terms of gender, males are more dominant in Physics while females in Biology.

Table 2.4 Registration for Science & Mathematics at STPM, 2011 – 2019

Year	2016	2017	2018	2019
Mathematics				
A+	25,293	31,827	22,157	20,434
A	53,258	59,281	64,356	64,939
A-	18,575	20,247	16,896	17,618
B+	19,126	21,195	18,035	18,382
B	19,991	23,078	19,777	19,160
C+	21,234	23,055	22,036	20,937
C	24,013	27,920	28,897	26,320
D	44,643	50,761	43,192	39,356
E	55,188	47,653	50,328	53,861
G	85,996	66,402	63,702	64,652
TOTAL	367,317	371,419	349,376	345,659
Additional Mathematics				
A+	5,915	4,718	3,689	3,247
A	10,418	10,755	11,266	10,150
A-	7,786	6,670	5,058	5,369
B+	9,014	7,995	6,158	6,923
B	10,760	9,967	8,303	7,631
C+	11,104	11,132	10,221	9,994
C	12,262	12,019	11,759	11,893
D	16,073	14,840	14,355	13,687
E	17,057	17,112	14,973	14,608
G	29,491	30,428	28,474	24,950
TOTAL	129,880	125,636	114,256	108,452
Physics				
A+	7,887	8,858	5,616	6,201
A	3,187	1,451	4,778	3,911
A-	10,260	11,910	8,394	8,856
B+	12,128	14,383	10,731	10,744
B	14,151	14,246	12,973	12,198
C+	14,214	14,487	14,054	13,238
C	14,713	13,290	14,461	12,131
D	14,911	12,352	12,204	11,584
E	4,760	3,757	3,299	3,736
G	929	608	452	706
TOTAL	97,140	95,342	86,962	83,305
Chemistry				
A+	7,657	7,807	5,460	6,509
A	4,785	1,657	4,014	3,599
A-	7,791	8,743	7,292	7,431
B+	8,497	10,227	8,536	8,037
B	9,090	10,254	8,603	8,646
C+	9,300	10,881	9,568	10,012
C	11,128	12,234	10,536	9,668
D	20,854	18,830	18,776	15,648
E	16,326	12,650	12,943	11,895
G	3,794	3,812	2,769	3,205
TOTAL	99,222	97,095	88,497	84,650

	2016	2017	2018	2019
	Biology			
A+	2,923	2,558	2,658	2,309
A	6,655	6,107	5,954	5,969
A-	8,327	7,712	6,060	6,439
B+	10,736	10,185	7,419	7,955
B	12,129	11,013	9,666	10,304
C+	12,769	11,766	11,182	10,670
C	10,261	12,051	10,522	8,966
D	10,333	10,796	10,563	9,095
E	3,665	3,619	4,009	3,522
G	739	677	589	604
TOTAL	78,537	76,484	68,622	65,833

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

Source: Malaysian Examination Council, MOE

Table 2.5 Registration by Urban-Rural Regions at STPM, 2011 – 2019

Year	Mathematics (M)		Mathematics (T)		ICT		Physics		Chemistry		Biology	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
2011	1,674	67	7,703	406	397	41	3,336	141	7,609	404	4,389	280
2012	1,612	48	7,586	390	394	50	3,420	169	7,471	388	4,189	229
2013	1,514	84	7,533	1,206	429	146	3,354	460	7,434	1,131	4,214	769
2014	1,025	66	6,166	1,002	289	60	2,746	438	6,081	958	3,443	587
2015	993	85	5,739	810	328	98	2,639	338	5,671	820	3,130	501
2016	896	65	5,396	751	320	110	2,341	308	5,309	740	3,072	480
2017	793	86	4,788	697	426	144	2,260	267	4,705	657	2,528	495
2018	662	41	3,885	636	362	144	1,968	288	3,836	607	1,950	371
2019	794	78	4,030	616	450	153	2,166	303	3,976	592	1,863	322

Source: Malaysian Examination Council, MOE

Table 2.6 displays the grades achieved at the STPM examination, 2016–2019. In terms of percentages, the performance over the years is very similar: Mathematics (T) recorded improvements in band A (21% in 2016 to 24% in 2019) with reduced Fs (12% in 2016 to 9% in 2019). In terms of gender, males are in general, performing better than females for grades A and B (Table 2.7).

Table 2.6 Grades for Mathematics and Science at STPM

GRADE	2016	2017	2018	2019
	Mathematics (M)			
A	132	121	111	137
B	299	282	221	269
C	341	286	219	268
D	86	67	64	84
F	103	123	88	114
TOTAL	961	879	703	872
	Mathematics(T)			
A	1,298	1,076	974	1,109
B	2,098	1,863	1,518	1,694
C	1,430	1,369	1,112	1,048
D	610	569	391	376
F	711	608	526	419
TOTAL	6,147	5,485	4,521	4,646
	ICT			
A	107	146	129	158
B	204	243	234	267
C	102	143	123	154
D	13	28	12	16
F	4	10	8	8
TOTAL	430	570	506	603
	Physics			
A	497	439	484	539
B	926	817	780	890
C	830	804	694	726
D	251	279	181	184
F	145	188	117	130
TOTAL	2,649	2,527	2,256	2,469
	Chemistry			
A	914	722	659	714
B	2,458	1,990	1,768	1,903
C	2,194	2,094	1,619	1,612
D	419	505	340	320
F	64	51	57	19
TOTAL	6,049	5,362	4,443	4,568
	Biology			
A	483	420	342	327
B	1,344	1,012	830	942
C	1,299	1,262	893	673
D	360	292	210	177
F	66	37	46	66
TOTAL	3,552	3,023	2,321	2,185

Source: Malaysian Examination Council, MOE

Table 2.7 Grades by Gender for Mathematics and Science at STPM

GRADE	Male				Female			
	2016	2017	2018	2019	2016	2017	2018	2019
	Mathematics (M)							
A	46	40	43	47	86	81	68	90
B	84	85	68	87	215	197	153	182
C	113	91	74	103	228	195	145	165
D	33	27	21	26	53	40	43	58
F	46	44	42	51	57	79	46	63
Mathematics (T)								
A	621	549	520	578	677	527	454	531
B	889	819	682	757	1,209	1,044	836	937
C	559	563	475	452	871	806	637	596
D	210	184	150	162	400	385	241	214
F	288	242	232	183	423	366	294	236
ICT								
A	48	79	59	80	59	67	70	78
B	79	105	90	106	125	138	144	161
C	48	55	59	68	54	88	64	86
D	9	13	7	8	4	15	5	8
F	1	6	2	2	3	4	6	6
Physics								
A	340	303	331	386	157	136	153	153
B	593	507	478	530	333	310	302	360
C	495	487	408	417	335	317	286	309
D	161	167	118	125	90	112	63	59
F	101	117	76	79	44	71	41	51
Chemistry								
A	431	376	349	404	483	346	310	310
B	1,075	888	796	853	1,383	1,102	972	1,050
C	816	813	690	702	1,378	1,281	929	910
D	179	196	153	124	240	309	187	196
F	26	22	27	11	38	29	30	8
Biology								
A	151	136	104	95	332	284	238	232
B	352	292	228	261	992	720	602	681
C	294	271	251	170	1,005	991	642	503
D	83	69	68	50	277	223	142	127
F	20	10	13	19	46	27	33	47

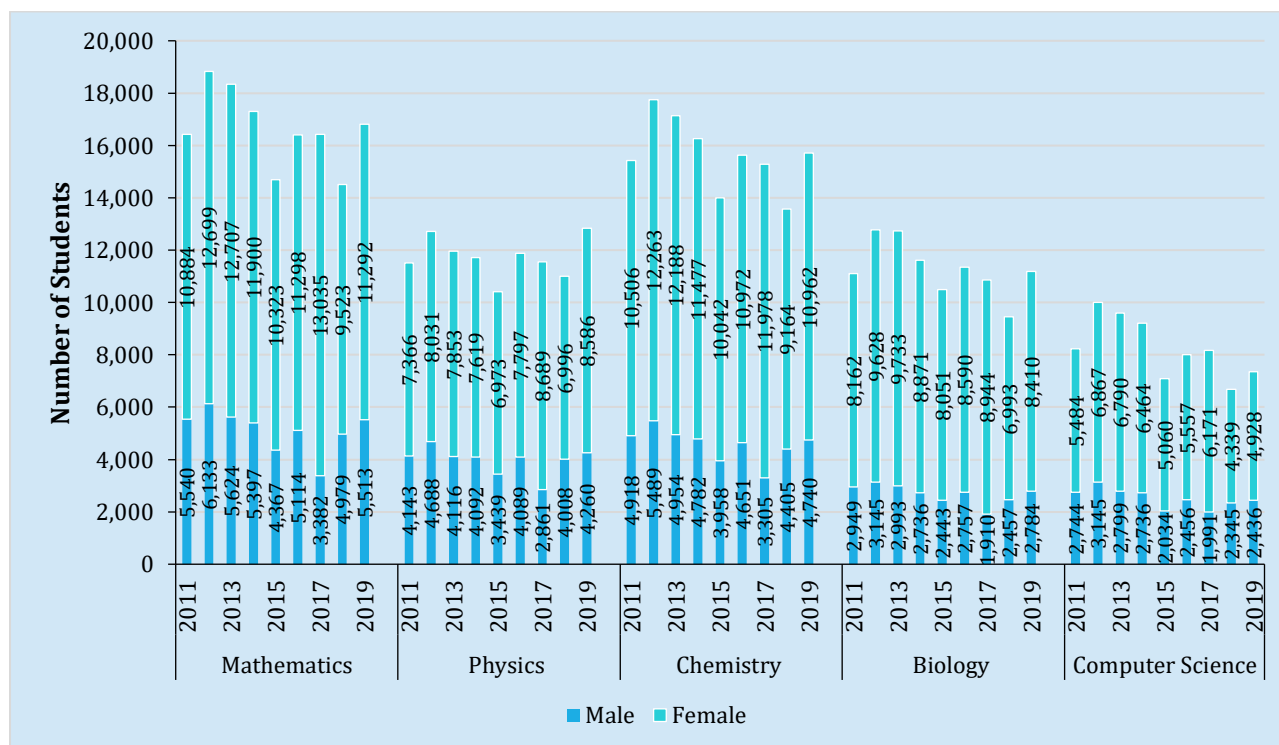
Source: Malaysian Examination Council, MOE

2.2.3 Science, Mathematics and Technical Enrolment at Matriculation Level

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, Technical and Accounting Programmes. 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 Technical Programme comprises four subjects, namely, Mathematics, Chemical Engineering, Physical Engineering and Engineering Study. The Technical Programme was first introduced in the academic session of 2009/2010. The data reported here are programmes offered under the Ministry of Education, Malaysia.

Figure 2.3 shows the number of students registered for Mathematics and Pure Sciences subjects offered for the period 2011-2019. In the 2014/2015 enrolment, a drop is observed for all Science courses, most likely influenced by an increase in enrolment for Technical and Accounting programmes. In terms of gender distribution, females are twice more than males in Science.

Figure 2.3 STEM Enrolment in Matriculation Programmes



Source: MOE, Malaysia

The performance of students in Mathematics and Science Matriculation courses has improved over the time span of 2011-2019 (Table 2.8). In terms of percentages, students have improved most in Chemistry with reduced number of failures (grade C- and below) from 11.5% in 2017 to 3% in 2019. Similar trend is also observed for other subjects.

Table 2.8 STEM Performance Achievement in Matriculation Programmes

	Subject	A	B	C	FAIL	TOTAL
2011/2012	Maths	6,506	7,197	2,046	675	16,424
	Physics	5,670	4,492	1,148	199	11,509
	Chemistry	6,504	6,950	1,632	338	15,424
	Biology	4,799	4,815	1,358	139	11,111
	Computer Science	6,077	2,101	47	3	8,228
2012/2013	Maths	6,534	9,850	1,955	493	18,832
	Physics	6,133	4,959	1,400	227	12,719
	Chemistry	7,052	9,060	1,518	122	17,752
	Biology	4,915	6,231	1,380	247	12,773
	Computer Science	8,557	1,431	23	1	10,012
2013/2014	Maths	6,796	8,262	2,325	948	18,331
	Physics	5,693	4,982	1,127	167	11,969
	Chemistry	6,627	8,480	1,890	145	17,142
	Biology	5,874	5,103	1,503	246	12,726
	Computer Science	8,291	1,251	34	13	9,589
2014/2015	Maths	6,911	7,576	1,997	813	17,297
	Physics	5,892	4,575	1,130	114	11,711
	Chemistry	6,701	7,515	1,954	89	16,259
	Biology	5,557	4,642	1,289	119	11,607
	Computer Science	7,350	1,808	41	1	9,200
2015/2016	Maths	5,395	5,522	2,199	1,574	14,690
	Physics	5,563	4,125	675	49	10,412
	Chemistry	6,265	6,411	1,292	32	14,000
	Biology	6,652	3,318	463	61	10,494
	Computer Science	5,356	1,709	26	3	7,094
2016/2017	Maths	6,013	7,613	2,170	616	16,412
	Physics	6,507	5,091	281	7	11,886
	Chemistry	6,774	7,153	1,682	14	15,623
	Biology	6,274	4,550	507	16	11,347
	Computer Science	6,162	1,807	43	1	8,013
2017/2018	Maths	6,403	7,223	2,246	545	16,417
	Physics	6,686	4,341	516	7	11,550
	Chemistry	6,273	7,259	1,737	14	15,283
	Biology	4,737	5,304	787	26	10,854
	Computer Science	4,771	3,191	184	16	8,162
2018/2019	Maths	5,898	7,029	1,407	168	14,502
	Physics	6,524	4,155	309	16	11,004
	Chemistry	4,596	7,618	1,280	75	13,569
	Biology	4,372	4,383	671	24	9,450
	Computer Science	4,289	2,360	33	2	6,684
2019/2020	Maths	7,316	8,067	1,359	63	16,805
	Physics	8,099	4,401	328	18	12,846
	Chemistry	7,994	7,212	469	27	15,702
	Biology	6,114	4,846	232	2	11,194
	Computer Science	5,496	1,802	64	2	7,364

Source: MOE, Malaysia

2.2.4 Enrolment and Graduations in TVET Diploma Programmes

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 occupations in various sectors of economic life”.

The TVET programmes in Malaysia are offered at Certificate, Diploma, and Degree levels by seven ministries that include MOHE. According to the Malaysia Education Blueprint (Higher Education) 2015-2025, there will be an increase in demand for an additional 1.3 million TVET workers by 2020 in the 12 National Key Economic Areas (NKEA) identified under the government’s Economic Transformation Programme (ETP). To meet this demand, the government has increased the development expenditure given to public TVET institutions from RM1.8 billion in 2010 to RM2.1 billion in 2014. Currently there are over 1,000 TVET institutions in Malaysia of which 506 are public institutions. TVET Diploma programmes at polytechnic enrol nearly 100,000 students annually.

The TVET Diploma programmes offered under Malaysia Technical Universities (MTUN) focus on two broad programmes (by NEC code): Engineering, Manufacturing & Construction and Science, Mathematics and Computing. Table 2.9 displays the enrolment and graduation in TVET Diploma Programmes; Engineering, Manufacturing & Construction make up 80% - 83% of all STEM enrolment. A 36% increase is observed in enrolment for Engineering, Manufacturing & Construction in 2019 from that of 2015, while Science, Mathematics and Computing saw an increase by 22% over the same period. Similar trends are also observed for graduations.

Table 2.9 Enrolment and Graduations in TVET Diploma Courses (MTUN)

	Subject	Science Based		Non-Science
		Science, Mathematics and Computing	Engineering, Manufacturing & Construction (By Narrow Field: 52, 54, 58)	Services
Enrolment	Year			
	2011	750	3,943	28
	2012	865	4,278	24
	2013	1,031	4,610	24
	2014	1,034	4,123	18
	2015	1,024	4,097	5
	2016	1,091	4,855	1
	2017	972	4,994	1
	2018	1,251	5,848	1
	2019	1,251	5,578	1
	2020	973	4,651	-
Graduation	2011	122	766	-
	2012	148	891	-
	2013	208	1,047	-
	2014	305	1,576	6
	2015	296	1,321	13
	2016	329	1,293	4
	2017	301	1,099	-
	2018	307	1,346	-
	2019	392	1,990	-
	2020	269	885	-

Source: MOHE, Malaysia

The TVET Diploma programmes at polytechnics, comprise Engineering, Manufacturing & Construction, Science, Mathematics & Computing and Agriculture & Veterinary constitute 68% - 71% of all enrolment (see Table 2.10). A similar trend is also observed for graduation at these polytechnics.

Table 2.10 Enrolment and Graduations in TVET Diploma Courses, Polytechnics

	Subject	Science, Mathematics and Computing	Engineering, Manufacturing & Construction (By Narrow Field: 52, 54, 58)	Agriculture & Veterinary	Arts & Humanities	Social Sciences, Business and Law	Services
	Year						
Enrolment	2016	9,000	55,709	2,004	2,291	23,686	5,000
	2017	8,544	56,247	2,293	2,468	23,710	4,464
	2018	8,040	55,773	2,509	2,326	22,191	3,712
	2019	8,640	55,703	2,715	2,276	21,873	3,661
Graduation	2016	1,953	14,800	252	663	6,386	1,504
	2017	2,697	14,982	431	656	6,658	1,748
	2018	3,117	16,751	608	738	7,953	1,791
	2019	2,315	16,922	795	728	7,319	1,207

Source: MOHE, Malaysia

The Community Colleges under the Ministry of Higher Education offers TVET programmes at the Diploma and Certificate levels. At Diploma level, it is observed that Engineering, Manufacturing & Construction registered an enrolment of 55% - 60% of all enrolment for the period 2016-2020 (Table 2.11).

Table 2.11 Enrolment and Graduations in TVET Diploma Courses, Community Colleges

	Subject	Engineering, Manufacturing & Construction (By Narrow Field: 52, 54, 58)	Arts & Humanities	Social Sciences, Business and Law	Services
	Year				
Enrolment	2016	279	61	42	131
	2017	334	86	20	112
	2018	468	164	20	189
	2019	460	155	1	195
	2020	242	41	-	200
Graduation	2016	59	15	0	22
	2017	93	13	14	47
	2018	162	40	17	67
	2019	144	39	1	35
	2020	8	1	-	27

Source: MOHE, Malaysia

At the Certificate level, Engineering, Manufacturing & Construction registered an enrolment of 40% - 42% while Science, Mathematics and Computing contributes about 14% of all total enrolment for the year 2016-2020 (Table 2.12).

Table 2.12 Enrolment and Graduations in TVET Certificate Courses, Community Colleges

	Year	Engineering, Manufacturing & Construction	Science, Mathematics & Computing	Agriculture & Veterinary	Arts & Humanities	Social Sciences, Business & Law	Services
Enrolment	2016	8,377	2,727	334	2,786	734	4,598
	2017	8,645	2,802	437	2,866	810	4,678
	2018	9,922	3,478	572	3,577	1,028	6,360
	2019	10,140	2,990	510	3,712	1,012	6,753
	2020	6,395	2,148	184	1,999	843	4,016
Graduation	2016	3,808	1,561	213	1,284	267	2,196
	2017	4,095	1,477	198	1,452	452	2,485
	2018	4,350	1,816	276	1,379	481	2,436
	2019	2,950	388	63	1,074	94	2,024
	2020	2,894	1,034	104	891	356	1,652

Source: Statistics of Higher Education

2.3 Science and Technology at Public HLIs

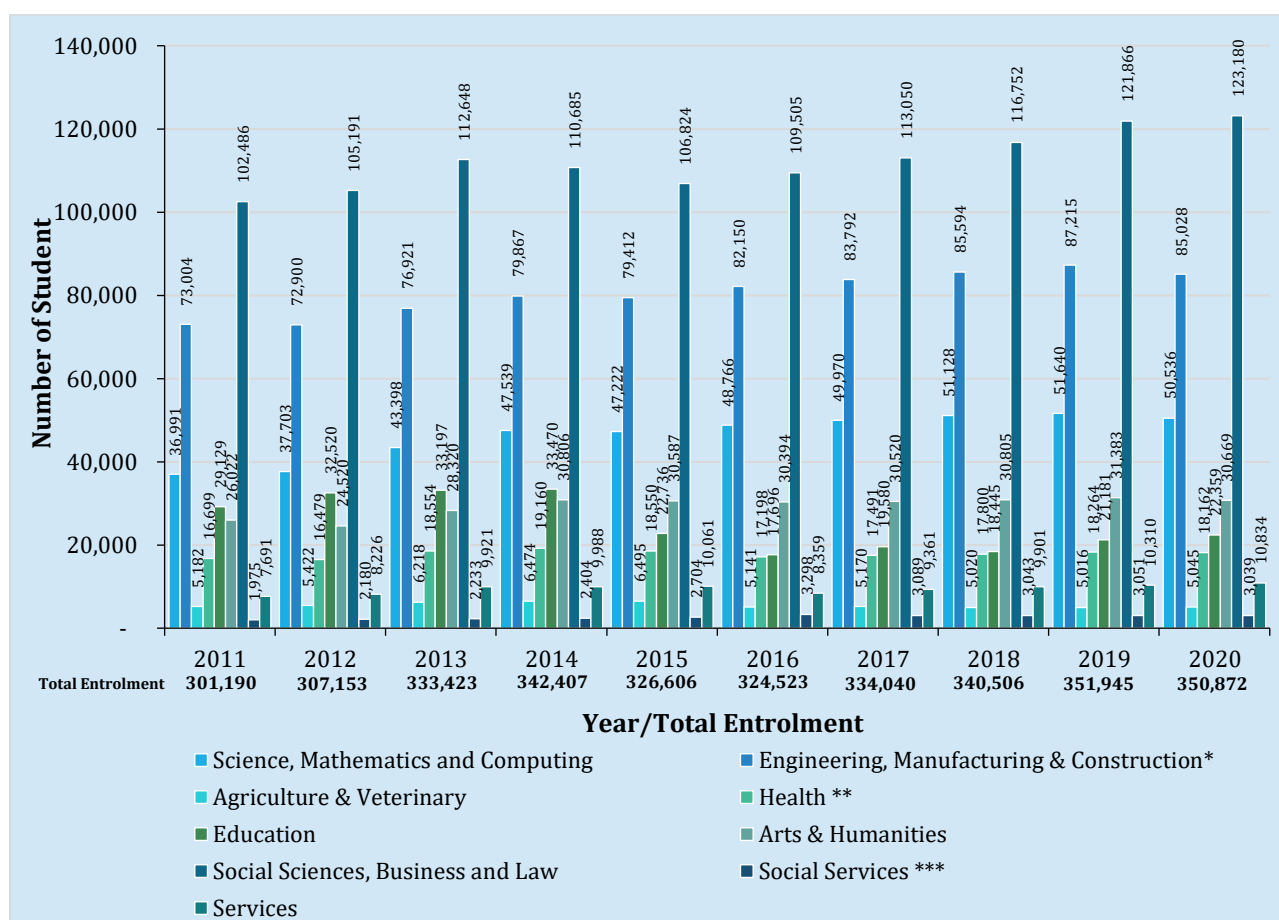
Higher education, also known as tertiary education, refers to all post-secondary education, including both public and private universities, colleges, and technical training institutes. A highly skilled workforce with a strong post-secondary education is without a doubt, a prerequisite for innovation, advancement and growth. In brief, HLIs have the ability to prepare individuals not only by providing relevant job skills and sufficient work abilities, but also in preparing them to be dynamic individuals of their communities and societies.

Currently, there are 20 public universities, 36 polytechnics, 104 community colleges and 436 private HLIs, in Malaysia that offers courses leading to Certificate, Diploma, Bachelor, Master, and Doctoral degrees, in diverse areas including S&T. The STEM programmes offered by public universities are classified under the NEC codes comprising these broad programmes: Science, Mathematics and Computing, Engineering, Manufacturing & Construction, Agriculture & Veterinary, Health & Welfare. This section discusses the enrolment and graduations at the undergraduate and postgraduate levels for STEM programmes in public and private HLIs.

2.3.1 First Degree Courses Enrolment and Graduations at Public HLIs

Over the period of 2011 to 2019, the number of students enrolled in STEM related subjects has increased from 131,876 to 162,135 respectively. Although the aspiration of the government and MOE has always been to ensure a 60-40 enrolment for STEM- to non-STEM-based, the percentages of students enrolled in STEM-based programmes in 2011 -2020 are within the range of 43% - 48% (Figure 2.4). Enrolment in Engineering, Manufacturing and Construction represents around 25% of all enrolment while Science, Mathematics and Computing enrolment saw an increase from 12% to 15% during this period. As for non-STEM based programmes, the enrolment has steadily increased from 167,303 in 2011 to 190,081 in 2020. The percentage enrolment in Social Sciences, Business and Law makes up 35% of all enrolment, while the percentage enrolment in Education experiences a dip from 10% in 2011 to 6% in 2020.

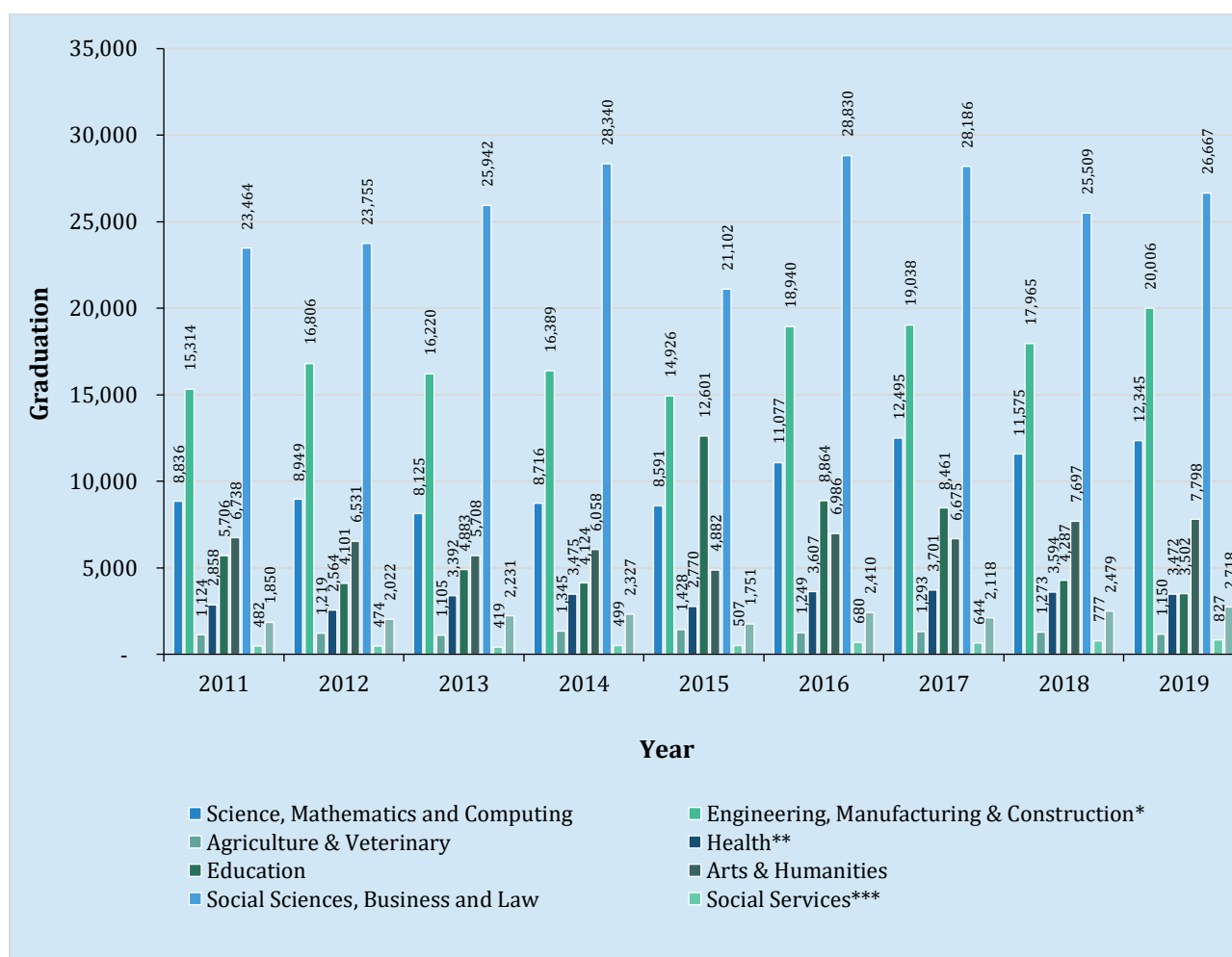
The percentage of enrolment for the broad programme areas (by NEC) has not changed significantly over the years. For Malaysian Research Universities (MRU), Engineering, Manufacturing and Construction has the highest share of 27% to 29% annual enrolment (but this is expected to be influence by enrolment at UTM). Of all Science-based enrolment at Comprehensive Universities, 44% of these are from Engineering, Manufacturing and Construction enrolments, followed by Science, Mathematics and Computing at 38% in 2020. For MTUN, Engineering, Manufacturing and Construction registered approximately 70% of all enrolment in 2020 (which is a five percent decrease from 2011). On the other hand, around 80% of all enrolment at Focus Universities are in non-STEM-based programmes with majority being in Social Sciences, Business and Law.

Figure 2.4 First Degree Enrolment, Public HLIs by Fields of Study

Note: NEC Code: * narrow field: 52, 54, 58; ** narrow field: 72 and *** narrow field 76

Source: Ministry of Higher Education, Malaysia

Figures 2.5 display the breakdown of STEM graduation, by programme of study at the undergraduate level (First Degree Level). In general, the proportion of STEM graduates (among all graduates) are in the range of 42% to 47% for the period of 2016 - 2020. For most of the STEM programme (by NEC broad discipline), the graduation rate (on time) is estimated to be around 80%.

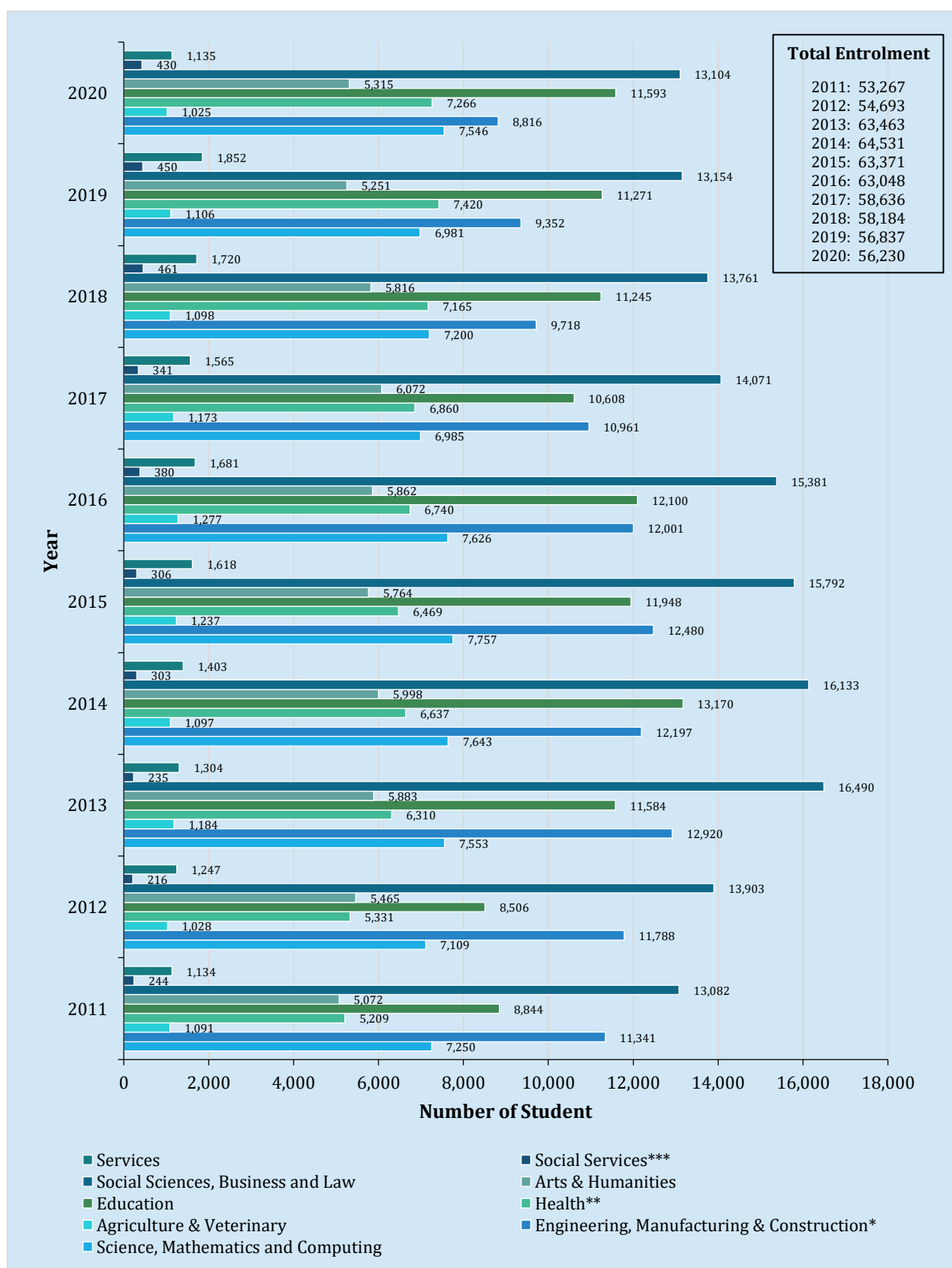
Figure 2.5 First Degree Graduation by Programme of Study (NEC), Public HLIs

Note: NEC Code: * narrow field: 52, 54, 58; ** narrow field: 72; *** narrow field 76
 Source: Ministry of Higher Education, Malaysia

2.3.2 Enrolment and Graduations in Master's Degree at Public HLIs

Figure 2.6 shows an increasing trend in the total enrolment for Master's degree from around 53,000 in 2011 to more than 64,000 in 2014 (that is a 21% increase) especially in Engineering, Manufacturing & Construction, Social Sciences, Business and Law and Education. A gradual decrease in enrolments for all programmes is observed since 2015 to 56,230 in 2020. As for Science, Mathematics and Computing, the percentage of enrolment remains almost unchanged since 2013 while Health related programmes increases from 10% (in 2011) to 13% (in 2020) of all STEM enrolment.

Similar trends are observed for Research University and Comprehensive University with an increased percentage of enrolment in Education as well as Social Sciences, Business and Law. The Technical Universities observed an increase in Science Mathematics and Computing in 2020. In terms of graduation at Masters level, the proportions by field of study is quite similar to that of enrolment (Table 2.13).

Figure 2.6 Master's Degree Enrolment by Courses, Public HLIs

Note: NEC Code: * narrow field: 52, 54, 58; ** narrow field: 72; *** narrow field 76

Source: Ministry of Higher Education, Malaysia

Table 2.13 Master's Degree Courses Enrolment and Graduations, Public HLIs

Subject		Science, Mathematics & Computing	Engineering, Manufacturing & Construction*	Agriculture & Veterinary	Health **	Education	Arts & Humanities	Social Sciences, Business & Law	Social Services ***	Services
Enrolment	2011	7,250	11,341	1,091	5,209	8,844	5,072	13,082	244	1,134
	2012	7,109	11,788	1,028	5,331	8,506	5,465	13,903	216	1,247
	2013	7,553	12,920	1,184	6,310	11,584	5,883	16,490	235	1,304
	2014	7,643	12,197	1,097	6,637	13,170	5,998	16,133	303	1,403
	2015	7,757	12,480	1,237	6,469	11,948	5,764	15,792	306	1,618
	2016	7,626	12,001	1,277	6,740	12,100	5,862	15,381	380	1,681
	2017	6,985	10,961	1,173	6,860	10,608	6,072	14,071	341	1,565
	2018	7,200	9,718	1,098	7,165	11,245	5,816	13,761	461	1,720
	2019	6,981	9,352	1,106	7,420	11,271	5,251	13,154	450	1,852
	2020	7,546	8,816	1,025	7,266	11,593	5,315	13,104	430	1,135
Graduation	2011	1,585	2,329	137	660	1,730	938	3,568	93	292
	2012	1,953	2,980	153	1,115	2,300	1,190	4,098	87	385
	2013	1,987	3,464	171	1,153	2,550	975	4,185	91	413
	2014	2,121	3,663	158	1,161	2,555	1,099	4,634	62	394
	2015	1,874	3,361	185	1,219	3,202	1,079	4,139	63	300
	2016	1,816	3,558	175	1,223	3,122	1,092	4,461	92	423
	2017	1,873	3,300	215	1,332	3,291	1,157	4,178	104	456
	2018	1,979	2,948	210	1,326	3,020	1,165	4,018	140	387
	2019	1,786	3,120	191	1,324	2,734	1,247	4,238	129	406
	2020	453	835	42	241	832	224	924	49	72

Note: NEC Code: * narrow field: 52, 54, 58; ** narrow field: 72; *** narrow field 76

Source: Ministry of Higher Education, Malaysia

2.3.3 Enrolment and Graduations in Doctoral Degree Programmes

In general, the students' enrolment in Doctoral degree programmes increased over the years 2011-2020, for both STEM and non-STEM courses. This aligns with the aims of MyBrain15 of Pelan Strategik Pengajian Tinggi Negara (PSPTN³) 2007 -2020, which aims at producing adequate number of PhD or equivalent, as drivers of innovation that will mobilise the country's economic competitiveness. The proportion of STEM to non-STEM reached 50:50 in 2012-2014 but gradually reduced to 46:54 in 2019 (Table 2.14). In terms of graduation, more STEM graduates are observed over the years, relative to the non-STEM.

³ Refer to *Pelan Tindakan Pengajian Tinggi Negara Fasa 2 (2011-2015): Mencetus Transformasi Pengajian Tinggi, Kementerian Pengajian Tinggi, Malaysia*.

Table 2.14 Doctoral Degree Courses Enrolment and Graduations, Public HLIs

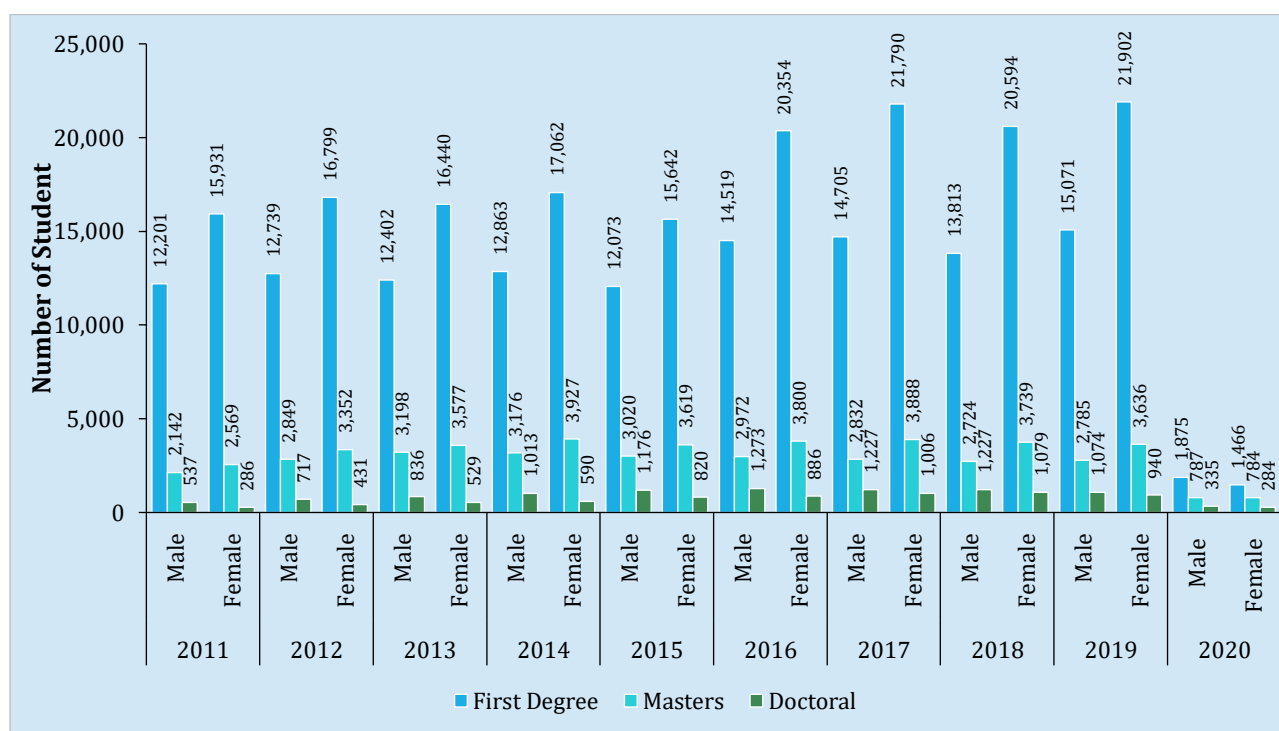
Subject		Science, Mathematics & Computing	Engineering, Manufacturing & Construction*	Agriculture & Veterinary	Health **	Education	Arts & Humanities	Social Sciences, Business & Law	Social Services ***	Social Services
Enrolment	2011	4,336	5,134	420	1,293	3,031	1,717	6,439	31	193
	2012	4,926	5,992	426	1,289	3,001	2,222	6,893	46	245
	2013	5,703	6,987	490	1,529	3,808	2,350	8,065	52	296
	2014	6,024	7,301	526	1,652	3,866	2,527	8,663	77	378
	2015	6,126	7,659	544	1,760	3,738	2,578	9,368	88	521
	2016	6,340	7,714	554	1,879	3,719	2,869	9,766	112	712
	2017	6,489	7,721	547	1,844	3,811	3,487	8,912	107	909
	2018	6,331	7,511	564	1,994	4,192	3,883	9,671	118	1,033
	2019	6,292	7,591	610	2,103	4,382	4,067	9,983	109	1,099
	2020	6,902	7,352	601	2,164	4,438	4,219	10,031	102	444
Graduation	2011	327	350	53	93	166	112	411	-	15
	2012	470	494	70	114	203	200	498	1	14
	2013	576	585	58	146	217	179	555	4	13
	2014	632	723	51	197	297	233	628	4	25
	2015	779	941	79	197	283	281	788	1	28
	2016	801	1,021	76	261	370	267	880	3	40
	2017	965	858	77	333	404	391	948	5	59
	2018	876	1,012	90	328	360	393	974	7	81
	2019	735	911	81	287	355	385	937	11	125
	2020	228	313	20	58	121	89	343	6	14

Note: NEC Code: * narrow field: 52, 54, 58; ** narrow field: 72; *** narrow field 76

Source: Ministry of Higher Education, Malaysia

2.3.4 Science and Technology Degrees Awarded by Gender at Public HLIs

Figure 2.7 displays the number of graduates in S&T at public universities, by gender, for the period 2011-2020. At the Bachelor's degree programmes, there are more female students than that of male (for example, of all enrolment in 2011-2020, 56% are females). This is contrary to those observed at the Doctoral degree programmes, where the male dominates (of all Doctoral programmes enrolment in 2011-2020, 54% are males).

Figure 2.7 Science-Based Programmes - Graduation by Gender, Public HLIs 2011-2019

Source: Ministry of Higher Education, Malaysia

2.4 Education in Science and Technology at Private HLIs

Private higher educational institutions have demonstrated an increasingly important role in Malaysia Higher Education system. This section discusses the trend in enrolments and graduations of students for S&T, as well as non-Science courses at the Bachelor's, Master's and Doctoral level.

2.4.1 Enrolment and Graduations at Private HLIs

Table 2.15 illustrates an increasing trend in enrolment for the period of 2017-2019, at private HLIs, with enrolments in non-STEM programmes consistently larger than STEM programmes at all First degree, Master's and Doctoral programmes. The private HLIs contributes between 38% - 45% of all First-degree enrolment (excluding enrolments at Polytechnics), 17% -28% of all Masters programme enrolment and 6% - 11% of all Doctoral Programmes in 2014-2019. In terms of graduation, a similar trend is observed as in the public university, that is, more STEM graduates are observed over the years relative to the non-STEM.

Except for 2016, increasing trend in enrolment for Masters and Doctoral are observed from 2014 to 2020 (Table 2.16 and 2.17). Social Sciences, Business and Law has the largest share in enrolment at both Masters (56% in 2020) and Doctoral (41% in 2020) programmes. Overall, few positive trends are observed in terms of increasing enrollment of students in education programmes. Nevertheless, without proper strategy for employability of those graduate,

leveraging on such human capital would limit Malaysia's progress. Box 2.1 illustrates the issue of employability.

Table 2.15 First Degree Enrolment and Graduation, Private HLIs

Subjects		Science Based				Non-Science Based			
		Science, Mathematics & Computing	Engineering, Manufacturing & Construction	Agriculture & Veterinary	Health & Welfare	Education	Arts & Humanities	Social Sciences, Business & Law	Social Services
Enrolment	2014	19,697	28,180	781	19,855	26,559	13,486	93,910	5,348
	2015	19,588	33,486	2,485	24,544	21,050	18,012	103,624	5,366
	2016	21,720	30,567	121	9,607	19,681	8,817	70,188	5,740
	2017	20,427	43,233	1,885	42,228	13,254	13,985	137,588	10,068
	2018	27,634	48,861	222	23,736	19,065	27,733	123,391	10,194
	2019	30,524	48,966	247	25,479	17,069	19,919	126,380	12,811
	2020	29,180	47,071	287	23,627	18,347	15,106	121,153	10,341
Graduation	2014	2,564	3,580	42	2,755	691	1,450	11,001	741
	2015	4,165	5,874	11	6,729	8,869	2,855	19,107	1,160
	2016	9,365	5,964	10	7,653	48,079	3,721	30,213	1,498
	2017	4,824	8,947	13	4,319	6,314	3,017	34,858	1,842
	2018	4,528	10,600	51	5,939	3,091	2,606	28,026	1,479
	2019	5,359	11,846	20	5,456	1,920	3,394	24,813	1,682
	2020	2,689	5,237	31	1,237	555	1,965	11,867	996

Source: Ministry of Higher Education, Malaysia

Table 2.16 Master's Degree Enrolment and Graduation, Private HLI

Subject		Science Based				Non-Science Based			
		Science, Mathematics & Computing	Engineering, Manufacturing & Construction	Agriculture & Veterinary	Health & Welfare	Education	Arts & Humanities	Social Sciences, Business & Law	Social Services
Enrolment	2014	887	973	50	626	1,916	1,016	7,447	423
	2015	715	905	178	721	2,725	1,945	6,629	723
	2016	12,486	13,147	76	18,339	49,482	10,038	70,416	3,702
	2017	1,081	1,739	-	849	1,357	950	9,550	655
	2018	938	1,632	-	1,104	3,726	2,361	11,802	1,082
	2019	865	2,163	-	1,210	3,552	1,931	11,682	968
	2020	939	1,806	-	1,176	3,315	1,294	11,804	733
Graduation	2014	156	145	2	83	114	143	889	14
	2015	142	242	-	138	869	177	2,168	61
	2016	304	284	-	246	2,187	348	4,101	44
	2017	339	290	-	93	509	446	3,230	71
	2018	77	266	-	108	671	142	2,043	69
	2019	123	439	-	174	1,920	88	1,482	16
	2020	80	232	-	50	101	24	675	5

Source: Ministry of Higher Education, Malaysia

Table 2.17 Doctoral Degree Enrolment and Graduation, Private HLI

Subject		Science Based				Non-Science Based			
		Science, Mathematics & Computing	Engineering, Manufacturing & Construction	Agriculture & Veterinary	Health & Welfare	Education	Arts & Humanities	Social Sciences, Business & Law	Social Services
Enrolment	2014	159	278	3	73	316	326	802	8
	2015	274	378	70	83	507	422	1,193	10
	2016	614	915	0	3,037	4,220	1,025	5,603	250
	2017	429	1,466	0	149	256	208	1,527	87
	2018	338	804	0	141	811	558	1,855	33
	2019	365	874	0	242	708	646	1,793	28
	2020	400	888	0	148	712	587	1,913	28
Graduation	2014	16	37	0	11	115	5	19	8
	2015	14	32	0	7	149	72	56	2
	2016	30	58	0	5	32	49	110	0
	2017	45	66	2	15	46	198	114	2
	2018	27	69	0	11	26	70	54	3
	2019	34	102	0	13	20	79	86	3
	2020	24	56	0	3	0	40	33	0

Source: Ministry of Higher Education, Malaysia

Box 2.1 Supply, Demand and Employability in STEM related fields

While enrolment and student progress in preparing the needed human capital is critical, equally important is the employability of such graduates. The graduate unemployment and underemployment issues have given rise to many policy implications for higher education in many developing countries. In 2018, over 290,000 students graduated from the HLIs in Malaysia (2018 Graduate Tracer Study, MOE). Of these, one in five fresh graduates remain unemployed 6 months after graduation. Among those unemployed fresh graduates are from Engineering, Manufacturing and Construction that makes up 24.1% while Sciences, Mathematics and Computing contributes 11.3% (by NEC broad subject classification). According to the Khazanah Research Institute's School-to-Work Transition Survey 2018, the top reasons for fresh graduate unemployment are:

- Skills mismatch where education institutions emphasise academic and professional qualifications while employers prioritise soft skills and work experience.
- Low take up rate from Science, Technology, Engineering and Mathematics with 32% enrolment.
- Low participation in TVET with only 9% of students in polytechnics.
- Job search and recruitment mismatch where employers are moving towards online advertisement and informal networks.
- Lack of entrepreneurship skills.

Unemployed Graduates (%)			
Year	Sciences	Technical Studies	Information and Communication Technology
2014	25.1	24.5	23.5
2015	27.7	23.6	23.3
2016	27.8	19.7	21.5
2017	24.6	17.0	18.1

Year	Sciences, Mathematics & Computing	Health & Welfare	Agriculture & Veterinary	Engineering, Manufacturing & Construction
2018	19.6	20.9	23.9	16.6

With the dawn of the IR 4.0, there is a high demand for digital skills which includes digital marketing, software and application development, e-commerce, big data analytics and database management. As such, aligning supply and demand of skill workforce, ensuring employability, is crucial for the human capital to contribute significantly to the developmental process.

Source: MOE, Tracer Study, various issues

2.5 Malaysian Student Performance at International Level

The Fourth Industrial Revolution (IR 4.0) brings rapid technological advancements, changing the nature of work and increasing demand for a skilled workforce. In order to be aligned with IR 4.0, education sectors must be well prepared to train students to be ready for this new era

of industry. The Malaysian students' performances at the international level, in Mathematics and Science, can be evaluated by the scores attained at the OECD PISA and TIMSS examination. The OECD PISA is a triennial international survey which aims at evaluating the knowledge and skills of 15-years old students, directly, through a metric that was internationally agreed upon; linking that with data from students, teachers, schools and systems to understand performance differences. To do well in PISA, students have to be able to extrapolate from what they know, think across the boundaries of subject-matter disciplines, apply their knowledge creatively in novel situations and demonstrate effective learning strategies. As Angel Gurría, the OECD Secretary-General puts it:

“Equipping citizens with the knowledge and skills necessary to achieve their full potential, to contribute to an increasingly interconnected world, and to convert better skills into better lives needs to become a more central preoccupation of policy makers around the world. Fairness, integrity and inclusiveness in public policy thus all hinge on the skills of citizens. In working to achieve these goals, more and more countries are looking beyond their own borders for evidence of the most successful and efficient education policies and practices.” Angel Gurría, OECD Secretary-General (PISA 2018)

TIMSS, on the other hand, focus on formal mathematical knowledge, thus measuring more traditional classroom content, among the 4th- and 8th-graders internationally (an equivalent to Malaysia's 10-year-old and 14-year-old respectively).

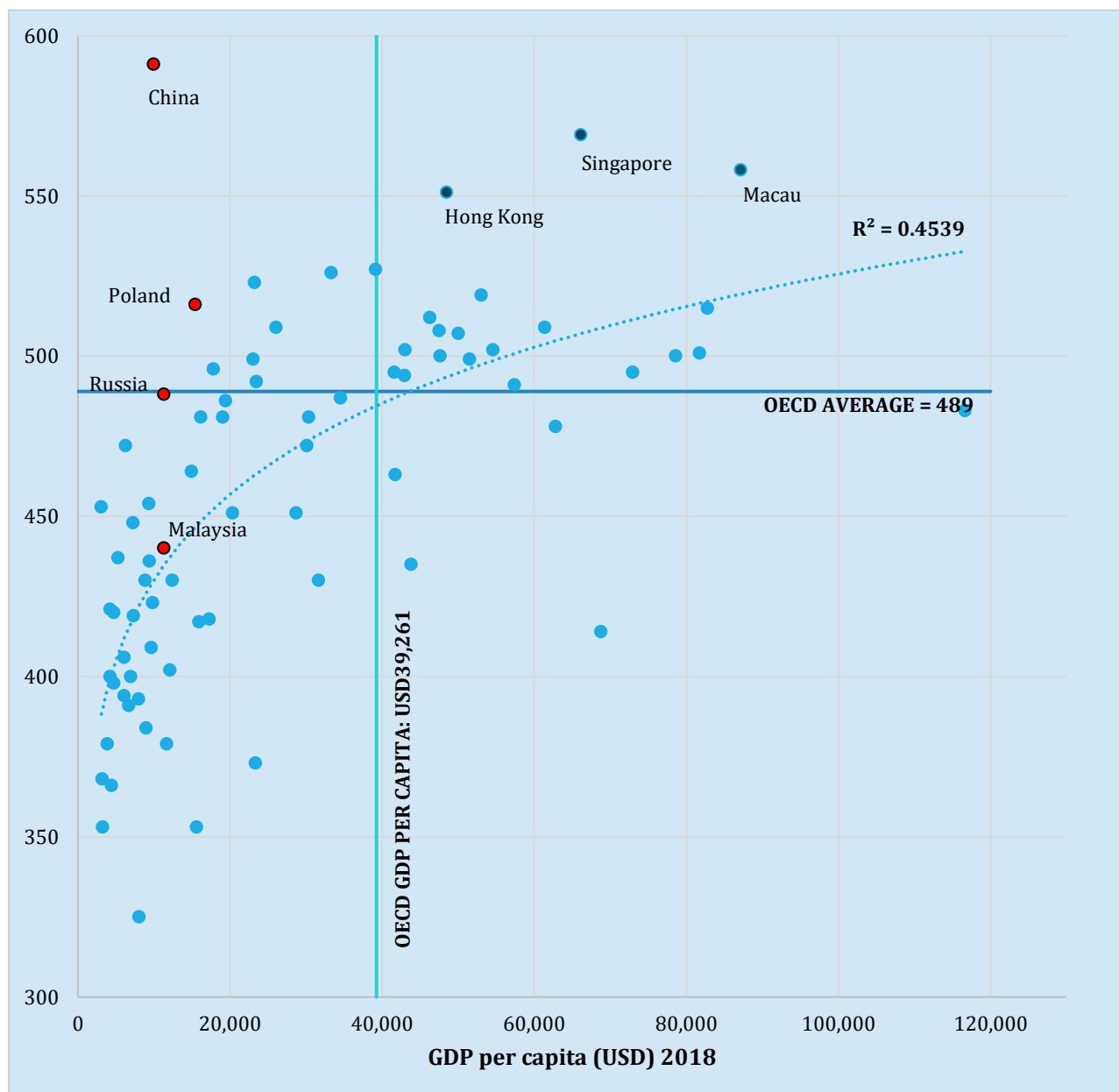
2.5.1 Performance in Mathematics

Malaysia overall performance in PISA 2018 has improved slightly from 2012: ranked 47 out of 78 countries for Mathematics in 2018 with a score of 440, compared to 52 out of 65 countries in 2012 with a score of 421. The maximum score for PISA 2018 is 591. As an indicator, a student with a Level 2 proficiency in Mathematics can, at a minimum, interpret and recognize, without direct instructions on how a (simple) situation can be represented mathematically (e.g. comparing the total distance across two alternative routes, or converting prices into a different currency). In Malaysia, about 59% of students attained a Level 2 or higher in Mathematics relative to the OECD average of 76%. As a comparison, the share of 15-year old students who attained minimum levels of proficiency in Mathematics (Level 2 or higher) are more than 90% for Estonia and around 98% in Beijing, Shanghai, Jiangsu and Zhejiang (China).

At Level 5 and above, the students have the ability to model complex situations mathematically, to select, compare and evaluate appropriate problem-solving strategies. A very small percentage of 2% of students in Malaysia scoring Level 5 and above is observed, relative to an 11% for the OECD average. Six Asian countries and economies had the largest shares of students who are in this category: Beijing, Shanghai, Jiangsu and Zhejiang (China) (44%), Singapore (37%), Hong Kong (China) (29%), Macao (China) (28%), Chinese Taipei (23%) and Korea (21%).

Figure 2.8 displays the attainment in Mathematics in other participating countries relative to the 2018 GDP per capita. More specifically, Table 2.18 shows some comparisons between countries in Asia and some high performers of PISA 2018. A huge disparity in terms of scores attained is observed; for example, gap of 76 points between Malaysia and Poland, and a staggering gap of 151 between Malaysia and China.

Figure 2.8 Mathematics Performance and GDP Per Capita (USD)



Source: OECD PISA 2018 Database

Table 2.18 Performance in Mathematics and Science, Selected Countries, 2012 - 2018

	2012		2015		2018	
	Mathematics	Science	Mathematics	Science	Mathematics	Science
Malaysia*	421	420	-	-	440	438
Singapore	573	551	564	556	569	551
Thailand	427	444	415	421	419	426
Vietnam**	511	528	495	525	-	-
Japan	536	547	532	538	527	529
South Korea	554	538	524	516	526	519
Poland	504	521	504	501	516	511
Russia	481	497	494	487	488	478
Estonia	521	541	520	534	523	530
China***	613	580	531	518	591	590
Taiwan	560	523	542	532	531	516
OECD	494	501	490	493	489	489

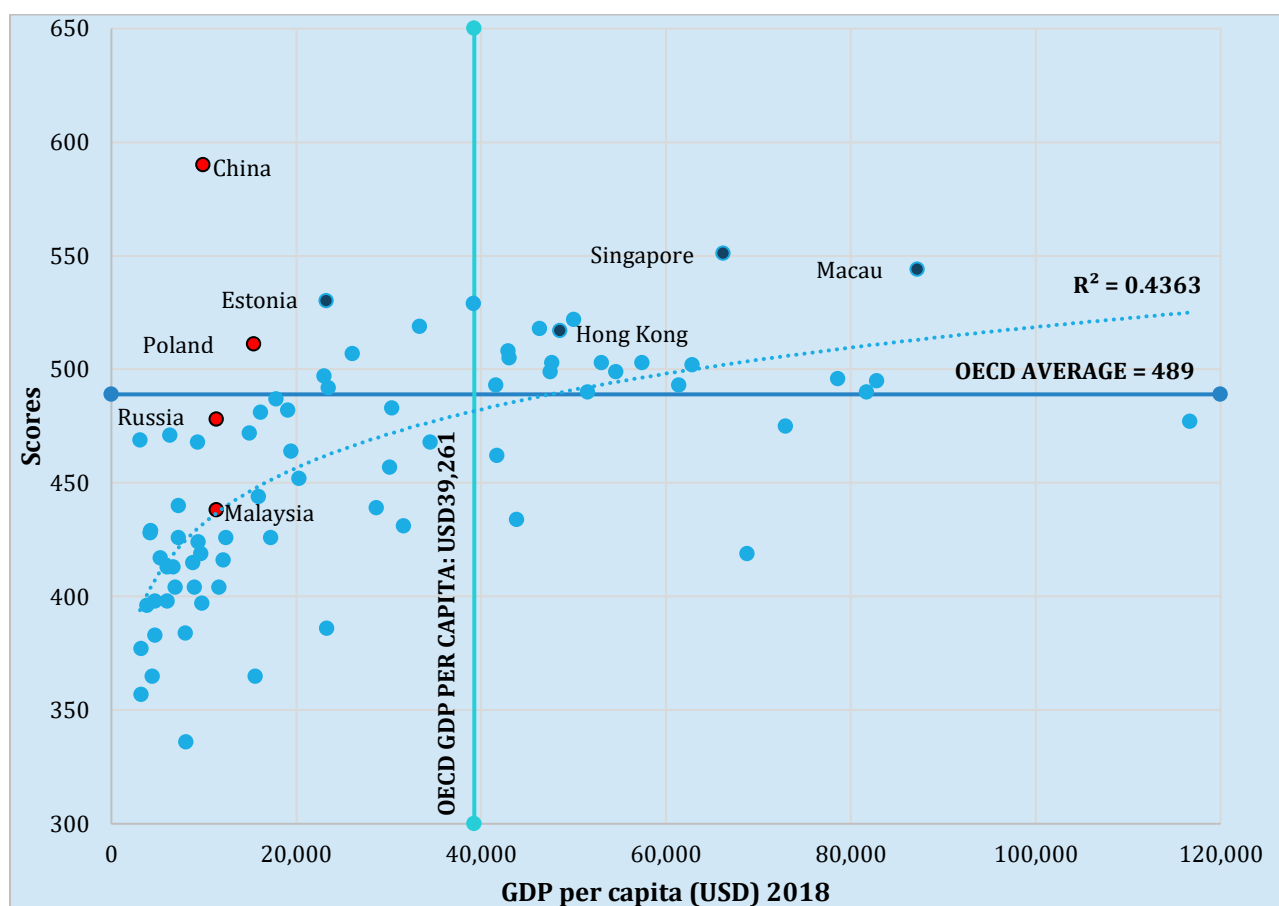
Note: * Malaysia's data is excluded in 2015 due to insufficient samples ** Vietnam's data was not included in the 2018 report. *** China's 2012 data is based on students only in Shanghai. Data from 2015 and 2018 however were collected from Beijing, Shanghai, Jiangsu and Guangdong (B-S-J-G).

Source: OECD PISA 2018 Database

2.5.2 Performance in Science

In Science, a Level 2 proficiency is indicative that the students, at a minimum, can recognize the correct explanation for familiar scientific phenomena and use such knowledge to identify, in simple cases on whether a conclusion is valid based on the data provided. Some 63% of students in Malaysia attained Level 2 or higher in Science relative to the OECD average of 78%. As for China and Estonia, these are 91% and 98% respectively. In terms of score gaps, Malaysia is lagging the OECD average by 51 points.

As for Level 5 and above, the 1% of students in Malaysia in this category, has the ability to creatively and autonomously apply their knowledge of and about Science to a wide variety of situations, and beyond. Figure 2.9 displays the attainment in Science for the various economies (2018 GDP per capita, USD).

Figure 2.9 Science Performance and GDP Per Capita (USD)

Source: OECD PISA 2018 Database

2.5.3 Malaysian Students Profiles

In PISA 2018, a socio-economically advantaged (disadvantaged) student is a student in the top (bottom) quarter of Economic, Social and Cultural Status (ESCS) in his or her own country/economy where ESCS refers to the PISA index of economic, social and cultural status. Socio-economic status was a strong predictor of performance in Mathematics and Science in all PISA participating countries. For both Mathematics and Science achievement in Malaysia, this factor explains 17% of the respective total variation in performance, slightly more than that of the OECD average, that is 14% and 13% respectively). Thus, as expected, high performing students more often are clustered.

In all countries and economies that participated in PISA 2018, girls significantly outperformed boys in Reading, Mathematics and Science. In Malaysia, girls scored higher than boys by seven score points in Mathematics and six score points in Science.

2.5.4 Benchmarking with High Performers in PISA

There are several high performers in PISA 2018, that we can learn through benchmarking and best practices - especially in terms of education reforms, commitment and deliverables. This is extremely important since the gap between the Malaysian students and the 15-years old of the higher performers in PISA 2018 is huge. Among the OECD countries, Estonia has one of the strongest education systems; the rate of educational attainment at the secondary level is among the highest in the EU and OECD areas, while the proportion of adults holding a tertiary qualification is above the OECD average (Santiago et al., 2016). Box 2.2 illustrates the Estonia's education system and reforms.

Box 2.2 Estonian Education System and Reforms.

Demographically, Estonia is a small Eastern European country with a population of 1.3 million. It is one of the poorest OECD countries: in 2018, its per capita GDP was around USD23,258 compared to the OECD average of USD39,261. Estonia has one of the strongest education systems - in terms of reading literacy, 90% of the population could read and write and another 5.3% could read only, according to a census from 1992. **Formal education:** Comprises three sequential levels: pre-primary education (ISCED 0, up to 7 years of age), basic education (ISCED 1 and 2, typical ages: 7 to 16); and upper secondary education (ISCED 3, Years 10-12/13, typical ages: 16 to 18/19). Basic education is organised according to two stages: primary education (ISCED 1, Years 1-6); and lower secondary education (ISCED 2, Years 7-9). School attendance is compulsory until acquiring basic education or attaining age 17. **Student performance assessment:** This includes assessments by national exams, sample-based national tests and regular classroom assessments. For graduation from basic school, students must reach a satisfactory level on curricular subjects and present creative work. Also included are three mandatory and standardized final examinations to provide comparable information about the achievement of learning goals established by the state curriculum. **School Autonomy:** With decentralization of school system in 1990, the school principals are granted extensive levels of autonomy, including the authority to hire and fire staff as well as making decisions about school finances, education priorities and development plans (Santiago et al., 2016). An important advisory body in school management within general education is the board of trustees. A mandatory requirement for schools to conduct self-evaluations at least once every three years was established since 2006. The Education reforms include:

- The new curriculum for general education (1996) was seen as an instrument for building a democratic, dynamic, information-based society, turning towards Europe, and supporting the establishment of a market economy after decades of communist rule. Specifically, it emphasizes on problem solving, democratic decision making, critical thinking and an awareness of personal responsibility.
- The Education Act of 1992 affirmed the principles of comprehensive schools, legalized private education and allowed four-year post-secondary schools ("technicums") to apply for the status of applied/vocational higher education institutions.
- Appointments of experts from the Finnish Board of Education as consultants in the development of the Estonian National Curriculum 1996 - Estonia towards building a more effective education system.

- Estonia's integration plan for 2008-2013 - a commitment, guaranteeing equal education opportunities regardless of students' ethnic origin.
- Support for weaker students and ensuring equity and inclusiveness where a yearly development interview for each student is required and schools must implement appropriate measures for students with unsatisfactory year-end marks. A directive adopted in 2007 mandates additional personalised support to prevent students from dropping out of education.
- All schools in Estonia must have coordinators who provide services to students with special needs including speech therapy, psychological assistance and social pedagogical counselling.
- Equal access to education: school meals, study books and learning materials are provided for free to students in basic education since 2006.
- Estonian Lifelong Learning Strategy 2020, adopted in 2014, emphasis on the importance of competent and highly motivated teachers and school principals, calls for an alignment of lifelong learning opportunities with labour market needs, and aims to guarantee lifelong learning opportunities for everyone, including through digital platforms.

Source: OECD 2016: Country Note

As for the non-OECD countries, Singapore has many best practices to share. Box 2.3 demonstrates Singapore's education system and its reforms.

Box 2.3 Singapore's Education System

Demographically, Singapore is a city-state of approximately 700 km² in Southeast Asia, with a population of 5.9 million. Today, Singapore is a vibrant global hub of trade, finance and transportation, with a strong and harmonious community of citizens of different ethnicities and religions. Its transformation from third world to first in one generation is one of Asia's great success stories (Lee, 2000; OECD, 2010). **Formal education:** All children start a 6-year primary school education at age 7. This compulsory six-year course is designed to give a strong educational foundation with aims at developing language and numeracy skills, build character and nurture sound values and good habits. At the lower secondary levels (grades 7 and 8), students experience a broad-based education in the languages, the Humanities and the Arts, Mathematics and Sciences and Technology, physical education as well as character and citizenship education. At grades 9 and 10, all students learn two languages, Social Studies and Mathematics, and select from a wide range of elective subjects and programmes (MOE, 2016b). Almost all students proceed to one of the following post-secondary education institutions: junior colleges / centralized institutes, polytechnics, the Institute of Technical Education (ITE) and Arts Institutions. **Education reforms include:**

- The survival phase 1959-1978: A single national education system was created and efforts was focused on expanding basic education which provide Singapore with a literate and skilled workforce to meet the needs of the shift in its economy from entrepot trade to export-oriented manufacturing.

- The efficiency-driven phase 1979-1996: a new model of education was introduced in the effort of moving higher up the economic value chain. The new model includes more pathways for students. The new education system has resulted in:
 - Reduced dropout rates from 50% in the '60s to only 6% in 1986 - with fewer than 10 years of education
 - Improved the quality of education with O-level pass rate of 90% 1984 from 40% in the '60s, and good performance in TIMSS study.
- Ability-base, aspiration-driven phase 1997-2011: New education philosophy, 'Thinking Schools, Learning Nation'. While Thinking Schools would develop creativity and critical thinking skills and passion for lifelong learning, Learning Nation would place education at the heart of the national identity (Lee et. al., 2008).
 - Curriculum was reduced to create space for more inquiry-based activities
 - Schools were organized around clusters of 10-14 schools with greater autonomy and collegial sharing enabling school to be innovative in their programmes and teaching.
- Student-centric, values-driven phase 2012 to present: The development of a framework for 21st Century Competencies and Student Outcomes - which articulate the core competencies and values that enable youths of Singapore to thrive in the 21st century.

Source: OECD 2016: Country Note

2.5.5 Malaysian Student Performance at TIMSS

Table 2.19 reports the TIMSS scores measuring the formal mathematical knowledge through traditional classroom content. Over the years 1995 - 2015, the scores have declined, and lagged behind Singapore, South Korea, Japan, United States and Thailand. Compared to 2011, the performance in terms of scores has improved by 25 points in 2015. Similar findings are observed for Science scores (Table 2.20).

Table 2.19 Performance in Mathematics for Selected Countries, 1995 - 2015

Mathematics						
	1995	1999	2003	2007	2011	2015
Malaysia	-	519	508	474	440	465
Indonesia	-	403	411	397	386	-
Singapore	609	604	605	593	611	621
Thailand	516	467	-	441	427	431
Japan	581	579	570	570	570	586
South Korea	581	587	589	597	613	606
USA	492	502	504	508	509	518

Note: TIMSS Center Point Scale = 500

Source: TIMSS 2015 International Reports, IEA

Table 2.20 Performance in Science for Selected Countries, 1995 - 2015

Science						
	1995	1999	2003	2007	2011	2015
Malaysia	-	492	510	471	426	471
Indonesia	-	435	420	427	406	-
Singapore	580	568	578	567	590	597
Thailand	510	482	-	471	451	456
Japan	554	550	552	554	558	571
South Korea	546	549	558	553	560	556
USA	513	515	527	520	525	530

Source: TIMSS 2015 International Reports, IEA

2.6 Summary

The performance of students in Mathematics, Physics, Chemistry and Biology at SPM level has remained almost unchanged, in terms of percent grades achieved over the period of 2016-2020. Similar trends are observed for STPM Mathematics (T), Mathematics (M) and Pure Science subjects. In public Higher Learning Institutions, the number of enrolments for STEM courses is consistently less than that of non-STEM courses at the undergraduate level – at a ratio of 45:55. A similar trend is also observed for the postgraduate programmes. As we embark on the IR 4.0, technology will play a central role in nearly all aspects of our lives. Despite a larger pool of graduates of higher education, challenges remain that many still do not have the relevant skills to serve the dynamic labour market. Indeed, human capital is critical for firms and to improve labour productivity (Chandran, Rasiah and Lim, 2020). Teaching and learning approaches that enable the development of critical and creative thinking should be integrated into the educational system. Changes aimed at tapping the potential of information and communication technologies in the creation and dissemination of knowledge should also be addressed.

The MEB (HE) 2015-2025 proposes major reforms to Malaysia's higher education system to accelerate the positive upward trajectory of the system. The focus in higher education is to develop learned, values-driven talent — professionals, researchers, educators, entrepreneurs, and innovators — who have an international outlook to propel Malaysia's development forward. The MEB higher education also aims to unleash and empower both private and public HLIs to push the boundaries of innovation and strive for institutional excellence in all its forms. In addition to these, the recent NSTIP 2021-2030 has set a vision to create a sustainable, inclusive and scientific society towards a high-tech nation. To realize this aspiration as well as achieving the status of a developed country by 2030, this policy has outlined 6 key thrusts supported by 20 sound strategies and 46 realistic and comprehensive initiatives covering the implementation of Science, Technology, Innovation and Economy (STIE) in various sectors. Thrust 4 of NSTIP 2021-2030 focus on Adaptive STI Talent which is aimed at developing a competent and adaptable STI talent group in a variety of situations especially in global economic and technological change. The four strategies that are outlined to achieve the objectives under this thrust, and are related to this study are:

CHAPTER 2 EDUCATION ADVANCEMENT IN MALAYSIA

- Empowering national planning for competent and adaptive STI talent.
- Leading STEM education.
- Expand STI talent participation in the workforce.
- Increase demand for STI talent.

Success in realising NSTIP 2021-2030 certainly lies with strong will and commitment of all parties involved, strategic implementation and monitoring of the national agenda.

3

SOCIETY AND STI

CHAPTER 3: SOCIETY AND STI

3.1 Introduction

Almost every facet of our lives is being impacted by the wonders of STI. Our industry and thus our national prosperity depend on them. Increasingly, many public policy issues have scientific or technological implications. The devastation caused by the COVID-19 pandemic have underscored the importance of society understanding, among others, the key symptoms of the disease, its transmission behaviour and mechanisms to protect ourselves. Everybody, therefore, needs some understanding of science in order to be equipped to address the many issues that confront them as citizens.

Over the years, Malaysia has invested considerably, through institutions and programmes, to promote and enhance scientific literacy among the general population. Despite these investments, Malaysians have not done well in the international scientific literacy benchmarking surveys as will be discussed in this chapter. STI culture in the country can be described as still very nascent and efforts need to be enhanced to make Malaysia a scientifically literate society for the 21st century.

Since 1994, the MASTIC has carried out seven national surveys of Public Awareness of STI to assess the public's awareness and understanding of, interest in, and attitude towards STI as well as to discern their involvement in STI programmes. This chapter will discuss on the key findings of the report on this latest survey – eighth in this series -as well as make comparisons with earlier reports in order to analyse changes in trends with respect to the public's level of interest in, knowledge of, and attitudes towards STI and their awareness of STI-related programmes and sources of information as well as international comparison.

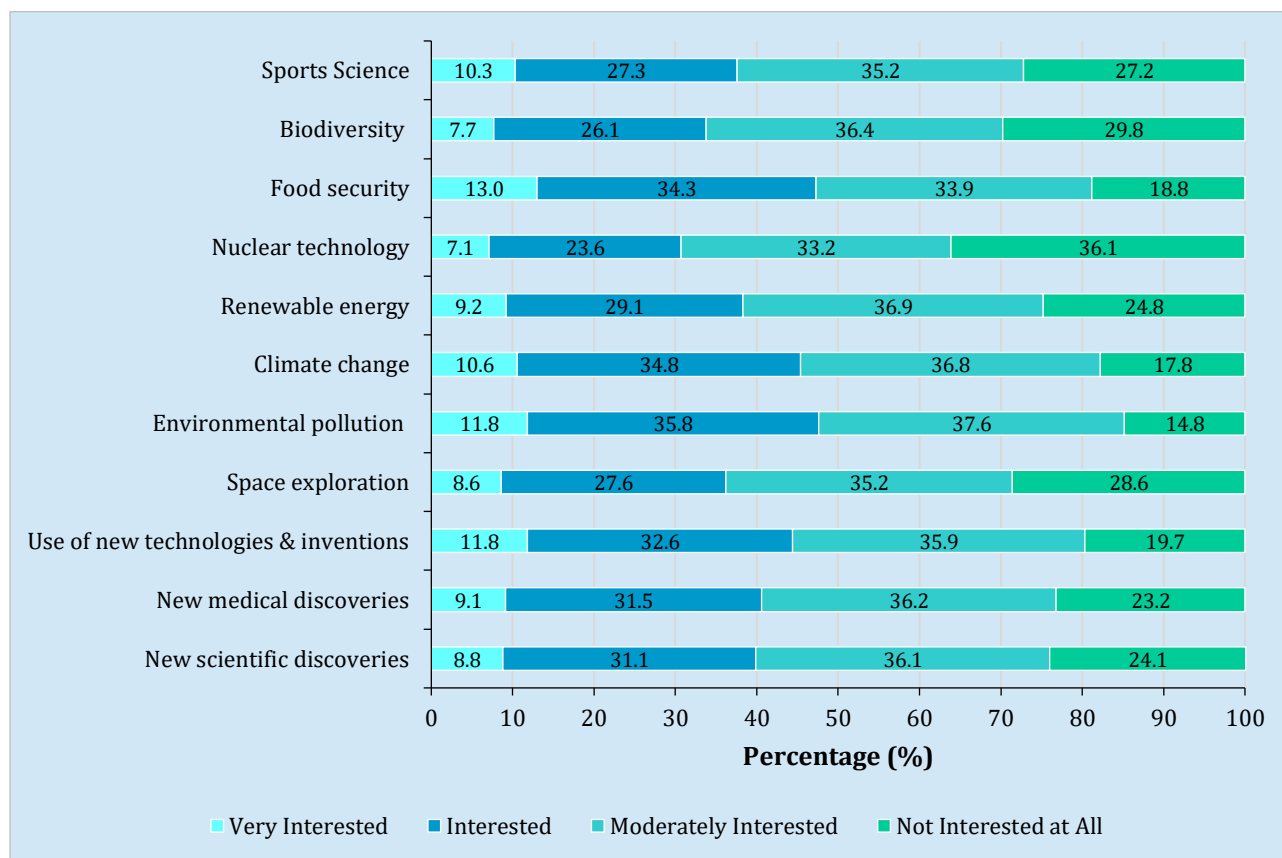
3.2 Public Interest in STI

Most Malaysians have expressed interest in STI with almost one out of two Malaysians attracted to current STI topics such as climate change, environmental pollution and food security (Figure 3.1). Environmental pollution issues which witnessed a declining interest since 2008, registered the highest level of interest (85.2%) among the selected topics. This sudden turnaround suggests a growing interest amongst the public in environmental issues given the wide coverage on the topic in the local media in recent years. An analysis of trends of mean scores from 2004 to 2019 has shown that the interest in STI topics has increased over the years (Figure 3.2).

The survey findings also reveal variation in public interest in STI issues based on the demographics of the respondents, namely, gender, locality, age-group and ethnicity (Appendix 3). There is a strong correlation between the percentages of public interest in STI topics with

the level of education of the respondents. Also, all the various races are united in the topic of least interest -nuclear technology.

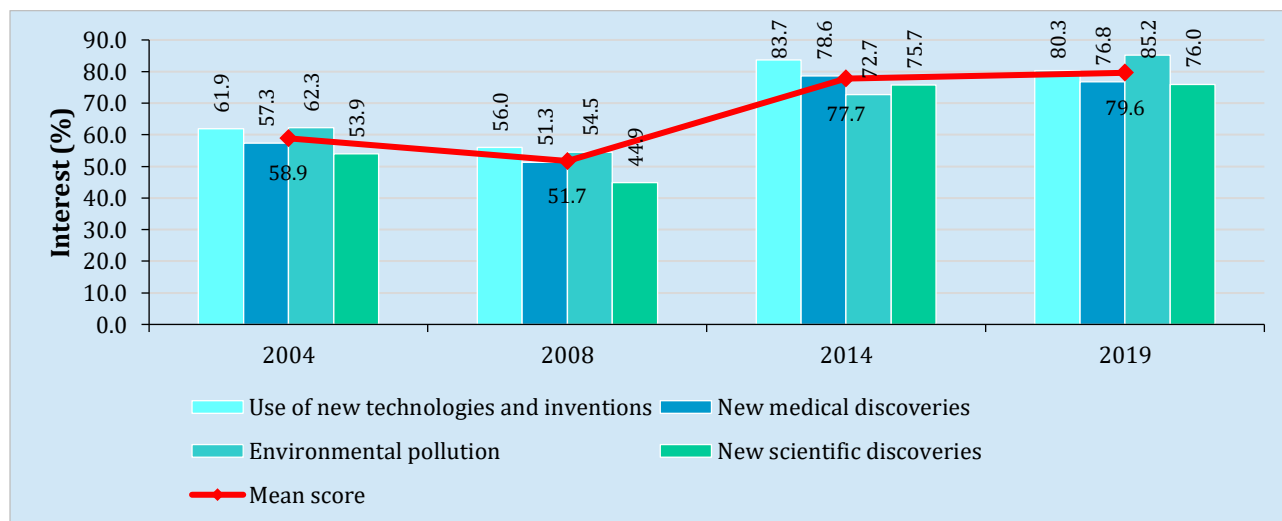
Figure 3.1 Public Interest in Selected STI Issues



Note: Due to rounding the total may not be 100.0%.

Source: Public Awareness of STI Malaysia, 2019

Figure 3.2 Public Interest in Selected STI Issues, Mean Scores, 2004 – 2019

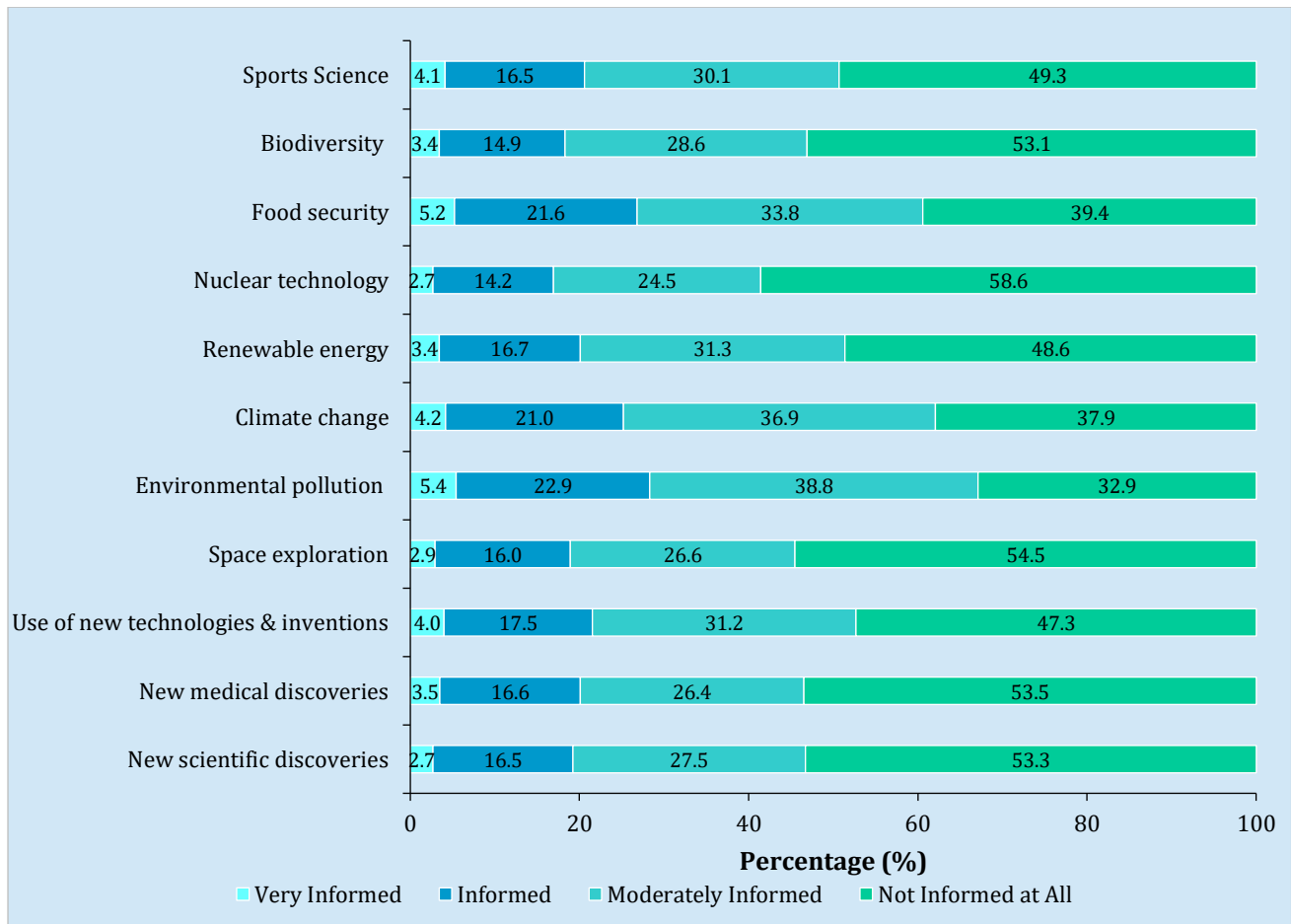


Source: Public Awareness of STI Malaysia, (2004, 2008, 2014 and 2019)

3.3 Public Perceived Knowledge in Selected STI Issues

Although a large percentage of Malaysians are interested in STI, only about a fifth consider themselves scientifically informed (informed and well informed) (Figure 3.3). Malaysians consider themselves most well informed in environmental pollution (5.4%), and least informed in the topics of nuclear technology (58.6%). Perceived public knowledge towards STI issues also exhibit variation based on the demographics of the respondents.

Figure 3.3 Public Perceived Knowledge in Selected STI Issues



Source: Public Awareness of STI Malaysia, 2019

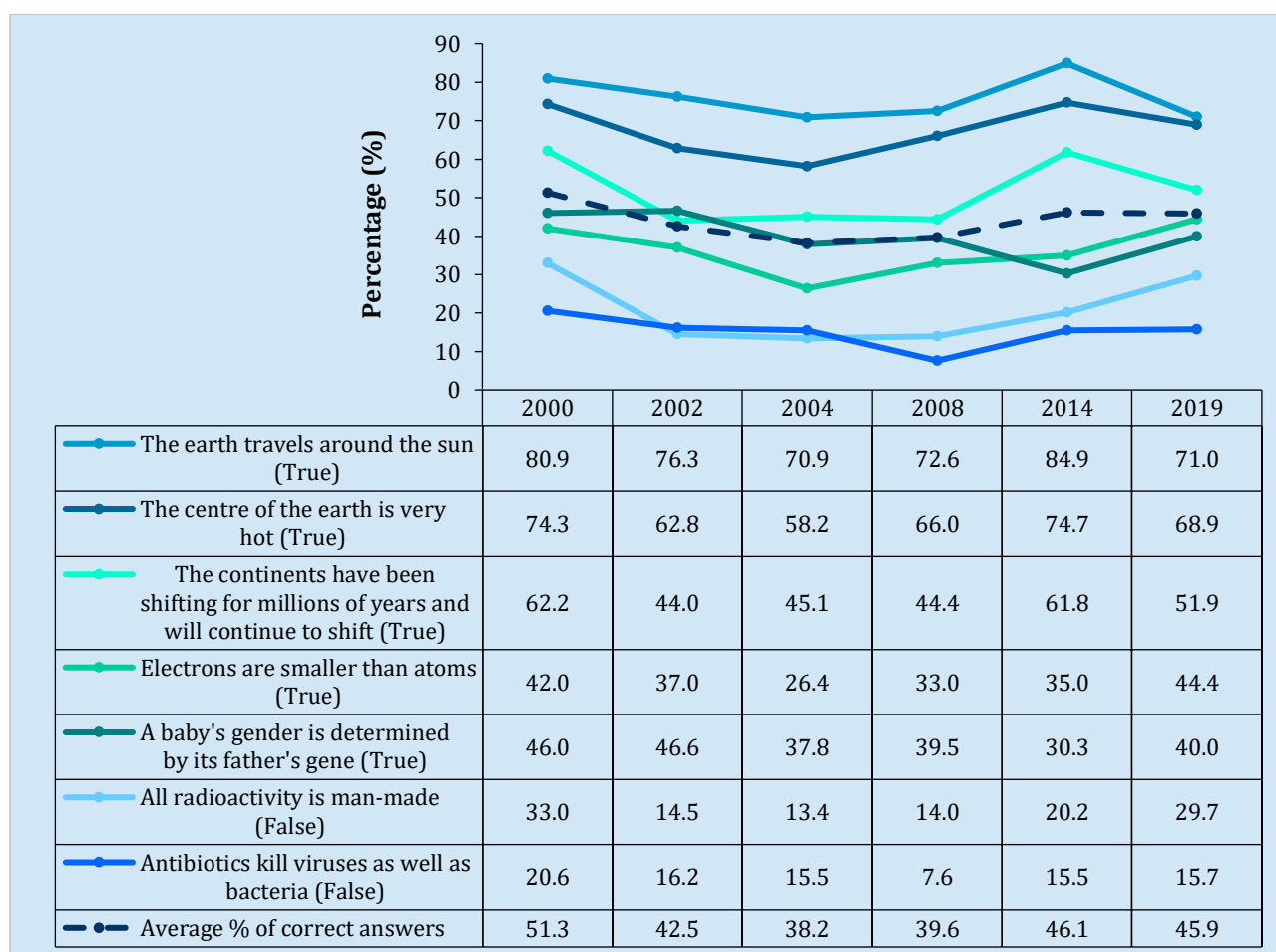
3.4 Public Knowledge and Understanding of STI Issues

Public knowledge and understanding of STI is assessed through two aspects: (i) the correct understanding of STI terms and concepts through 10 factual questions; 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 gives an indication of the Malaysian public's understanding of STI terms and concepts, and hence the public knowledge of STI.

3.4.1 Knowledge and Understanding of STI Terms and Concepts

Overall, Figure 3.4 shows that the average percentage of Malaysians answering correctly has declined marginally in 2019 (45.9%) compared to 2014 (46.1%). It is pertinent to note that the average public knowledge of STI in Malaysia has been below 50% for the past 19 years. Generally, Malaysians are more familiar with the basic scientific ideas they encountered in school (for example, our universe's heliocentric system and the earth's having a very hot centre), and with issues that affect their immediate environment (for example, haze) and physical well-being (for example, the percentage of water in the human body). However, Malaysians are less knowledgeable about more challenging science ideas, such as the source of radioactivity (less than 30.0% correct answers) and the function of antibiotics (with only 15.7% correct answers). Malaysians' STI knowledge is generally uniform across gender, age groups and ethnicities, but differs by locality and educational level.

Figure 3.4 Correct Answers to Questions on STI Concepts and Ideas (2000-2019)

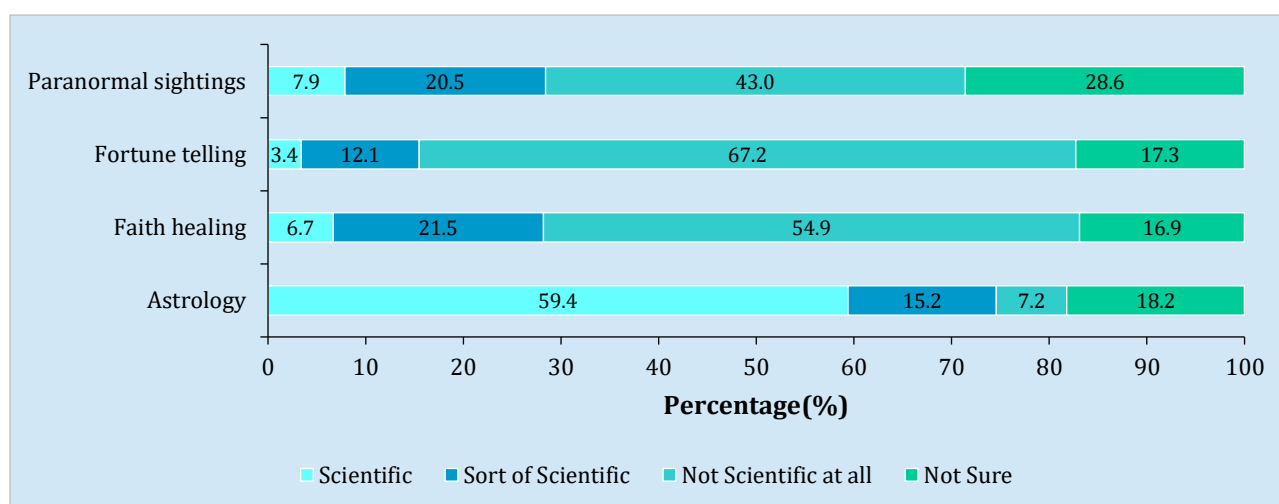


Source: Public Awareness of STI Malaysia, 2019

3.4.2 Understanding of Pseudoscience

Many Malaysians are able to distinguish science from pseudoscience—with the exception of one practice, which is astrology. They have a good grasp of paranormal sightings (43.0%), fortune telling (67.2%) and faith healing (54.9%) as being non-scientific practices (Figure 3.5), but tend to regard astrology as being either scientific (59.4%) or sort of scientific (15.2%). Malaysians' knowledge of pseudoscience is not defined by gender, locality and age group but more a function of educational level.

Figure 3.5 Understanding of Pseudoscientific Practices



Source: Public Awareness of STI Malaysia, 2019

3.5 Public Attitudes towards STI

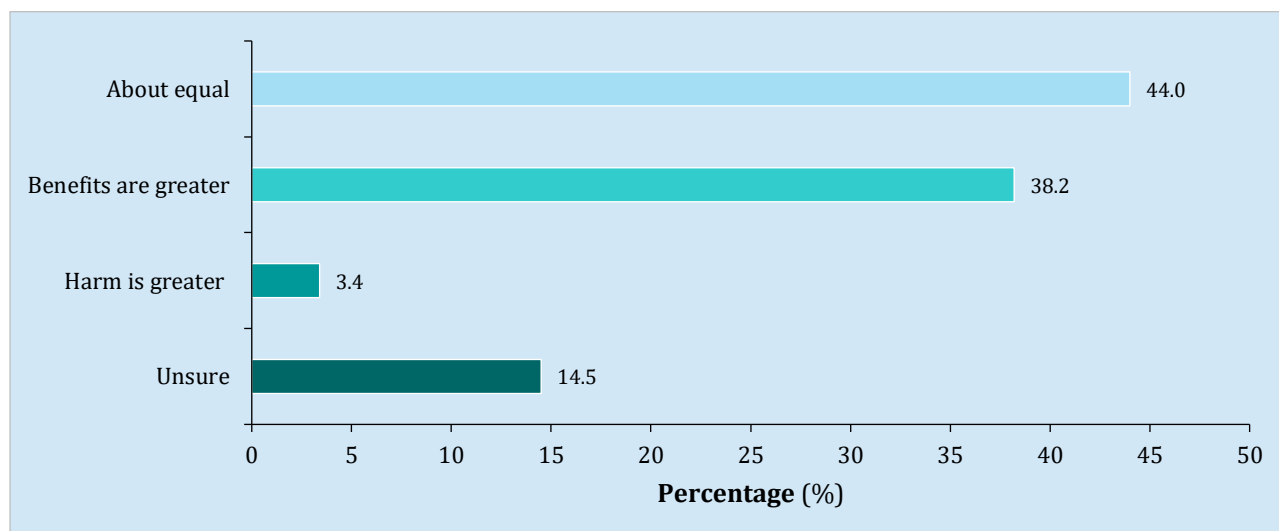
The knowledge about public attitudes towards STI such as obtained through surveys commissioned by MASTIC since 1994 will help, among others, the formulation of more effective policies and programmes – both in Government and in scientific institutions - that will contribute to the advancement of STI. The key findings from the 2019 survey on public attitudes towards STI are described in the following sections.

3.5.1 Public Attitudes towards Scientific Research

Malaysians' attitude towards science is generally positive (Figure 3.6). Essentially, the attitude of most Malaysians is either one of these two categories—they think either that science is more beneficial than harmful (38.2%), or it is about equal in benefits and harm (44.0%). Very few think negatively of it (3.4%), while about 14.5% are unsure. The percentage of respondents believing that scientific research brings more good than harm has decreased from 52.9% in 2014 to 38.2% in 2019 (Figure 3.7). However, the percentage of respondents believing that scientific research brings more harm than good is much smaller by comparison – 3.4% in 2019 (4.2% in 2014). Malaysians' attitude towards STI is associated with educational level, those

with more formal education tend to appraise STI benefits more positively than those with less or with no formal education.

Figure 3.6 The Malaysian Public's Attitude towards Science

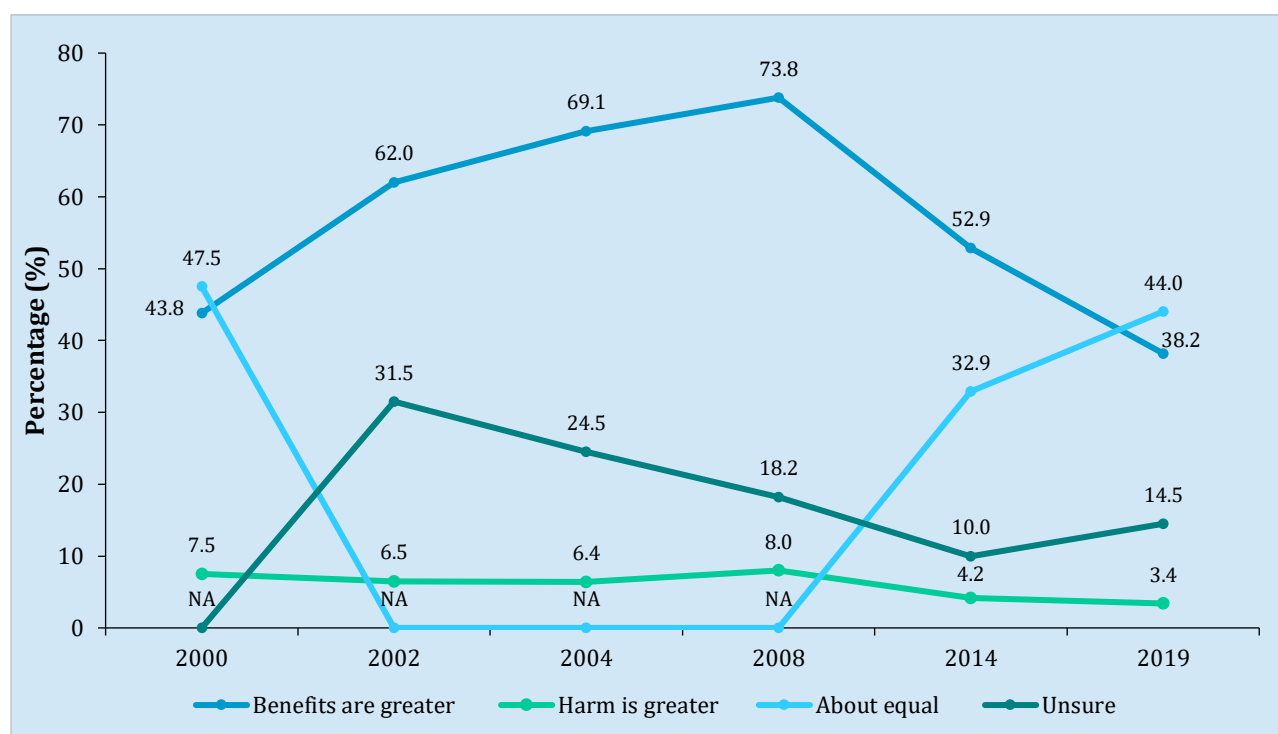


Source: Public Awareness of STI Malaysia, 2019

Based on the last six national STI surveys (from 2008 to 2019), three key trends suggest that Malaysians' attitude towards STI is declining as follows:

- (i) Firstly, there is a downward trend in the percentage of Malaysians agreeing that the benefits of science are greater than its harmful effects, with nearly 21.0% and 14.7% decreases, respectively, in 2014 and 2019. Over six national surveys spanning 19 years, 2019 recorded the lowest percentage (38.2%) of Malaysians saying the benefits of STI are greater.
- (ii) Secondly, the percentage agreeing that the harm and benefits are "about equal" rose by 11.1% in 2019 (i.e., 44.0% against 32.9% in 2014). In essence, the percentage of Malaysians saying the benefits are greater decreased, while the percentage saying that the benefits and harm are about equal increased.
- (iii) Thirdly, those unsure of the benefits increased by 4.5% in 2019. The trend implies that the positive acceptance or appraisal of science is becoming less prevalent among Malaysians as we move further into the 21st century.

Over the years, Malaysians are only consistent in rejecting the idea that the harm of science is greater than its benefits as repeatedly low percentages have been recorded for this statement from 2000 (7.5%) to 2019 (3.4%). Malaysians' uncertainty about the contributions and positive effects of science appear to be on the upward trend which can be attributed to increasing media coverage on the negative dimensions of STI such as wars, environmental pollution, uneven development and climate change.

Figure 3.7 Public Assessment of Scientific Research 2000-2019

Note: For year 2002, data for "Unsure" is not available (NA), while for year 2004-2008; data for "About Equal" is not available (NA)
 Source: Public Awareness of STI Malaysia, 2019

3.5.2 Public Attitudes towards STI, Scientific Research and Science

The 2019 survey findings reveal that there is an overall positive acceptance of STI and scientific research among Malaysians although the percentages in agreement with the statements are lower than those registered in the 2014 survey (Table 3.1). While there is still strong support for science and scientific research, there are concerns that these developments do not ignore other perspectives, for example, faith.

Table 3.1 Public Attitudes towards STI and Scientific Research, 1998 – 2019

Statements	Percentage Agreeing with Statement (%)						
	1998	2000	2002	2004	2008	2014	2019
We depend too much on science and not enough on faith	27.4	25.3	21.7	26.9	39.2	41.8	30.4
Science causes our lifestyles to change too fast	71.4	70.3	54.2	66.3	66.1	80.8	62.2
Scientific research increases knowledge although it does not produce immediate benefits	80.5	81.6	64.4	50.2	59.7	81.4	NA
We need scientific knowledge in order to manage our daily lives better/we need scientific knowledge to make informed decisions*	83.5	81.2	62.9	75.5	68.7	88.1	62.8
Science, Technology and Innovation improve the quality of our lives	83.9	87.1	80.6	74.2	84.3	91.8	79.0
Science, Technology and Innovation are very important for the progress of our nation/STI creates more opportunities for the next generation*	NA	NA	77.9	77.9	79.8	94.5	60.8
STI causes negative changes in our values	NA	NA	NA	NA	NA	NA	25.1

Note: NA = not available * statement used in 2019 survey

Source: Public Awareness of STI Malaysia 2014, 2019

3.5.3 Public Attitudes towards the Impact of STI

In 2019, most Malaysians view the impacts of STI as positive rather than negative, especially when it comes to health (75.5%) and quality of life (82.0%) (Table 3.2). Since 1998 there is increasing percentage of Malaysians perceiving positive effects of STI particularly on quality of life and healthcare. However, public opinion on positive impacts of STI on working conditions has generally been on the decline over the years. STI advancements in the workplace may have engendered an impersonal work culture besides threatening job redundancies.

Table 3.2 Assessment of STI Impacts on Various Aspects, 1998 – 2019

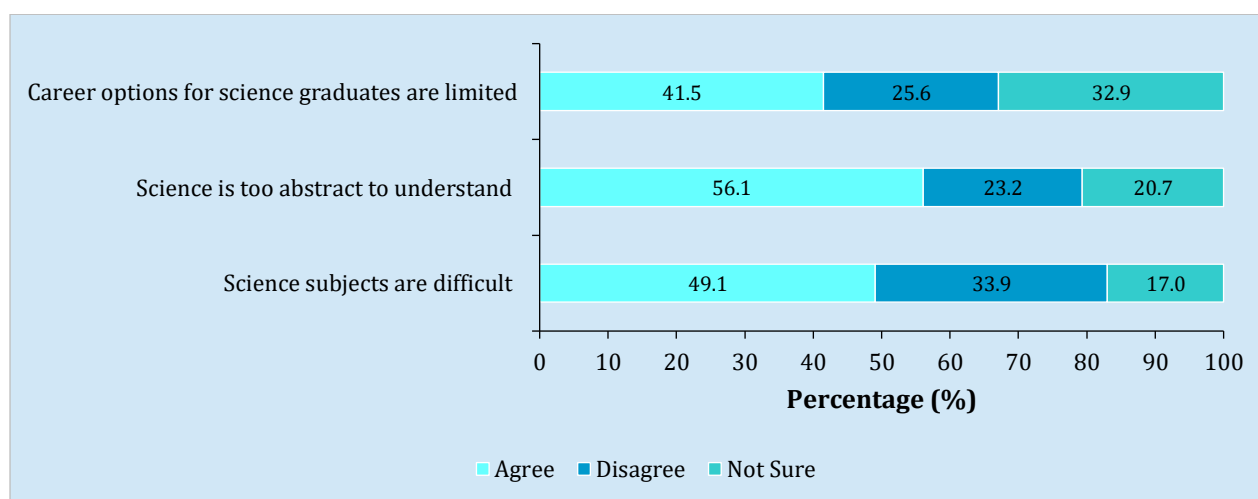
Aspect	Percentage Indicating Positive Effects (%)						
	1998	2000	2002	2004	2008	2014	2019
Cost of Living	40.3	39.6	43.3	49.1	56.0	62.6	NA
Public Healthcare	63.4	62.1	74.4	74.4	71.1	78.5	75.5
Working Conditions	89.1	89.5	82.1	78.8	67.3	70.3	64.3
Environment	39.3	36.0	42.1	52.9	54.1	66.4	63.0
Lifestyle/Quality of life*	67.8	70.7	65.0	63.0	59.9	67.6	82.0
World Peace	39.6	36.5	46.8	48.8	44.6	54.2	NA
Food Security	NA	NA	NA	NA	NA	NA	64.9

Note: In the 2014 survey, “Individual enjoyment of life” has been rephrased as “lifestyle”. *Rephrased as quality of life in 2019 survey.; NA = not available

Source: Public Awareness of STI Malaysia 2014, 2019

3.6 Reasons for Low Enrolments in Science

Malaysians rate the nature of science being too abstract to understand (56.1%) as the main reason for the low enrolments in the subject among students, followed by Science subjects being difficult (49.1%), and limited career options in the field (41.5%) (Figure 3.8). Much can be done in the teaching of science to ensure that it is relatable to the lives of students so that they are not overwhelmed by the abstractness of many scientific concepts. Also, perceived poor career opportunities in STI may cause students to switch to non-STEM related courses.

Figure 3.8 Reasons for Low Enrolments in Science

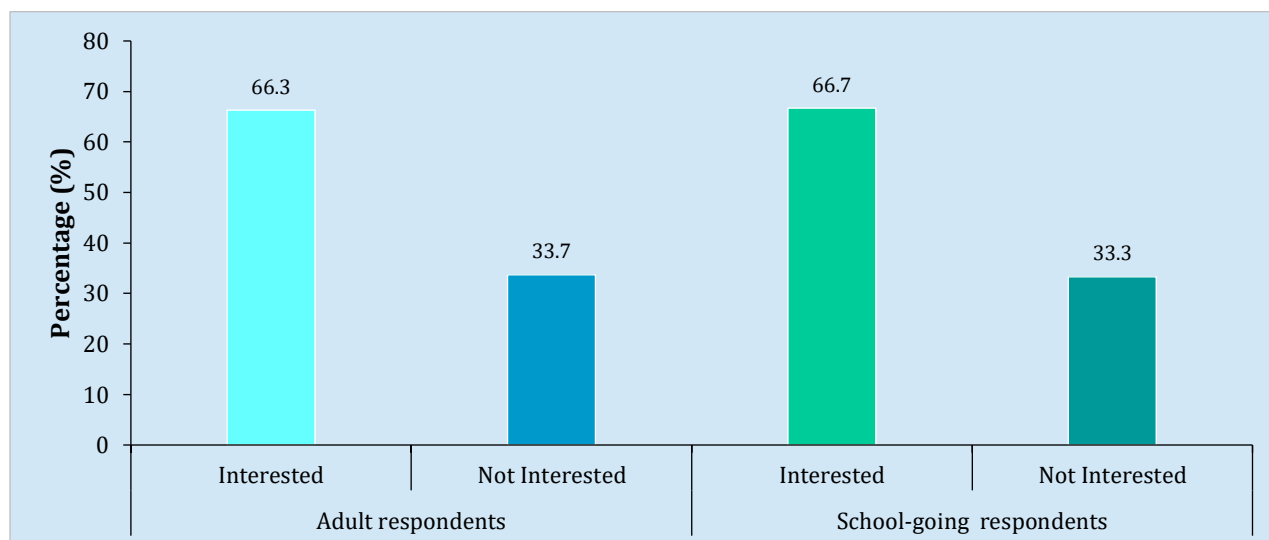
Source: Public Awareness of STI Malaysia 2019

3.7 Interest in Science among Malaysian Adults and School-Going Students

Most Malaysians expressed an interest in science (Figure 3.9). About 66.7% of school-going students and 66.3% of Malaysian adults said they are interested in the subject or field. This

interest among the younger generation is heartening since they represent the nation's future talent pool in STI.

Figure 3.9 Interest in Science among Malaysian Adults and School-Going Students



Source: Public Awareness of STI Malaysia 2019

3.8 Should Science Be Taught in English?

Malaysians are divided in their support for Science to be taught in English. Although 51.8% support the move, a large section of the Malaysian public is against it, especially among the rural people (60.9%). The reasons given by those opposing the move include: English will make it difficult for many students to understand Science, especially those in rural areas and with low proficiency levels (82.9%); the national language should be the language of instruction in Malaysian schools (8.3%); and Science should be taught in both Bahasa Malaysia and English, not just in English alone (5.6%).

3.9 Public Attitudes towards Specific STI-Related Issues

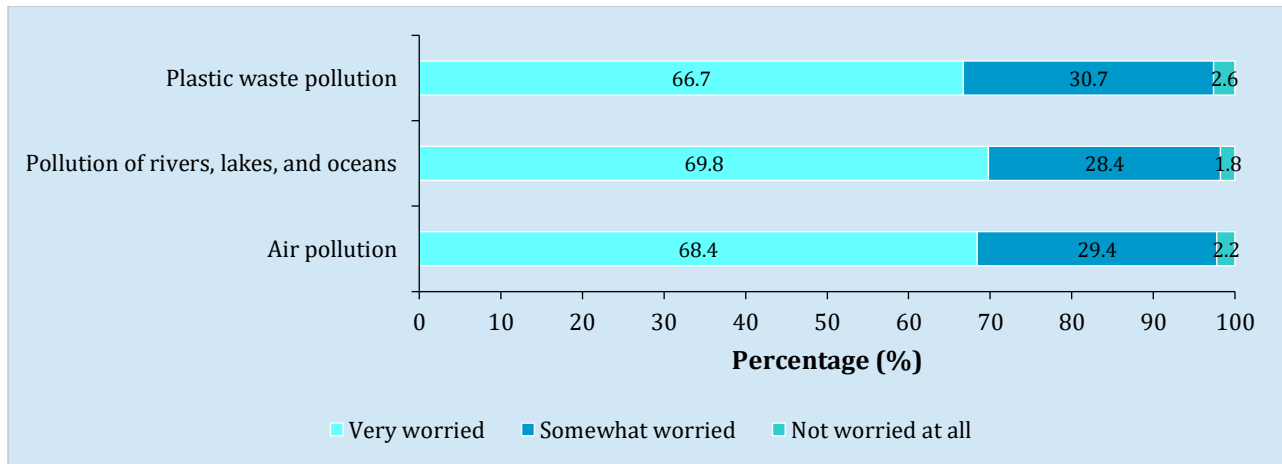
Over the years, a growing number of Malaysians have shown a keen interest in environmental pollution, with 60.8% indicating that they were interested and very interested in this issue in 2004, 72.7% in 2014, and 83.1% in 2019. In the 2019 STI national survey, this issue was expanded to include an assessment of whether citizens would also be concerned about different types of environmental degradation, such as that caused by plastic waste, air pollution and water defilement, which often leads to climate change.

3.9.1 Environmental Pollution

Several questions on specific environmental issues were included in the 2019 STI National Survey. A majority of Malaysians indicated that they are very worried about the pollution of rivers, lakes and oceans (69.8%), air pollution (68.4%), and plastic pollution (66.7%) (Figure

3.10). Not surprisingly, raw water pollution has the highest percentage of worried Malaysians amongst the three environmental concerns, consistent with the recent occurrence of several major cases of water contamination which has attracted widespread publicity.

Figure 3.10 Concern for Environmental Pollution among Malaysians

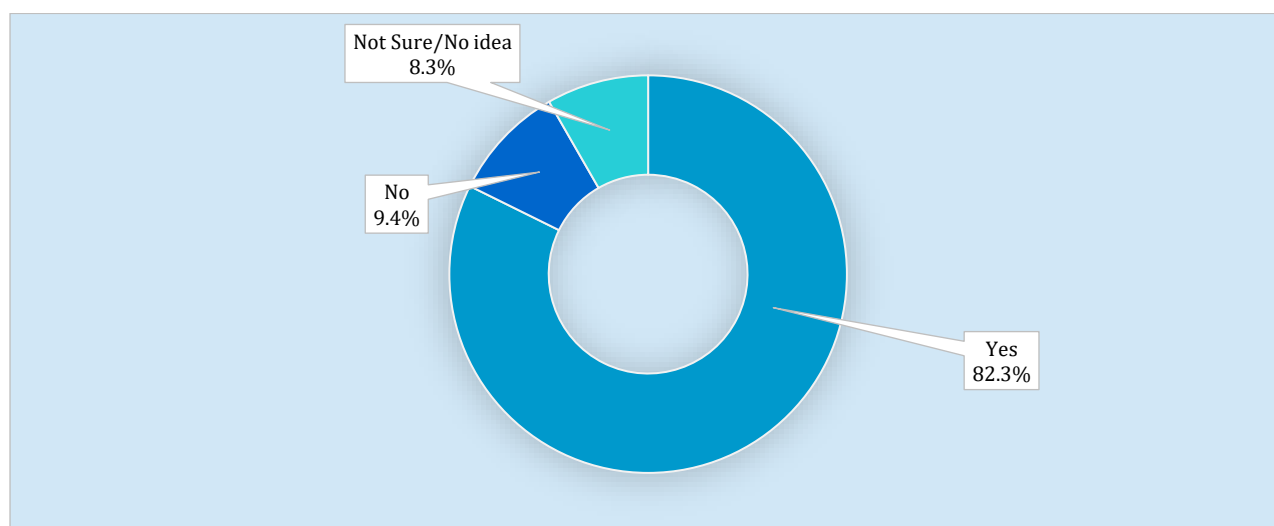


Source: Public Awareness of STI Malaysia 2019

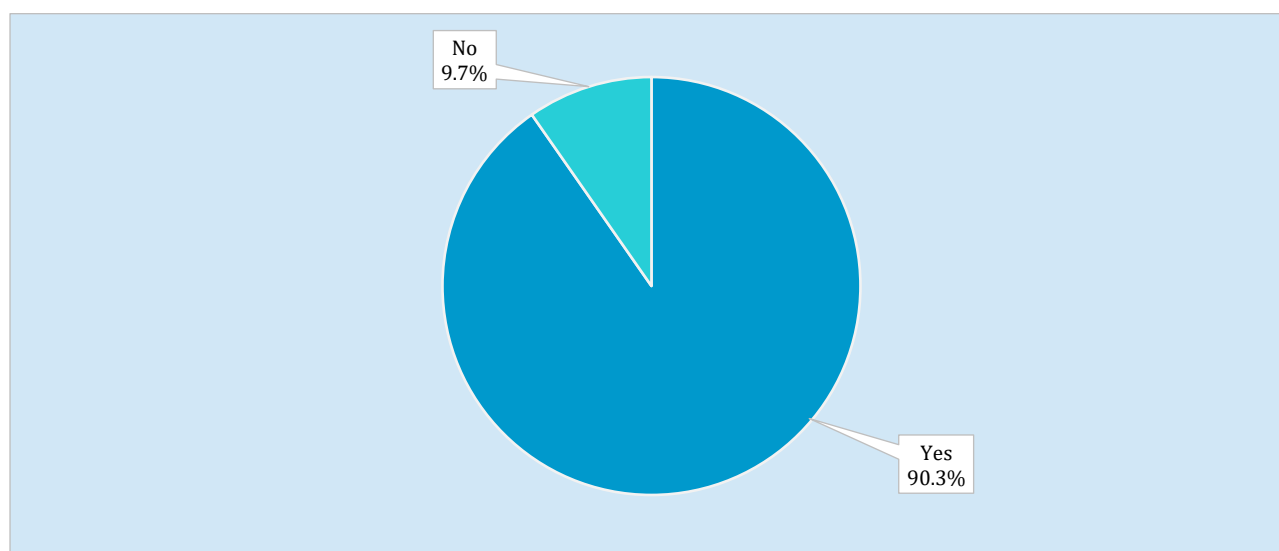
3.9.2 Plastic Waste Pollution

Plastic waste pollution has received extensive coverage in the media over the past two years with reports of small towns having large illegal dumping grounds of plastic waste and the government's initiative to send back containers of plastic waste to the countries of their origin. The survey findings indicate a high percentage of Malaysians (82.3%) who think that plastic pollution is a serious problem in Malaysia (Figure 3.11).

Malaysia is serious in its efforts to reduce plastic waste with several initiatives launched in recent times. The survey findings reveal that most Malaysians (90.3%) support these initiatives (Figure 3.12), indicating that a large majority of them are willing to contribute to the reduction of plastic waste.

Figure 3.11 Plastic Waste Pollution is a Serious Problem in Malaysia

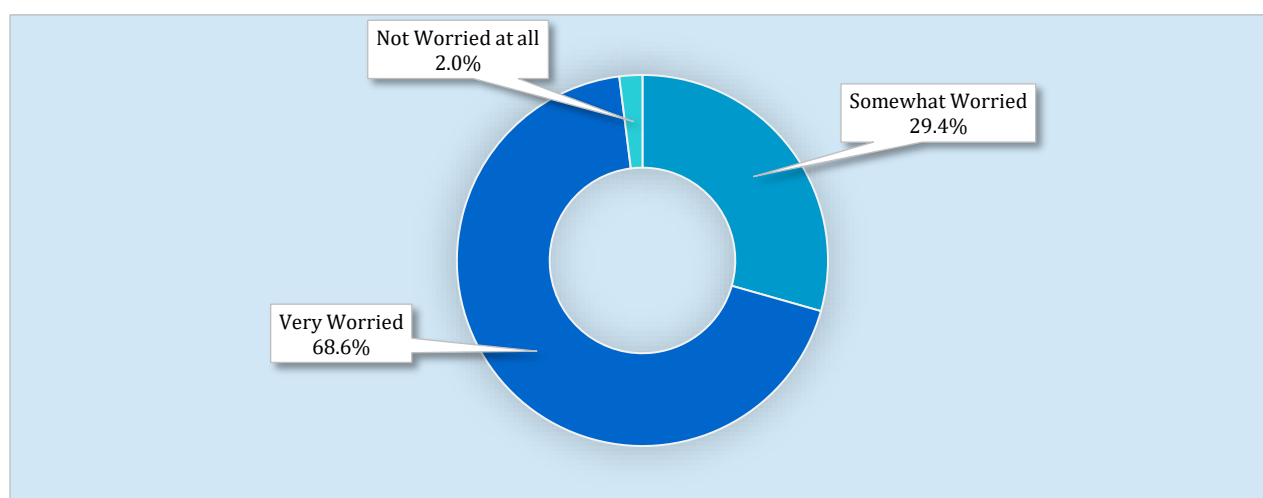
Source: Public Awareness of STI Malaysia 2019

Figure 3.12 Support for the Government's Initiative to Reduce Plastic Use

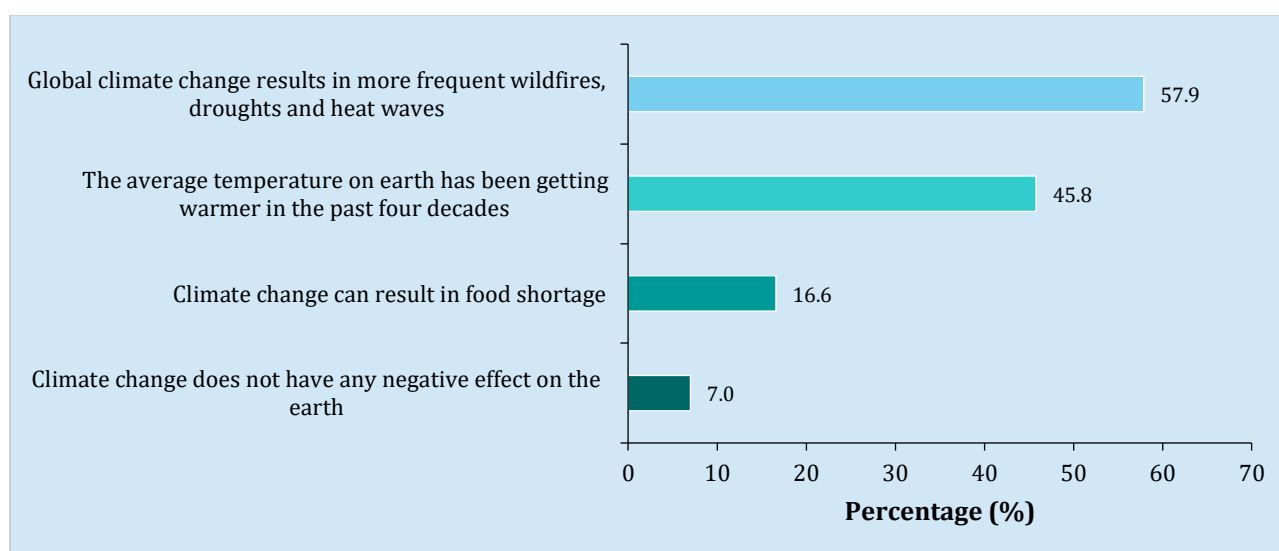
Source: Public Awareness of STI Malaysia 2019

3.9.3 Climate Change

There has been much public debate about the degree of climate change caused by human activities and what the government should do about it. A large number of Malaysians (68.6%) are worried about climate change (Figure 3.13). This concern for climate change is generally uniform across demographics, that is, by ethnicity, age group, locality and gender. Malaysians are also aware about the effects of climate change, where 57.9% know that global climate change results in frequent wildfires, droughts and heat waves, while 45.8% realise that the global temperature has been getting warmer in the last four decades (Figure 3.14). The high level of awareness reported by Malaysians is not surprising as the country has been affected by haze almost every year due to forest fires both in Malaysia itself and Indonesia since 1994.

Figure 3.13 Concern for Climate Change among Malaysians

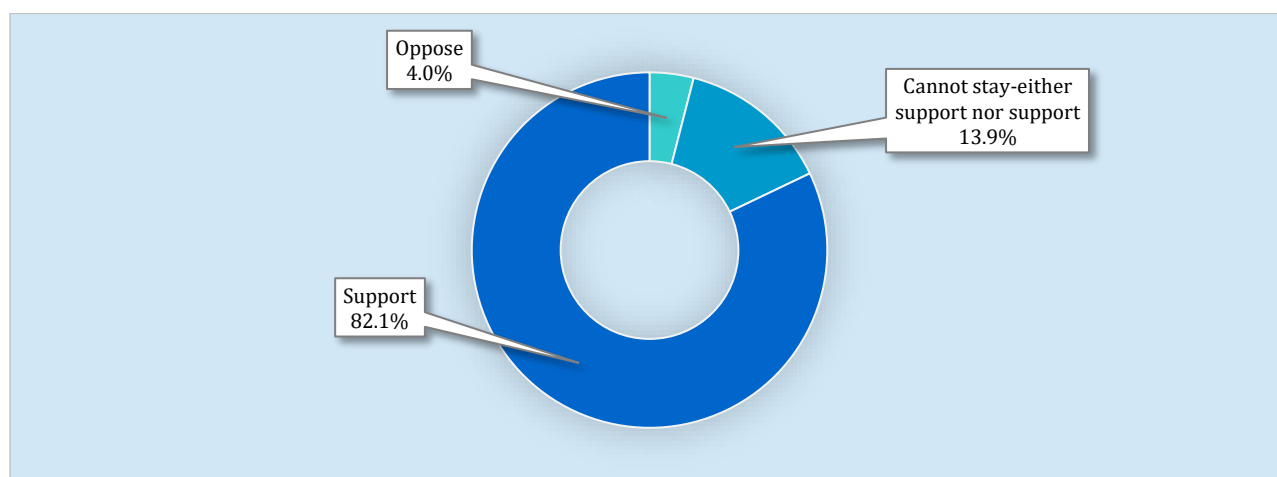
Source: Public Awareness of STI Malaysia 2019

Figure 3.14 Malaysians' Understanding of the Effects of Climate Change

Source: Public Awareness of STI Malaysia 2019

3.9.4 Renewable Energy

Malaysia is blessed with many renewable energy sources that can be developed such as solar, wind, biomass, hydro, geothermal and tidal wave. The Malaysian government has announced a target of 20% renewable energy in its electricity generation mix by 2025. The 2019 national survey assessed, among others, the Malaysian public's acceptance of renewable energy as a source of electricity. The results indicated that a large majority (82.1%) support the usage of renewable energy for this purpose (Figure 3.15), and the support is mostly consistent across demographics.

Figure 3.15 Malaysians' Support for Renewable Energy

Source: Public Awareness of STI Malaysia 2019

3.10 Information Sources on STI

Over the years from 1998 – 2019, the main source of information among Malaysians was television, followed by newspapers and radio (Table 3.3). There has been a declining percentage of respondents obtaining their information from magazines since 2000. Among the new media, social media—such as Facebook, Twitter and Instagram—ranked highest in 2019 with 63.3% of Malaysians relying on them for STI information. The 2019 survey reveal encouraging trends in the increasing use of the Internet as an important source of STI information. For example, based on the survey, 52.5% of Malaysians use e-news and 51.8% use science websites or videos for information on STI.

Table 3.3 Sources of Information, 1998 – 2019

Sources	1998	2000	2002	2004	2008	2014	2019
Newspapers	92.6	93.2	89.9	84.2	62.1	86.7	76.8
Magazines	81.0	82.3	64.2	63.8	22.1	51.3	34.3
Television	97.6	97.7	98.4	97.2	82.4	97.3	83.6
Radio	82.5	88.1	85.3	78.1	32.1	77.5	56.5
Internet/Social Media	22.1	40.2	43.9	34.4	24.8	65.2	63.3
E-news	NA	NA	NA	NA	NA	NA	52.5
Science websites/videos	NA	NA	NA	NA	NA	NA	51.8

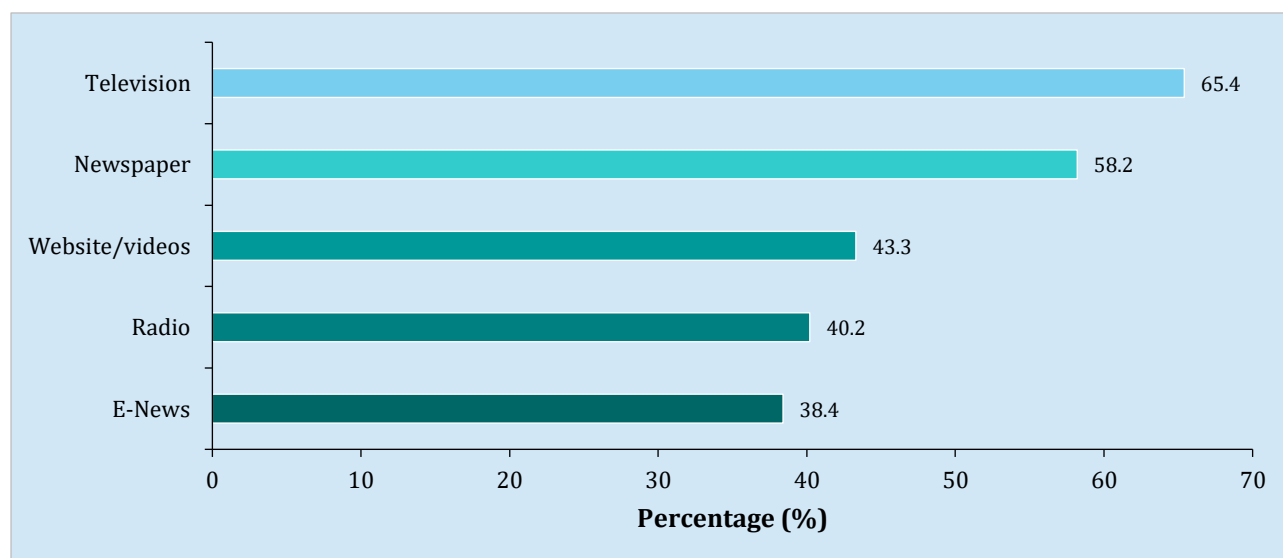
Source: Public Awareness of STI Malaysia 2019

3.11 Top 5 Most Trusted Sources of STI Information

For 2019, Malaysians ranked the two predominant forms of traditional media, that is, television (65.4%) and newspapers (58.2%), as their most trusted sources of STI information. Websites

and/or videos—sources coming from the Internet—are positioned at number three (43.3%), followed by radio (40.2%), and e-news (38.4%). The responses are mostly similar to the sources of STI information among Malaysians reported in Table 3.3, except for the third ranked item, that is, websites and videos (43.3%) (Figure 3.16).

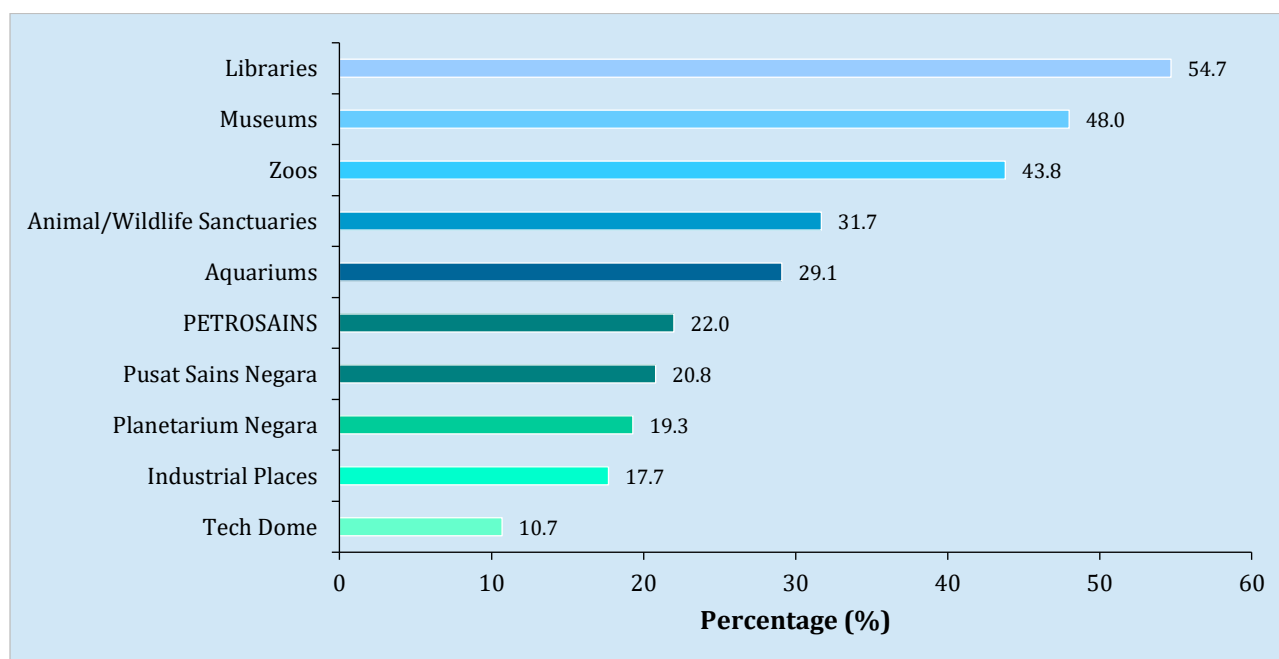
Figure 3.16 Top 5 Most Trusted Sources of STI Information among Malaysians



Source: Public Awareness of STI Malaysia 2019

3.12 Visits by Malaysians to STI-Associated Places

Visits to places associated with STI are an important aspect of raising STI enculturation within the society. The 2019 survey revealed that libraries (54.7%) and museums (48.0%) are the top two STI-related venues where a majority of Malaysians have visited in the last 12 months. Other STI-related venues that are well patronised include PETROSAINS, Planetarium Negara and Pusat Sains Negara and Tech Dome in Penang (Figure 3.17).

Figure 3.17 STI Places Visited by Malaysians in the Last 12 Months

Source: Public Awareness of STI Malaysia 2019

Across the six surveys (since 2000) on public awareness of STI, museums and zoos are the top two STI-related places visited by Malaysians given their presence in almost every state in the country. The reasons why Malaysians do not visit these STI-related centres include distance, lack of interest and unaware of existence of the centre (Tech Dome).

Table 3.4 STI Places Visited by Malaysians in the Last 12 Months, 2000-2019

Venue	2000 (%)	2002 (%)	2004 (%)	2008 (%)	2014 (%)	2019 (%)
Museums	31.0	45.7	32.4	29.9	22.7	48.0
Zoos	29.5	45.7	34.1	30.0	31.0	43.8
Aquariums	15.1	27.0	17.6	18.6	13.4	29.1
Pusat Sains Negara	15.0	21.5	13.1	11.1	7.4	20.8
Planetarium Negara	13.5	16.8	10.8	10.3	6.7	19.3
PETROSAINS	12.0	18.8	14.5	13.9	10.3	21.9

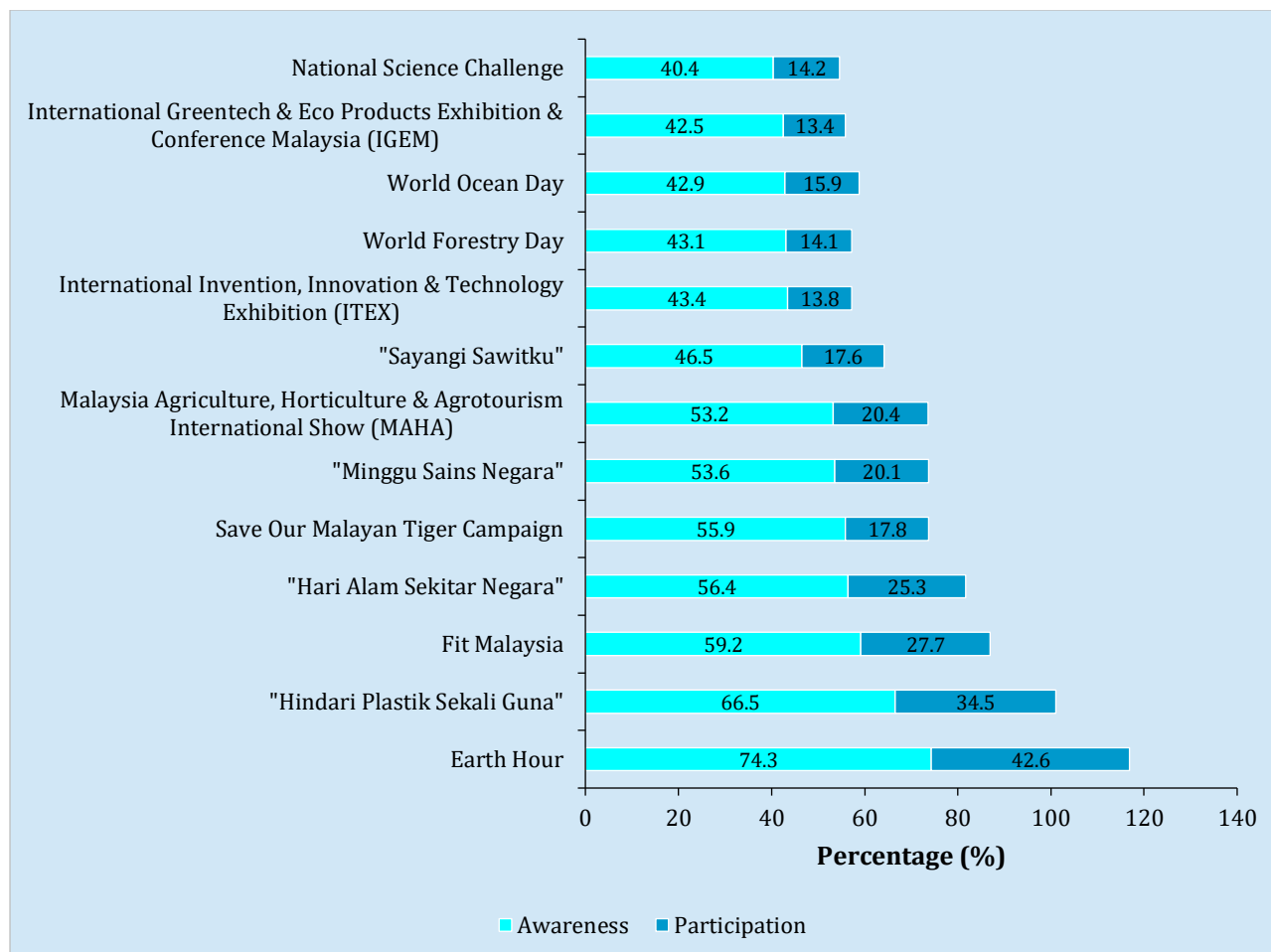
Source: Public Awareness of STI Malaysia 2019

3.13 Public Awareness and Participation of STI Programmes

The 2019 Survey examined Malaysians' awareness of 13 STI-related programmes. The results revealed that more than 40% of the respondents are aware of all the programmes. The level of awareness is most for Earth Hour (74.3%), followed by the "Hindari Plastik Sekali Guna" campaign (66.5%). The public participation of these programmes is commendable with 6

programmes having 20% or more respondent participation – much higher than the less than 2% respondent participation recorded in the 2014 survey (although with generally different set of programmes) (Figure 3.18).

Figure 3.18 Awareness and Public Participation of 13 STI-Related Programmes



Source: Public Awareness of STI Malaysia 2019

3.14 Awareness of the Government's STI Policies

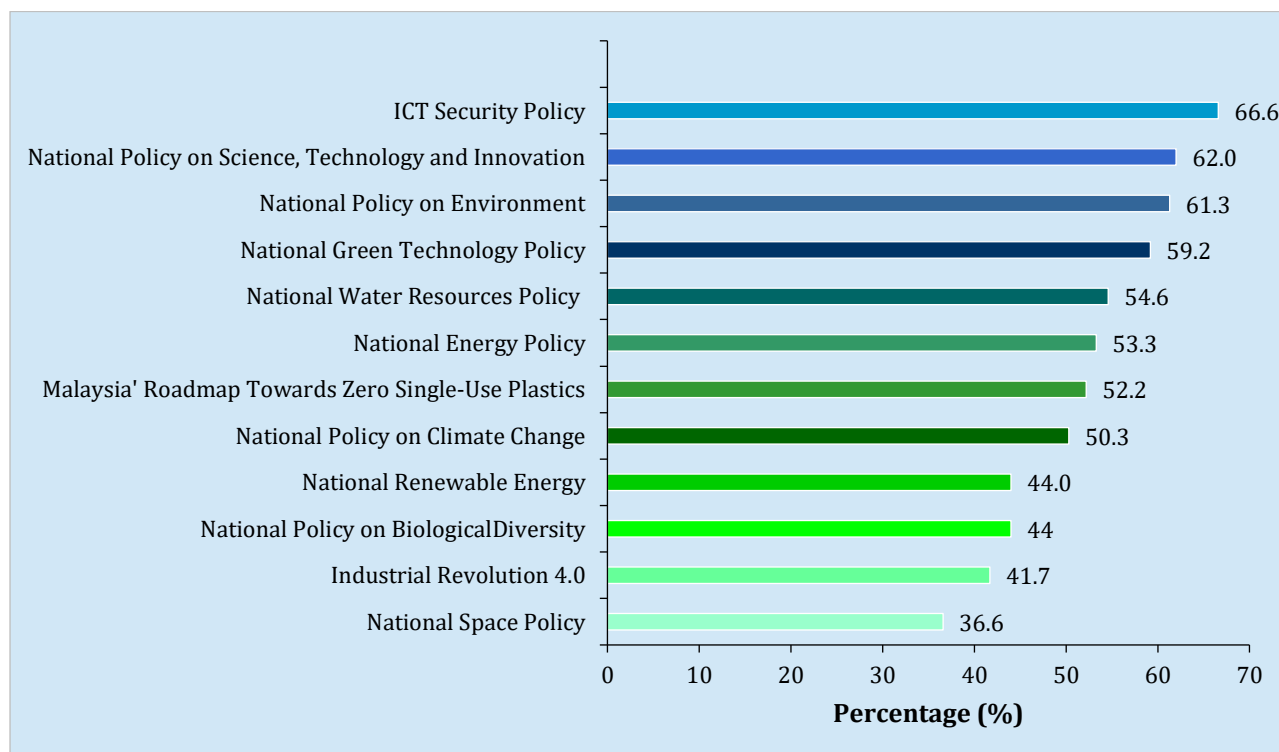
Public awareness of 12 STI-related government policies was examined in the 2019 survey (Figure 3.19). The findings revealed that more than 50% of the respondents are aware of 8 of these policies. Despite much fanfare and publicity, it is surprising to note that only 41.7% of respondents have indicated awareness of the policy on IR 4.0. Given the pervasive nature of this policy and its wide ramifications on the economy, much can be done to promote its importance and impact in a manner that is easily comprehensible to the lay public.

3.14.1 Awareness of STI-Related Government Policies (2014 and 2019)

Between 2014 and 2019, there is a decrease in the level of awareness of STI-related government policies in five out of six policies, namely, the National Policy on Science,

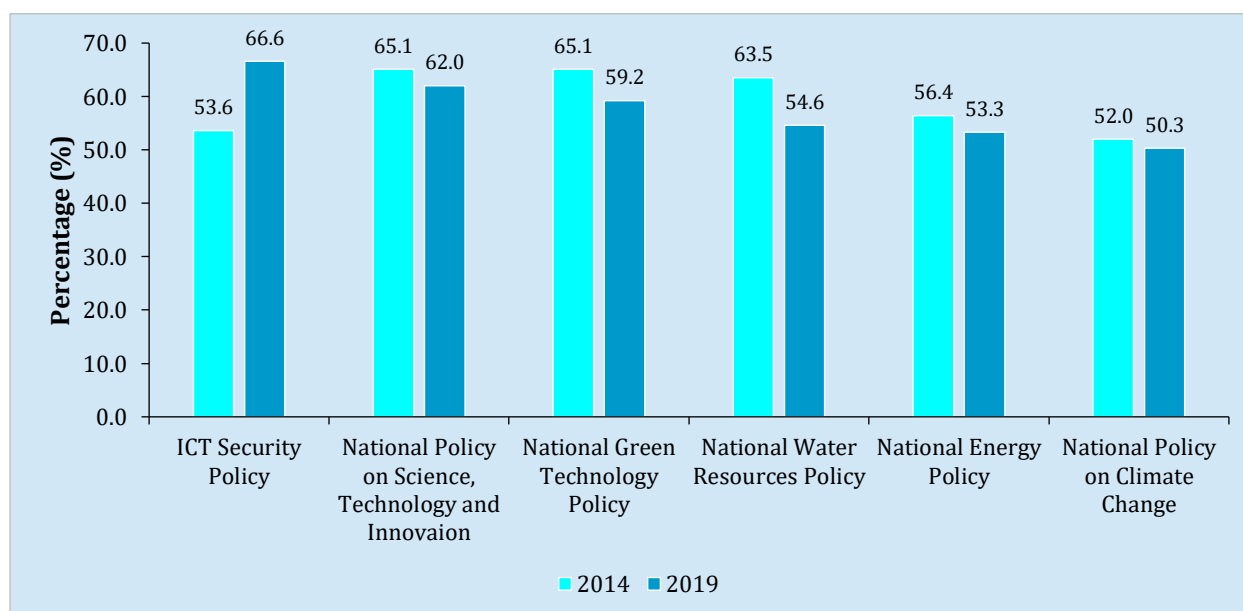
Technology and Innovation (a decline of 3.1%), National Green Technology Policy (5.9%), National Water Resources Policy (8.9%), National Energy Policy (3.1%) and National Policy on Climate Change (1.7%). However, the Malaysian public's level of awareness of the ICT Security Policy increased by 13% between 2014 (53.6%) and 2019 (66.6%) (Figure 3.20).

Figure 3.19 Awareness of STI-Related Government Policies among Malaysians



Source: Public Awareness of STI Malaysia 2019

Figure 3.20 Awareness of STI-Related Government Policies, 2014 & 2019

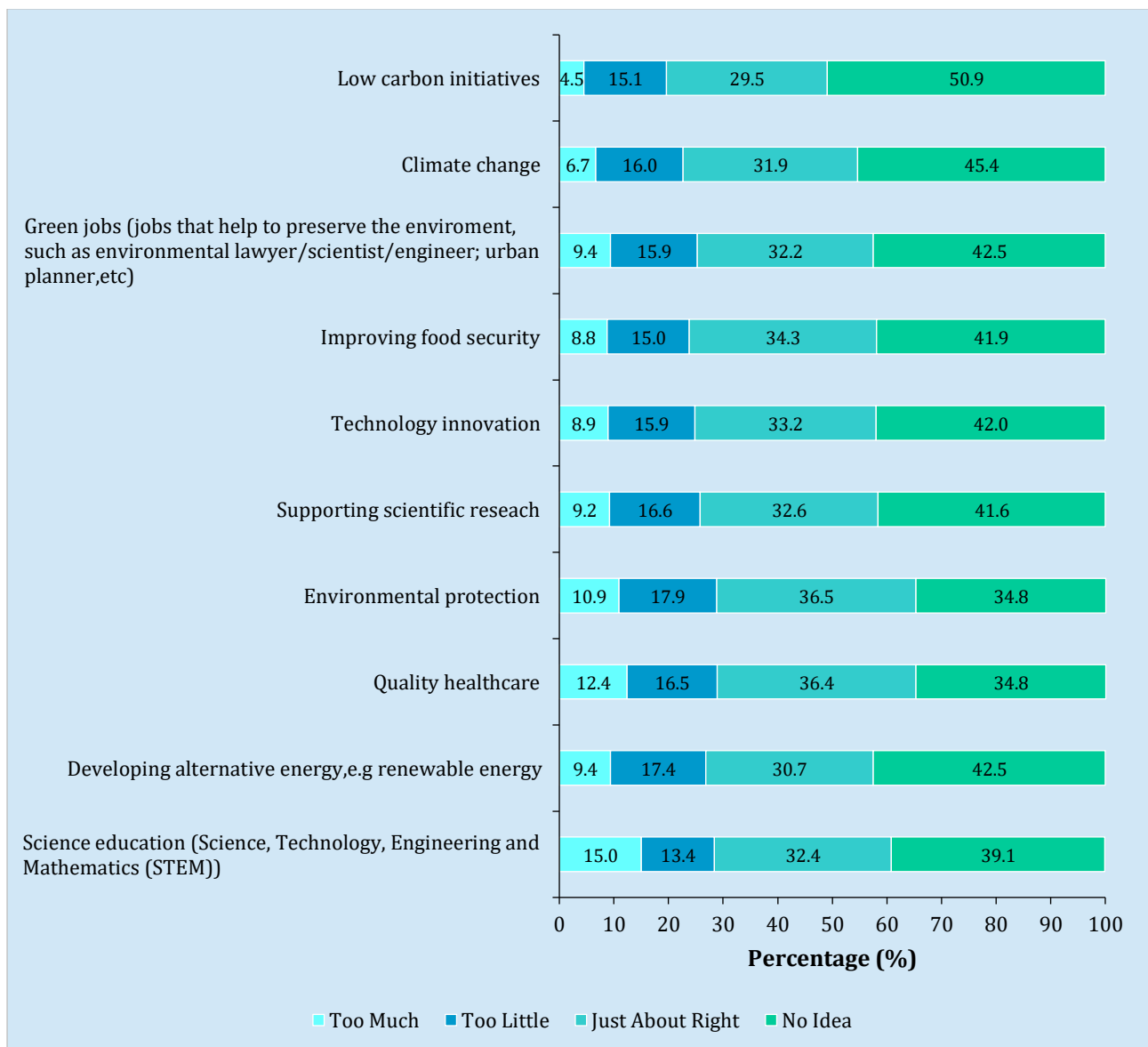


Source: Public Awareness of STI Malaysia 2019

3.15 Public Opinion on Government's Spending on STI-Related Matters

The predominant theme from public opinion on government's spending on STI-related matters is one of 'no idea' (Figure 3.21). It is fair to assume that ordinary Malaysians are unaware on the amount the government spends on STI given the numerous agencies overseeing STI-related matters. However, on issues that Malaysians can relate to, such as environmental protection and quality healthcare, the percentage of Malaysians responding "just about right" is higher than "no idea", at 36.5% and 36.4% respectively. Meanwhile, the highest response for spending too much on STI-related matters is recorded for Science education (STEM) with 15.0%, while the highest response for spending too little is for environmental protection with 17.9% (Figure 3.21).

Figure 3.21 Public Opinion on Government Spending on STI-Related Matters



Source: Public Awareness of STI Malaysia 2019

3.16 International Comparison

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

3.16.1 Public Interest in STI

Malaysia is compared with two leading nations, USA and China with respect to public interest in STI. The total mean percentage of respondents interested (including moderately interested) in selected STI issues in Malaysia (77.9%) is comparable to the level displayed in the USA (85.0%) and China (75.3%) (Table 3.5).

Table 3.5 International Comparison of Public Interest in Selected STI Topics

	Malaysia 2019 (%)			China 2018 (%)			USA 2018 (%)		
	Very Interested and Interested	Moderately Interested	Not Interested at All	Interested	Not interested	Don't Know	Very Interested	Moderately Interested	Not Interested at All
New scientific discoveries	40.0	36.0	24.0	77.0	12.0	10.0	41.0	44.0	15.0
New medical discoveries	41.0	36.0	23.0	73.0	16.0	12.0	56.0	39.0	5.0
Use of new technologies & inventions	44.0	36.0	20.0	76.0	13.0	11.0	40.0	47.0	13.0
Space exploration	36.0	35.0	29.0	NA	NA	NA	25.0	44.0	30.0
Environmental pollution	48.0	38.0	15.0	NA	NA	NA	45.0	44.0	11.0
Mean %	41.7	36.2	22.1	75.3	13.7	11.0	41.4	43.6	14.8

Note: NA = not available

Source: Science and Engineering Indicators 2020.

Main Findings from the Survey of Public Understanding of Science in China, 2018.

Public Awareness of STI Malaysia, 2019

3.16.2 Knowledge and Understanding of STI Concepts and Ideas

Overall, knowledge and understanding of STI concepts and ideas among the public in Malaysia is well behind that of Singapore and other advanced nations such as USA, EU, South Korea and Japan (Table 3.6). Less than one fifth (16.0%) of the Malaysian public correctly know that antibiotics do not kill viruses, compared to 50.0% of Americans, 46.0% of EU subjects, and 39.0% of Indians. On radioactivity, Malaysians are the least knowledgeable compared to all the other selected countries.

Table 3.6 Correct Answers to Questions on STI Concepts and Ideas

	Malaysia 2019 (%)	Singapore 2015 (%)	China 2015 (%)	Japan 2011 (%)	USA 2018 (%)	EU 2005 (%)	India 2004 (%)	South Korea 2004 (%)
The earth travels around the sun (True)	71.0	NA	NA	NA	72.0	66.0	70.0	86.0
The centre of the earth is very hot (True)	69.0	82.0	47.0	84.0	86.0	86.0	57.0	87.0
The continents have been shifting for millions of years and will continue to shift (True)	52.0	NA	51.0	89.0	79.0	87.0	32.0	87.0
Electrons are smaller than atoms (True)	44.0	64.1	22.0	28.0	46.0	46.0	30.0	46.0
A baby's gender is determined by its father's gene (True)	40.0	79.0	49.0	26.0	59.0	64.0	38.0	59.0
All radioactivity is man-made (False)	30.0	59.0	41.0	64.0	68.0	59.0	NA	48.0
Antibiotics kill viruses as well as bacteria (False)	16.0	46.0	24.0	28.0	50.0	46.0	39.0	30.0
Average % of correct answers	46.0	66.0	39.0	53.0	66.0	65.0	44.0	63.0

Note: NA = not available

Source: Public Awareness of STI Malaysia 2014 & 2019; Science and Engineering Indicators 2020

3.16.3 Understanding of Astrology as Pseudoscience: International Comparison

Knowledge and understanding of astrology as pseudoscience is less prevalent among Malaysians than it is among Americans (Table 3.7). Only 7.0% of Malaysians consider astrology as pseudoscience compared to 60.0% of Americans. Malaysians (59.0%) are at least seven times more likely to accept astrology as scientific compared to Americans (8.0%).

Table 3.7 Understanding of Astrology: International Comparison

	USA 2016 (%)				Malaysia 2019 (%)			
	Scientific	Sort of scientific	Not Scientific at all	Not Sure	Scientific	Sort of scientific	Not Scientific at all	Not Sure
Astrology	8	29	60	3	59	15	7	18

Source: Public Awareness of STI Malaysia, 2019

3.16.4 Public Attitudes towards Scientific Research

Unlike the overwhelming majority of American (74%) and Singaporean (62%) respondents, less than half the Malaysian (38%) respondents are convinced that the benefits of scientific research outweigh any harmful effects. Indeed, more Malaysians (44%) are neutral in their responses on the benefits of scientific research suggesting that they are unsure where S&T are taking us. This situation is unlike in the US and Singapore where percentages of respondents who are unsure are much smaller.

Table 3.8 Public Assessment of Scientific Research by Selected Countries

Statement	Malaysia (2019) (%)	US (2018) (%)	Singapore (2015) (%)
Benefits of scientific research strongly or slightly outweigh harmful results	38.0	74.0	62.0
Benefits of scientific research are about equal to harmful results	44.0	10.0	25.0
Harmful results of scientific research strongly or slightly outweigh benefits	3.0	10.0	10.0
Don't know	14.0	6.0	NA

Note: NA = not available

Source: Public Awareness of STI Malaysia 2019; National Science Board (2020) Science and Technology: Public Attitudes, Knowledge, and Interest 2018; A Survey of Public Views and Attitudes Towards Science and Technology Issues in Singapore, 2015

3.16.5 Public Attitudes towards Science and Technology in Selected Countries

Generally, majority of respondents from Malaysia (79%) – like their counterparts from USA, Singapore, China and EU – are in agreement that STI improves the quality of their lives. However, respondents from Malaysia (60.8%) are somewhat less optimistic than the other countries surveyed in terms of whether STI will create more opportunities for the next generation. Despite strong agreements that STI improve our lives, respondents in all the countries – more so in the USA – are concerned that STI changes their lives too fast. Although lower than the other countries, a considerable proportion of Malaysian respondents (30.4%) have indicated concern that we depend overly on STI at the expense of other perspectives such as faith. The combination of support and concern is not necessarily contradictory. It suggests that, while the public supports Malaysia's STI goals, they are concerned that we are pursuing scientific progress in isolation from other perspectives.

Table 3.9 Public Attitudes towards STI in Selected Countries

Statement	Percentage Agreeing with Statement (%)				
	Malaysia- 2019	USA-2018	Singapore- 2015	China- 2018	EU- 2013
Science, Technology and Innovation improve the quality of our lives	79.0	79.0	77.6	89.0	77.0
STI creates more opportunities for the next generation*	60.8	92.0	NA	85.0	75.0
Science causes our lifestyles to change too fast	62.2	48.0	70.7	NA	62.0
We depend too much on science and not enough on faith	30.4	50.4	56.3	49.2	39.0

Note: NA = not available, * statement used in 2019 survey

Source: Public Awareness of STI Malaysia 2014,2019; National Science Board (2020) Science and Technology: Public Attitudes, Knowledge, and Interest 2016, 2018

3.16.6 Concern for Environmental Pollution

At the international level, it is interesting to note that while Malaysians are most worried about raw water pollution, the Europeans, in contrast, are mostly worried about air pollution (56%) and water pollution (50%). The Americans are mostly worried about the pollution of rivers, lakes and oceans; air pollution from industries; and the use of pesticides (Table 3.10).

Table 3.10 International Comparison of Concerns for Environmental Pollution

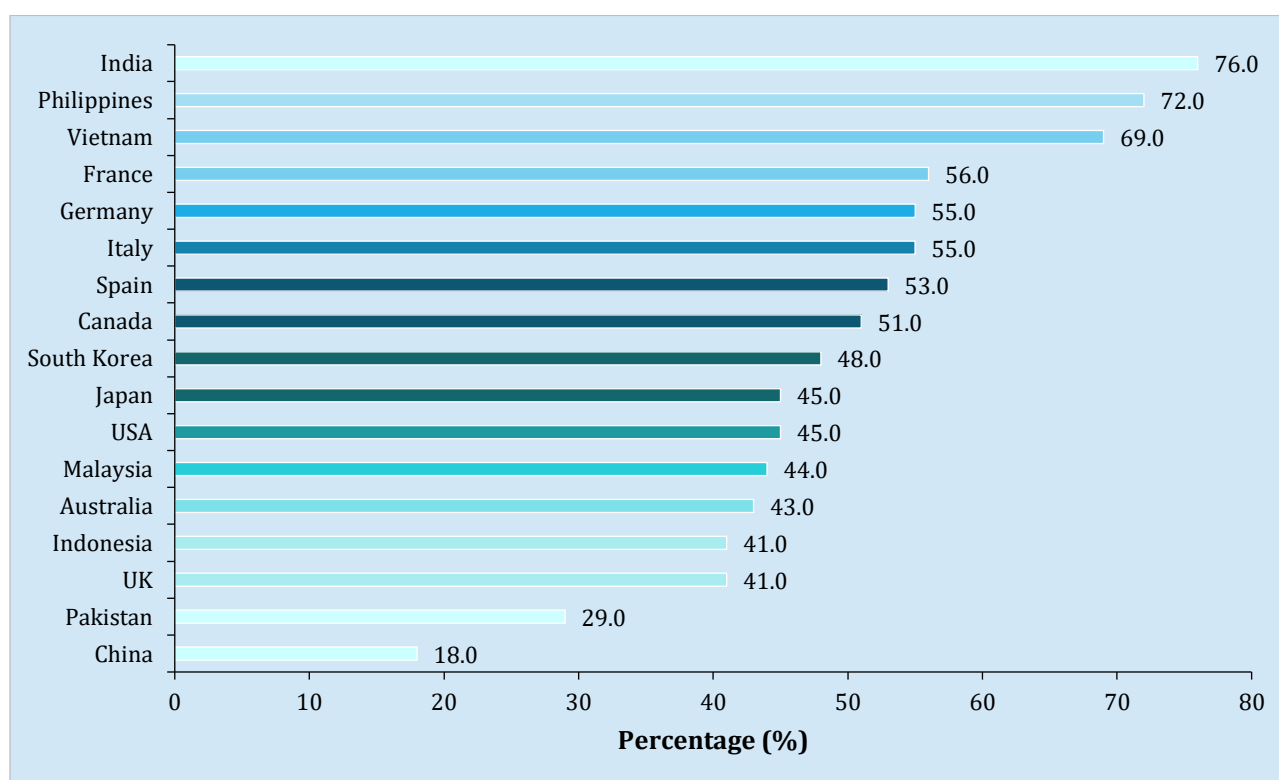
	Malaysia 2019 (% of Very Worried)	USA 2018 (% of Extremely Dangerous/Very Dangerous)	Europe 2014 (% of Worried)
Plastic Waste Pollution	66.7	NA	NA
Pollution of rivers, lakes and oceans	69.8	77.0	50.0
Air Pollution	68.4	73.0	56.0

Note: NA= not available

Source: Public Awareness of STI Malaysia, 2019

3.16.7 Climate Change Concerns

Around the world, citizens in most countries are concerned about climate change (Figure 3.22). In this survey, 44.0% of Malaysians consider climate change as a serious problem. This number is almost similar to the U.S. (45.0%), United Kingdom (41.0%) and Japan (45.0%). However, in comparison to our neighbouring Southeast Asian countries such as India (76.0%), the Philippines (72.0%) and Vietnam (69.0%), this level of concern is much lower. This may be due to the fact that the level of pollution in countries such as India and the Philippines is much higher compared to Malaysia, hence heightening their sensitivity to the issues.

Figure 3.22 International Comparison of Concern for Climate Change

Source: Spring 2015, Global Attitudes Survey, Q32, The Pew Research Centre (Majorities in Africa and Latin America Very Concerned about Climate Change | Pew Research Center n.d.).

3.16.8 Information Sources on STI

Available data from the US, UK, China and Malaysia suggest that the primary source of STI information is television and internet although newspapers constitute an important source in Malaysia. Television, however, is declining as a source of STI information in the US but represents the leading source of STI information in Malaysia. The internet is expected to become the leading source of STI information given its growing pervasive influence in our lives (Table 3.11).

Table 3.11 Responses on Information Sources for STI by Selected Countries (%)

Information Sources on STI	Malaysia 2019	UK 2019	USA 2018	China 2018
Newspapers	76.8	13.0	4.0	10.3
Magazines	34.3	9.0	4.0	5.9
Internet	63.3	53.0	57.0	64.6
Television	83.6	46.0	22.0	68.5
Radio	56.5	15.0	2.0	24.2
Books	44.3	5.0	3.0	8.1

Source: Public Awareness of STI Malaysia 2019; Department of Business, Energy and Industrial Strategy (2020) Public Attitudes towards Science 2019; Main Findings from the Survey of Public Understanding of Science in China, 2018; National Science Board (2020) Science and Technology: Public Attitudes, Knowledge, and Interest 2018.

The importance of effective science communication is underlined by the experiences of selected countries in confronting the challenges of COVID-19 as described in Box 3.1.

Box 3.1 COVID-19 and Science Communication: Lessons Learned from 4 Countries.

New Zealand

This pandemic has highlighted how a scientific issue connects every discipline and when those from seemingly different camps work collaboratively and innovatively, a powerful alchemy can result. I think New Zealand's response to COVID-19 has shown what is possible when good science and good communication come together. We have had extraordinary leadership in this country that not only invests in science, but invests equally in the public's understanding of it. New Zealand citizens were brought into the process of it every single day through effective storytelling across multiple platforms. Walls between science and society melted away, and no one had to question the reasons behind what we were being asked to do to protect ourselves and each other because the science was embedded in a crystal-clear story. And at the heart of that story is the message to trust in science like your life depends on it—because it does.

Gianna Savoie, Director of Filmmaking, Center for Science Communication, University of Otago

Australia

While early communication efforts by governments were marked by contradictions and confusion, one success has been the national broadcaster, the Australian Broadcasting Corporation, in spreading factual information through a range of media platforms. In particular are the activities of Norman Swan, presenter of ABC Radio National's Health Report, who has become a key voice of coronavirus information. His daily CoronaCast podcast quickly became one of the most downloaded science podcasts around the world, and though presentations were not without dire predictions, his softly-spoken manner generally gave science communication a voice that seemed sincere and proved reliable.

Tim Mendham, Executive Officer, Australian Skeptics

Germany

The brief guide on Proper Criticism by psychology professor Ray Hyman has been crucial for effective science communication, where he explains essential points, such as not going beyond your level of competence and using the principle of charity. Beyond presenting the facts and the science, which are often later forgotten by the audience, people remember the messenger. We have learned that coming across as compassionate, credible and trustworthy gives the message a far more significant and lasting impact.

Amardeo Sarma Chair, Gesellschaft zur wissenschaftlichen Untersuchung von Parawissenschaften (Society for the Scientific Investigation of Parasciences)

Malaysia

A lesson I learned during the pandemic as a science communicator: it takes a crisis for the public to heed science and see it as a solution provider. Followers on my Facebook page increased by more than 2,000; subscription to my newspaper, The Petri Dish, increased among the public; and more media interviews. How can we sustain this appetite for science? Highlight the WHY more than the HOW and WHAT.

Mahaletchumy Arujanan, Executive Director, Malaysian Biotechnology Information Centre (MABIC)

Source: https://assets.aspeninstitute.org/content/uploads/2020/06/The_Pandemic_Issue_June_2020.pdf

3.16.9 Public Opinion on Government STI Policy Spending

Generally, Americans are more critical of how much their government should invest in very important domains like public healthcare, the environment, education and scientific research. For education, healthcare and the environment, an overwhelming 77%, 70% and 66% of Americans think that their government is spending too little, compared to just 13%, 17% and 18% of Malaysians, respectively. A greater percentage of Americans (43%) also believe that too little is spent in supporting scientific research, compared to just 17% of Malaysians (Table 3.12).

Table 3.12 Responses on Government Spending by Selected Countries (%)

Policy Areas	Malaysia 2019			USA 2018		
	Too Little	About Right	Too Much	Too Little	About Right	Too Much
Education*	13	32	15	77	17	5
Developing Alternative Energy	17	31	9	55	34	6
Quality Healthcare	17	36	12	70	21	7
Environmental Protection	18	37	11	66	24	7
Supporting Scientific Research	17	33	9	43	44	7

Note: Figures do not add up to 100% since the "Don't Know" responses were not included; * Education = refers to STEM education in Malaysia
Source: Public Awareness of STI Malaysia 2019; National Science Board (2020) Science and Technology: Public Attitudes, Knowledge, and Interest 2018

3.17 Summary

The 2019 national survey findings can be summarized as follows. Interest in STI topics (79.6% in 2019) has been on the upward trend since 2008 with environmental pollution issues registering the highest level of interest (85.2%). However, Malaysians are less knowledgeable about more challenging science ideas. The average public knowledge of STI (45.9% in 2019) in Malaysia has been below 50% for the past 19 years. There is a marked difference of public interest and perceived knowledge in STI topics amongst rural and urban dwellers. Similarly, there is a disparity in attitudes towards STI based on level of education. A worrying trend is the declining percentage (38.2%) of Malaysians expressing that the benefits of STI are greater than its harmful effects.

Support among Malaysians for science and scientific research is much lower than in 2014. The impacts of STI are viewed positively especially when it comes to health (75.5%) and quality of life (82.0%). Malaysians rate the nature of science being too abstract to understand (56.1%) as the main reason for the low enrolments in the subject among students. There is growing concern among Malaysians about environmental pollution and climate change. Television and newspapers are ranked as the two leading and most trusted sources of STI information with the Internet emerging as an important source. Awareness of STI related government programmes and STI-related policies respectively is on the upward trend. However, only 41.7% of respondents have indicated awareness of the policy on IR 4.0. Similarly, most Malaysians are unaware of government spending on STI-related matters.

Internationally, Malaysia exhibits comparable level of public interest in STI as those achieved in developed countries. However, knowledge and understanding of STI concepts and ideas among the public in Malaysia is below that of these countries. Like their counterparts in USA and Europe, an increasing number of Malaysians consider climate change and environmental pollution as serious problems. Similarly, the primary source of STI information in Malaysia – like the USA, UK and China - is television and internet with newspapers also constituting an important source.

4

DIGITAL INFRASTRUCTURE

CHAPTER 4: DIGITAL INFRASTRUCTURE

4.1 Introduction

Digital infrastructure support enables businesses of an economy to drive productivity and increase efficiencies. Malaysia's economy to a large extent is committed to deliver ICT infrastructure aimed at improving the supply and demand for such markets. The government aspires to deploy emerging ICT related services such as cloud, internet-of-things (IoT), data analytics, cybersecurity, data centre, e-commerce and artificial intelligence (AI) to seize the opportunities in the technological wave of IR 4.0. It has launched the National Policy on Industry 4.0 in the mid of 2017 as an action plan to propel the uptake of these technologies. The action plan has an explicit target to achieve namely to increase manufacturing productivity for every worker by 30%, increase contribution of the manufacturing sector to national economy from RM254.7 billion to RM392 billion, strengthen innovation capacity and capability by improving Malaysia's ranking in Global Innovation Index from 35 into top 33 in 2020 and increase the number of skilled workers in the manufacturing sectors from 18% to 35%. On 19 February 2021, the government launched Malaysia Digital Economy Blueprint, with three main objectives in achieving inclusive and sustainable development. The objectives highlight the importance of: (1) empowerment in human capital, (2) industrial role in creating, using and adopting business models under the digital economy and (3) integrated ecosystem that would enable society to adopt digital technologies. In addition, the Jalanan Digital Negara (JENDELA) plan aimed to provide wider coverage and better quality of broadband experience whilst preparing Malaysia for 5G technology. Explore the many initiatives set up to bring you improved connectivity and communication. With a strong ICT infrastructure, companies can ride on the wave of Fourth Industrial Revolution and spawn niches in the global value chain production. It provides a means for businesses wishing to achieve desired productivity in their operations.

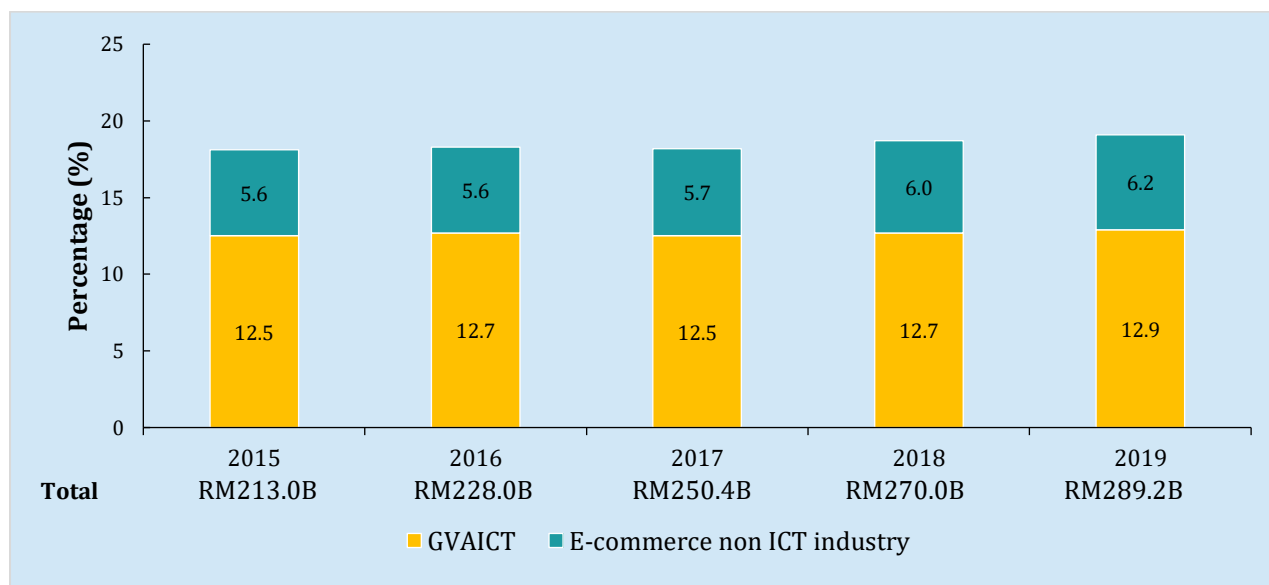
This chapter reviews the progress and performance of the ICT sector in Malaysia. It provides information on the contribution of ICT to the economy, the usage trends of ICT services and related products, the funding for R&D activities. This chapter would draw data from various sources, including ICT Satellite Account of Department of Statistics Malaysia (DOSM), Development data from International Telecommunication Union (ITU), data from Malaysia Digital Economy Corporation (MDEC), Pocketbook of Statistics from Malaysia Communications and Multimedia Commission, ICT Policy Division of MOSTI and PIKOM's Job Market Outlook.

4.2 ICT Contribution to the Economy

In 2019, the ICT industry including the E-commerce non-ICT industry contributed about 19.1% to the national economy (Figure 4.1). The total contribution is RM289.20 billion in 2019. It has increased slightly compared to 18.7% in 2018. The annual increase has indeed been incremental even though there is an increase of RM19.2 billion between 2019 and 2018. The

share for Gross Value Added of ICT Industry (GVAICT) has been sustaining between 12.7% and 12.9% while E-commerce non-ICT industry contributed an average of 5.8% from 2015-2019.

Figure 4.1 Contribution of ICT to the National Economy

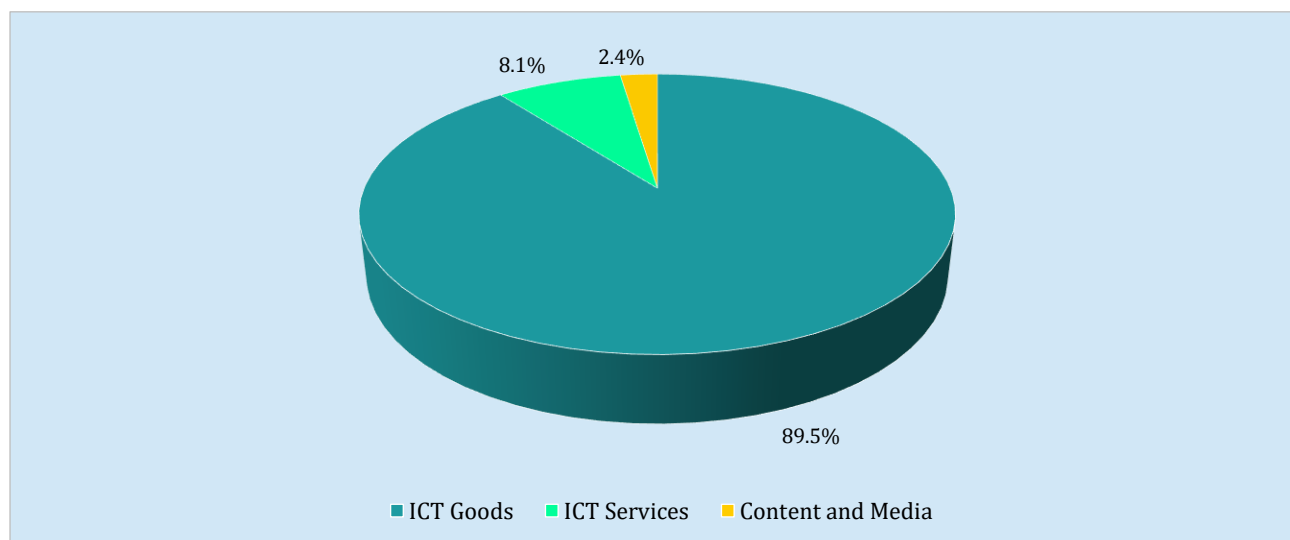


Note: B refers to billion.

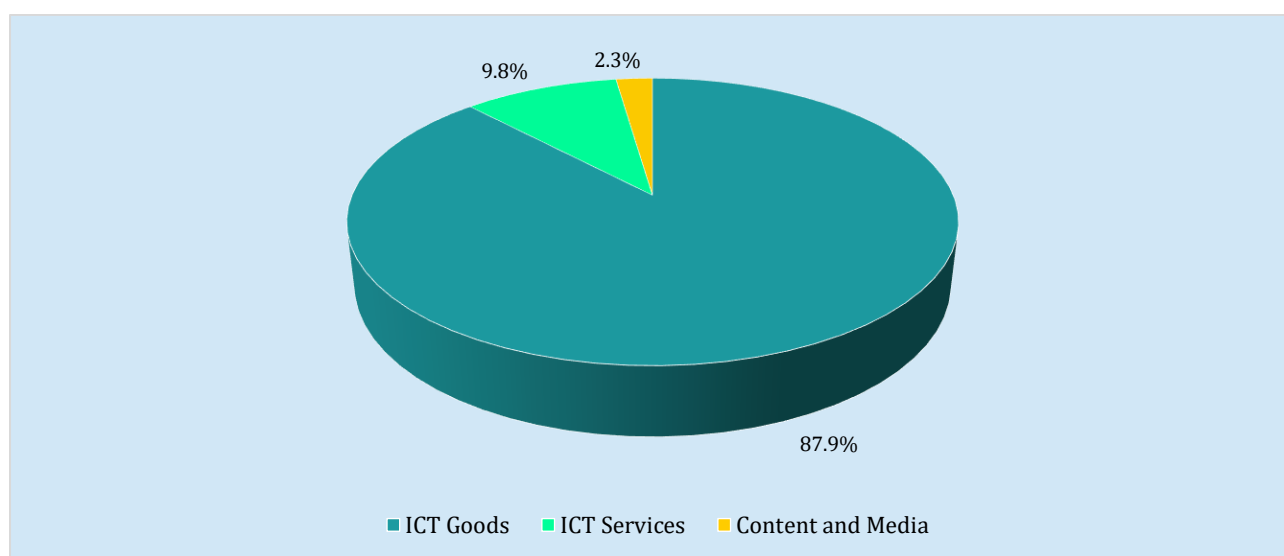
Source: ICT Satellite Account 2019, DOSM

The value-added of e-commerce (both ICT and non-ICT industries) in 2019 is RM127.0 billion contributing 8.4% to GDP. In terms of trade, ICT goods (89.5%) dominates the total exports (Figure 4.2) followed by ICT services (8.1%) and Content and Media (2.4%). For imports, ICT goods accounts for 87.9% of the total imports, while ICT services (9.8%) and Content and Media (2.3%) import shares are comparatively low (Figure 4.3). The total value of exports and imports in 2019 are RM290.5 billion and RM202.9 billion, respectively.

Figure 4.2 Share of ICT Export, 2019

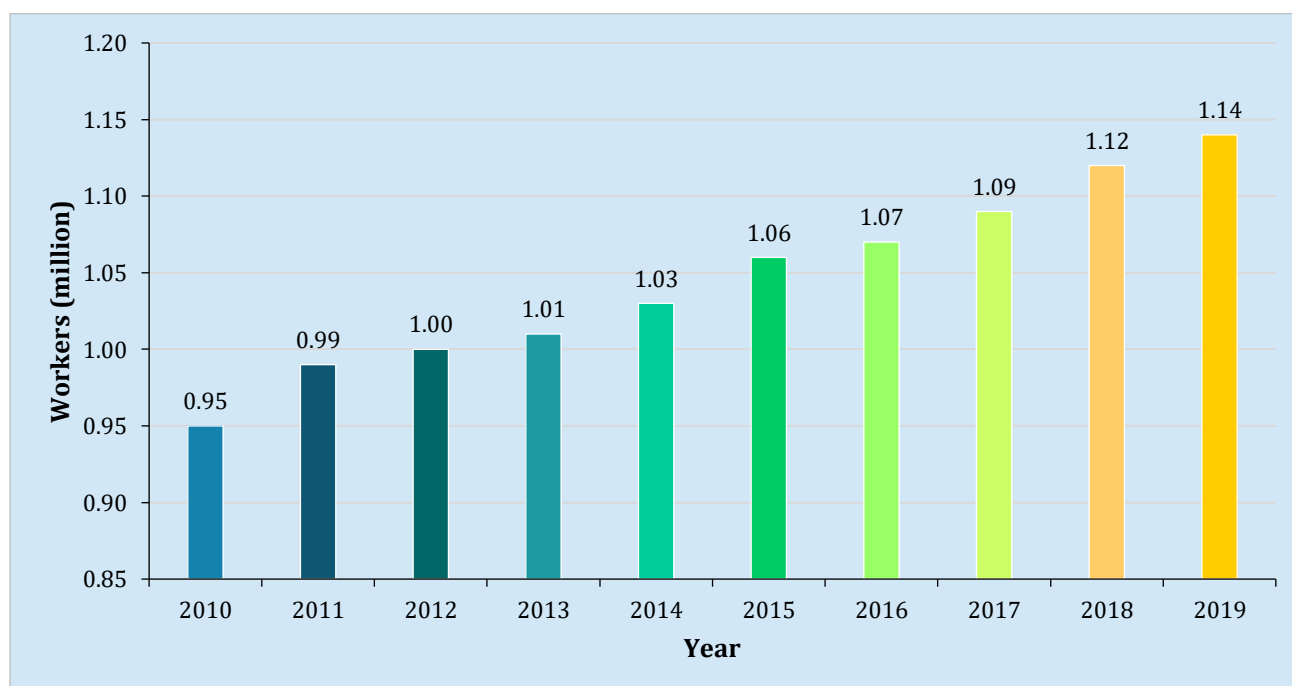


Source: ICT Satellite Account 2019, DOSM

Figure 4.3 Share of ICT Import, 2019

Source: ICT Satellite Account 2019, DOSM

Figure 4.4 shows the employment in the ICT industries. It has increased from 0.95 million persons in 2010 to 1.12 million in 2018. In 2018, the ICT manufacturing (37.0%) dominated the share of employment. This is followed by ICT services (28.2%), ICT trade (20.9%) and content and media (13.9%).

Figure 4.4 Number of Employees in the ICT Industry

Source: ICT Satellite Account 2019, DOSM
ICT Industry Outlook in Malaysia 2019, PIKOM

The MSC programme of Malaysia has been the catalyst of growth for the ICT sector. It created impacts in term of businesses in the ICT industry and opportunities in the job market. As of 2018, the MSC programme has led businesses in Malaysia to generate RM473 billion. Table 4.1

reports the number of MSC companies and jobs created under the MSC programme. The programme has propelled an emergence of 2,520 active MSC status companies in 2009 which has increased to 3,632 in 2014. As of May 2019, the contribution has decreased to 2,954 active MSC status companies. In term of job counts, the programme has created 99,590 jobs in 2009, 147,568 jobs in 2014 and 182,538 jobs as of 2018. The percentage change between the two periods (2009-2014 and 2014-2019) is 33% and 19% respectively.

Table 4.1 Total MSC Status Companies and Jobs (Cumulative), 2009, 2014 and 2019

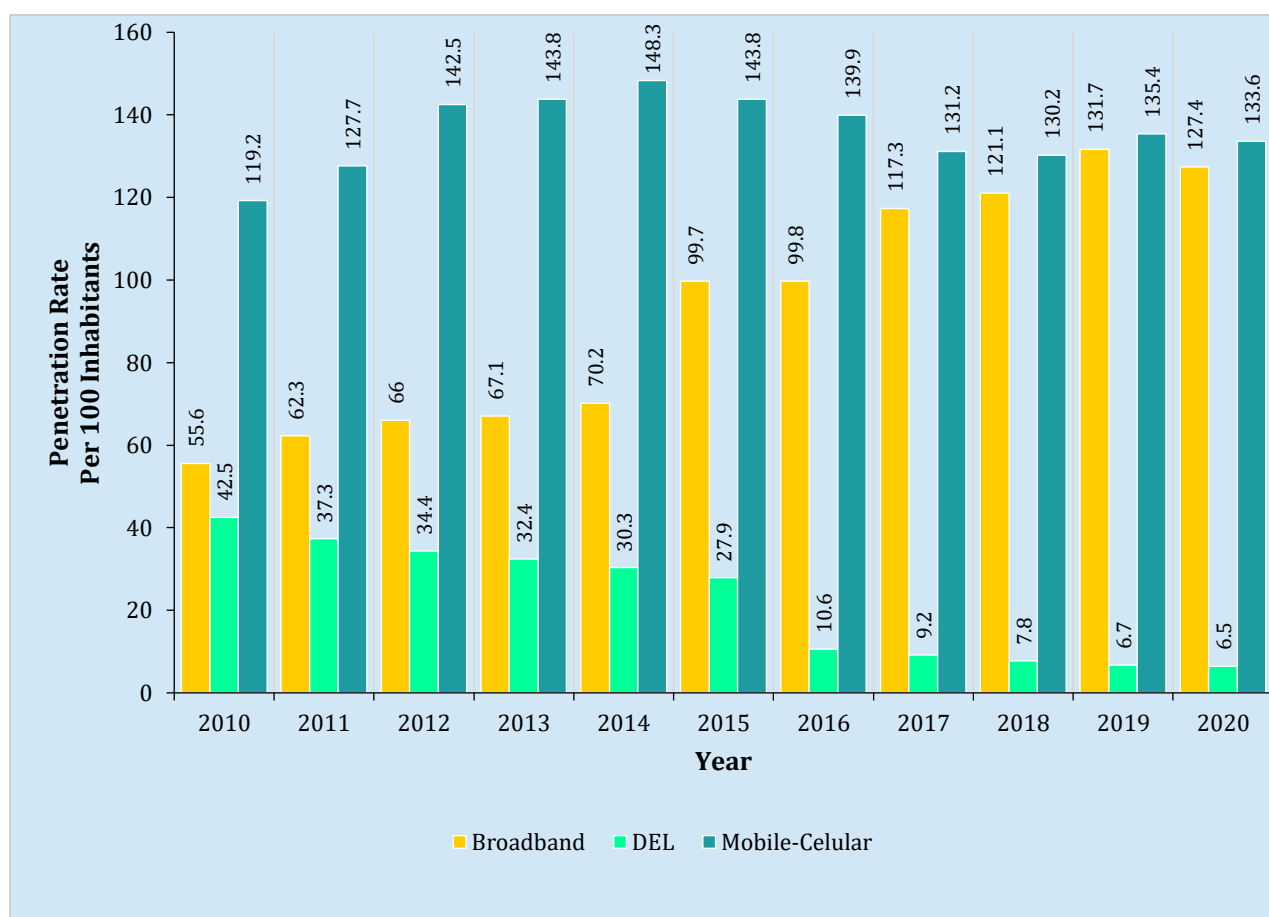
Year	Number	Jobs created	Jobs Changes (%)
2009	2,520	99,590	-
2014	3,632	147,568	33
2019	2,954	182,538	19

Note: Figure for 2019 is as of May 2019.

Source: Malaysia STI Indicators Report 2016, MOSTI and MDEC

4.3 ICT Access and Infrastructure

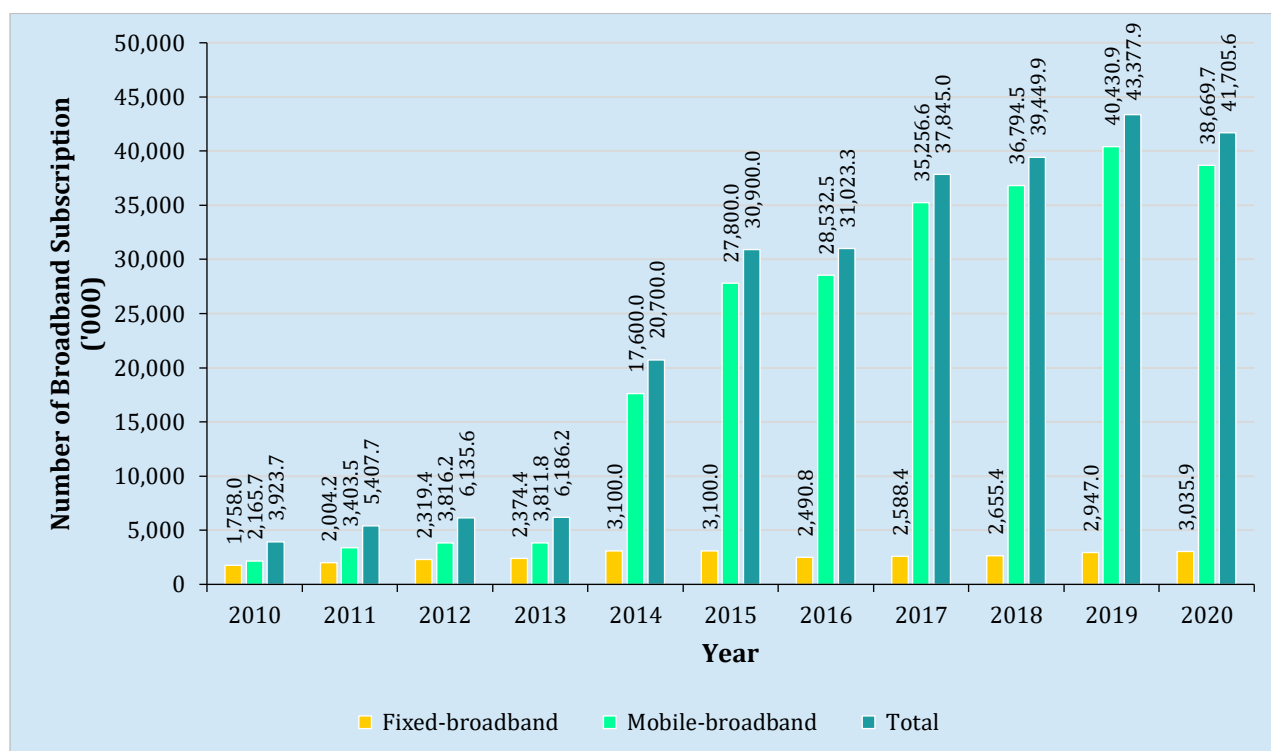
Figure 4.5 shows the penetration rates for broadband, direct exchange line (DEL) and cellular phones to indicate the extent of use of ICT by general public in Malaysia. It is observed that the adoption rates of broadband for internet access and cellular telephone have reached above 100 per 100 inhabitants. This not only highlights an accessible broadband service for an entire population but also a significant portion of the population owning multiple cellular phones that are connected to subscribed broadband service. The adoption rate for DEL has steadily decreased as the market value for such services have shifted to cellular telephone with broadband service.

Figure 4.5 Penetration Rate for ICT Devices, 2010-2020Q1

Note: DEL connects a customer's equipment to the Public Switched Telephone Network (PSTN) and has a dedicated port on a telephone exchange. 2020 – Data is until March.

Source: Pocketbook of Statistics, MCMC
Facts and Figures 1Q 2020, MCMC

In term of modes of broadband internet access, the wireless mode is the most common in Malaysia. Quarter 1 of 2020 witnessed 92% of wireless broadband in total broadband subscriptions. The wired mode has been comparatively low. Wireless platforms became the preferred mode as wireless provides users with the flexibility to access where and when they wish to as well as due to the significant efforts from broadband service providers to provide high-speed affordable data plan.

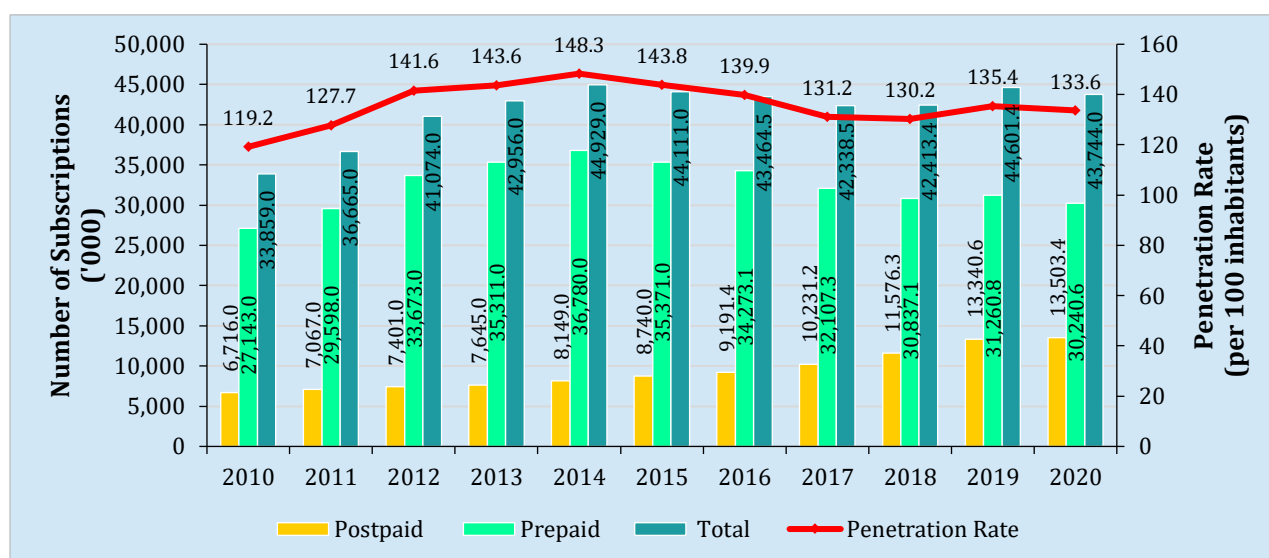
Figure 4.6 Modes of Broadband Internet Access, 2010-2020Q1

Note: 2020 – Data is until March

Source: Pocketbook of Statistics, MCMC

Facts and Figures 1Q 2020, MCMC

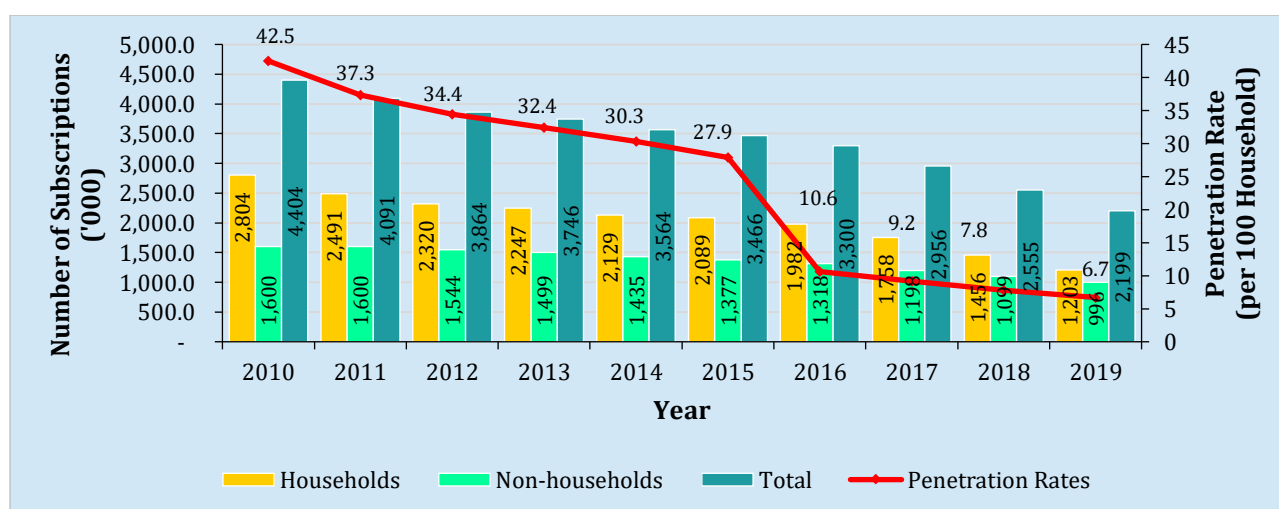
The penetration rate of cellular phones has increased from 119.2 per 100 inhabitants in 2010 to 133.6 in Quarter 1 of 2020 (Figure 4.7). For modes in cellular telephone subscriptions, it is observed that prepaid mode is the most preferred. The penetration rate of prepaid mode has increased from about 27 million subscriptions in 2010 to 35 million in 2015 before seeing a gradual contraction thereafter. Post-paid mode, on the other hand, witnessed a gradual increase and reached 13 million subscriptions in Quarter 1 2020. This can be attributed to the increasing affordability of post-paid mode.

Figure 4.7 Cellular Telephone, Subscriptions and Penetration Rates, 2010-2020Q1

Note: 2020 – Data is until March

Source: Pocketbook of Statistics, MCMC
Facts and Figure 1Q 2020, MCMC

Figure 4.8 shows the DEL subscriptions and penetration rates from 2010 to 2019. A gradual contraction of subscriptions is observed for the case of DEL. The household subscriptions seem to decrease at a much faster rate to that of non-households. This can be attributable to technology value migration of DEL to cellular telephone with broadband service. Non-households (particularly businesses in the rural area), on the other hand, find DEL service as essential services that allows businesses to stay connected.

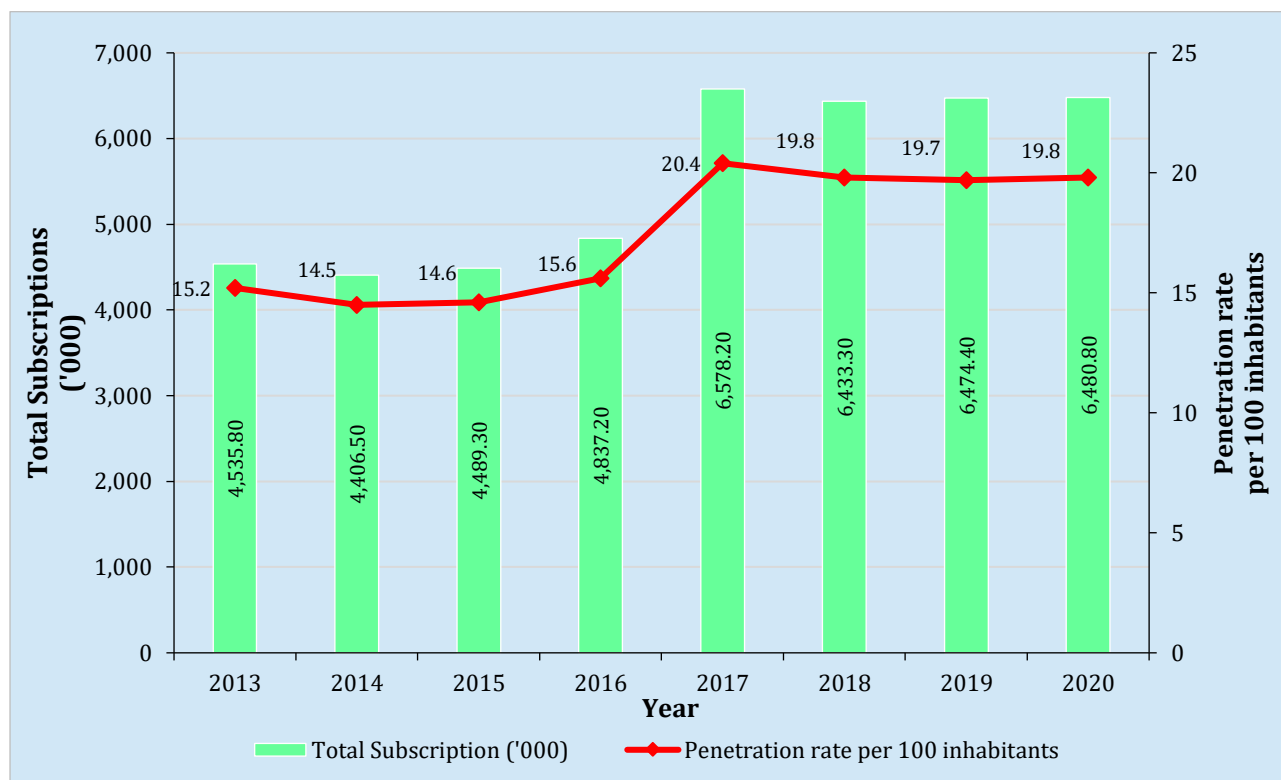
Figure 4.8 Direct Exchange Lines Subscriptions and Penetration Rates, 2010-2019

Source: Pocketbook of Statistics, MCMC

Figure 4.9 shows the fixed phone subscriptions per 100 inhabitants. The total subscriptions were about 4.6 million between 2013 and 2016 while between 2017 - Quarter 1 2020, there were about 6.5 million subscriptions. The penetration rates for the two periods showed slight increase. However, the subscription does not change significantly from 2017 to 2020. This

indicates the maturity of fixed phone adoption in Malaysia and the shift to cellular phone subscriptions.

Figure 4.9 Fixed Phone Subscriptions per 100 Inhabitants

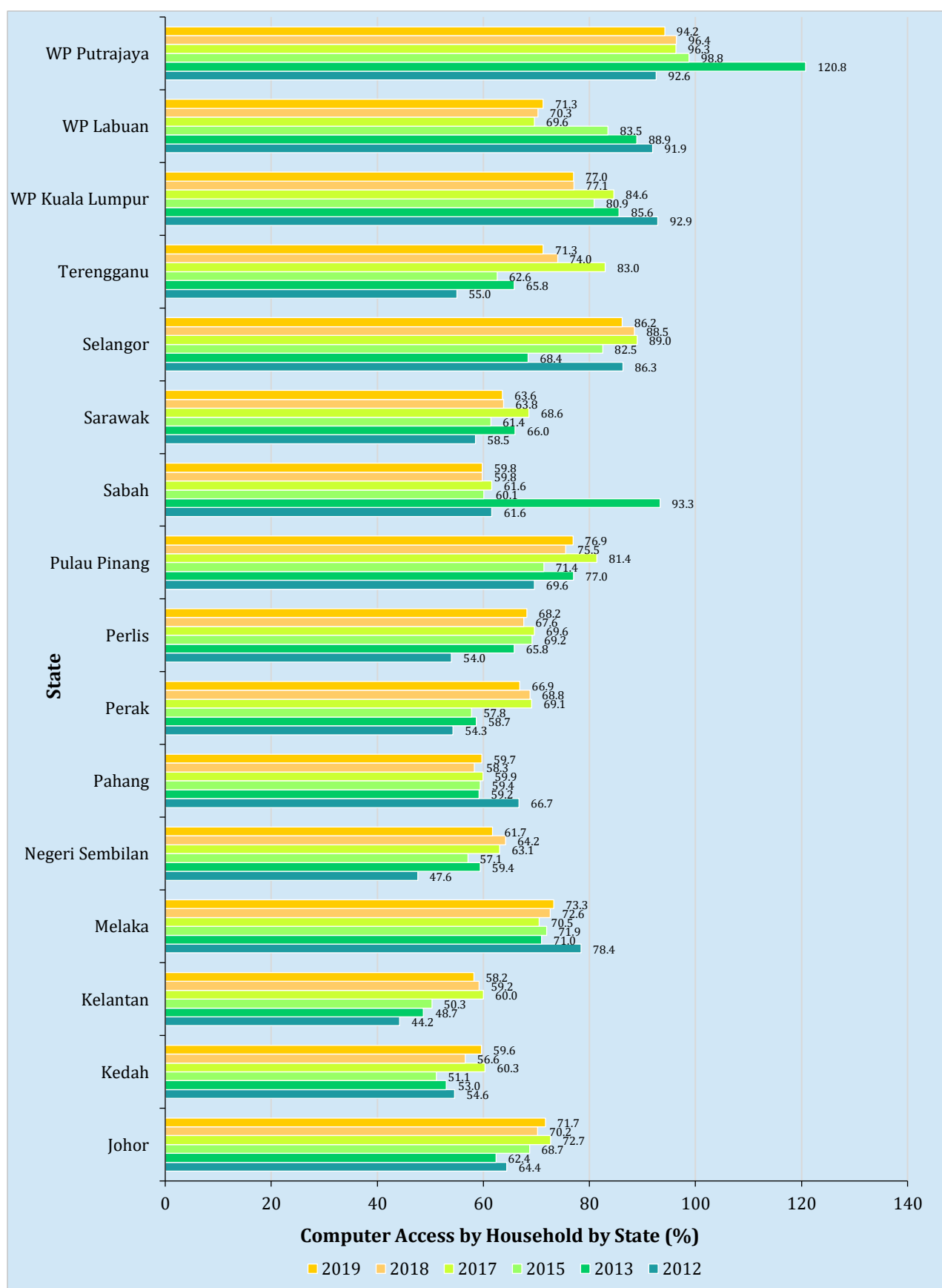


Note: 2020 – Data is until March

Source: Pocketbook of Statistics, MCMC
Facts and Figures 1Q 2020, MCMC

Figure 4.10 shows percentage of computer access by household by state. On average between 2012 and 2019 some states witnessing higher shares of household access to computer. The relatively more developed states such as Pulau Pinang, Kuala Lumpur, Selangor and Putrajaya are witnessing higher share of household computer access accounting for 76.9%, 77.0%, 86.2% and 94.2% respectively in 2019. For relative underdeveloped states such as Kelantan, Kedah, Pahang and Sabah, the percentage of household computer access only achieved 58.2%, 59.6%, 59.7% and 59.8% respectively. It is imperative that the digital gap between developed and underdeveloped states is significantly reduced. Other states such as Johor, Melaka, Terengganu and Labuan are moving towards narrowing the gap with the developed states.

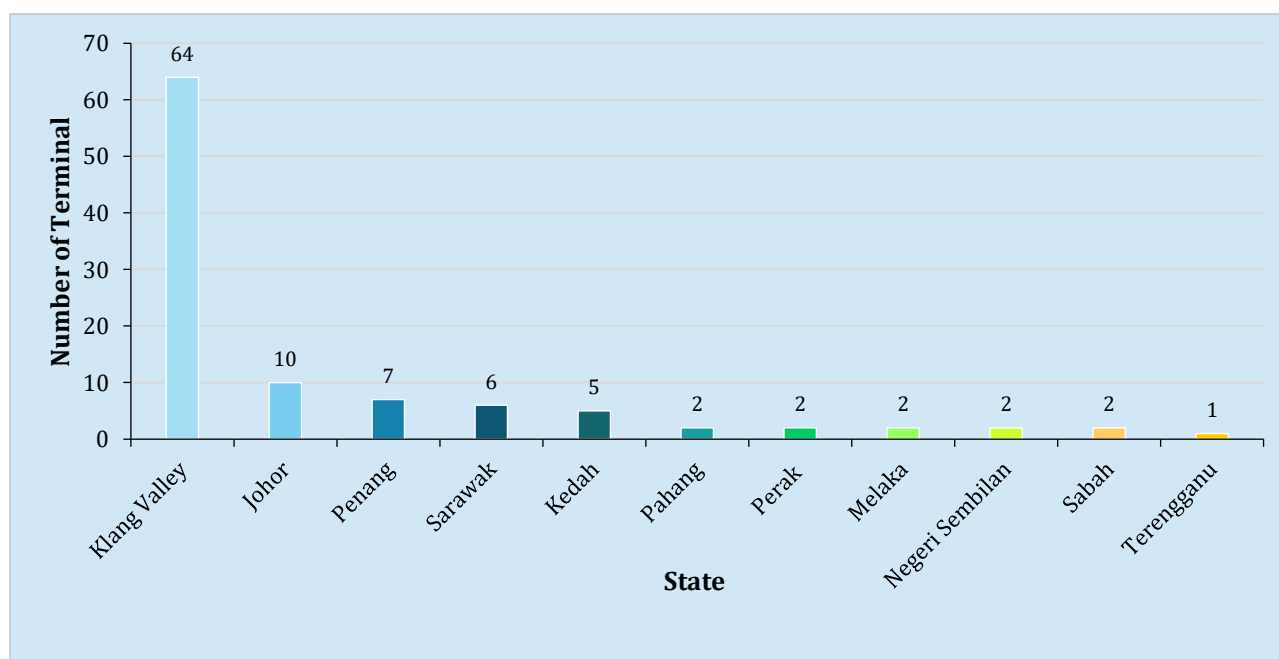
Figure 4.10 Percentage of Computer Access by Household by State



Source: Pocketbook of Statistics, MCMC

The achievement evaluation of the digital infrastructure, during the 10th MP, specifically household broadband penetration in 2014 indicated the penetration rate to be 70.2% - about 4.8% to achieve the targeted goal. As of 2014, Malaysia has 55,801 kilometres of fibre optic (Fkm) being deployed to 103 exchange terminals. Klang Valley has the highest exchange terminals (Figure 4.11) followed by Johor, Penang, Sarawak, Kedah, Pahang, Perak, Melaka, Negeri Sembilan, Sabah and Terengganu. It has installed 1.63 million ports that are used to serve 2.4 million premises. In 2017, Malaysia has achieved 77.2% and 93.6% for 4G and 3G wireless broadband coverage, respectively. It has increased to 82.2% (4G) and 95.5% (3G) in 2019. There are a total of 1038 community WIFI hotspot location in Malaysia. Sabah (220) and Sarawak (186) has the highest numbers followed by Pahang (127) and Kelantan (109) (Table 4.2).

Figure 4.11 Digital Infrastructure Achievement- FKM and Terminals



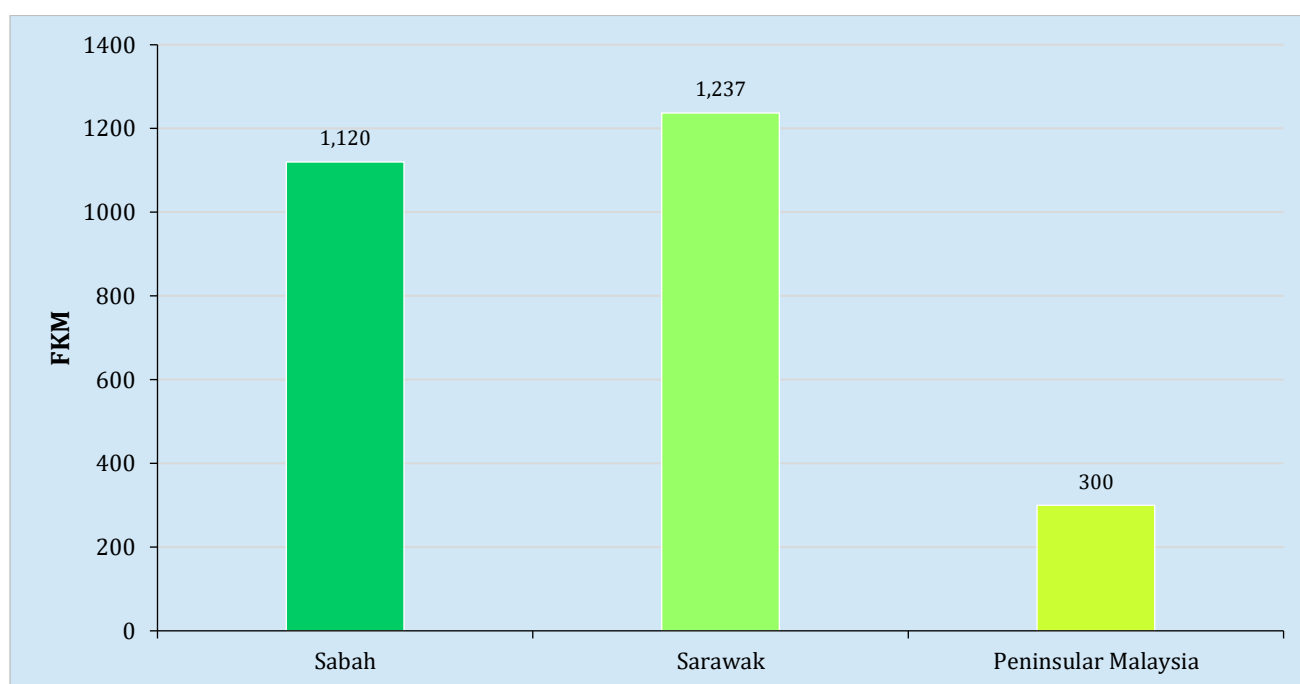
Source: Strategy Paper 15 for 11th MP, Economic Planning Unit (EPU)

Table 4.2 Community WIFI Hotspot Locations

No	State	Number of Hotspot Locations
1	Johor	57
2	Kedah	88
3	Kelantan	109
4	Melaka	31
5	Negeri Sembilan	34
6	Pahang	127
7	Perak	25
8	Perlis	0
9	Pulau Pinang	0
10	Sabah	220
11	Sarawak	186
12	Selangor	61
13	Terengganu	76
14	WP KL	6
15	WP Labuan	6
16	WP Putrajaya	12
	TOTAL	1038

Source: MCMC

Malaysia deployed Broadband for General Population (BBGP) in the early 2010 to increase broadband coverage to suburban and rural areas. As of 2014, BBGP rolled out Fiber Backhaul to provide 53 links with 1120Fkm for Sabah, 23 links with 1237 Fkm for Sarawak and 8 links with 300Fkm for Peninsular Malaysia (Figure 4.12). Rolling of BBGP along with High-Speed Broadband (HSBB) are laudable as they have achieved 83.7% broadband coverage in populated areas by 2014.

Figure 4.12 BBGP- FKM

Source: Strategy Paper 15 for 11th MP, EPU

Table 4.3 reports the cyber security threats from 2010 to 2019. Incidents such as fraud and intrusions are among the most common issues in Malaysia. The total cases for 2010 is 8,090. It increased to 11,918 in 2014 and dropped to 10,772 in 2019. As the country embraces emerging technologies of IR 4.0, it would potentially face more cyber threats over the years. It is vital for Malaysia to commit in cyber security infrastructure to safeguard the social wellbeing while adopting the emerging technologies.

The National Policy on Industry 4.0 highlighted the importance of safer cyberspace as one important factor to advance process innovation and lay a strong foundation for data centre and smart city infrastructure related investments. The policy has projected that the data centre industry in Malaysia will experience double-digit growth in years to come. There are about 200 specialised service providers capable of providing high quality data storage and retrieval services to multinational corporations in Malaysia. It is thus clear that Malaysia is determined to boost its commitment in advancing cybersecurity infrastructure as it is part of the foundation of ICT industries in Malaysia.

Table 4.3 Cyber Security Incidents, 2010-Sept, 2020

Incident	2010	2012	2014	2016	2018	2019	As of Sept 2020
Intrusion Attempt	685	67	1,302	277	1,805	104	71
Spam	1,268	526	3,650	545	342	129	102
Cyber Harassment	419	300	550	529	356	260	449
Content Related	39	20	35	50	111	298	147
Malicious Codes	1,199	645	716	435	1,700	738	427
Vulnerabilities Report	42	78	34	35	92	91	95
Intrusion	2,160	4,326	1,125	2,476	1,160	1,359	1,014
Fraud	2,212	3,991	4,477	3,921	5,123	7,774	6,048
Denial of Service	66	23	29	66	10	19	13
TOTAL	8,090	9,976	11,918	8,334	10,699	10,772	8,366

Source: <http://www.mycert.org.my/portal/>

4.4 ICT Funding and Support

The government of Malaysia has been committed to support research, development and commercialisations (R,D&C) and driving growth agendas of ICT. For the 9th MP, a total of RM260.52 million funds were approved for ICT. Among them are Strategic Funding for ICT (RM 111.59 million), MSC Malaysia R&D Grant Scheme (MGS) (RM100.55 million) and MSC Pre Seed Fund (RM48.38 million). MGS, during the 9th MP, is found to be effective in driving R,D&C. Almost all approved projects have been completed and they had led to 259 intellectual properties, 11 publications and 46 awards.

It is noted that the size of the fund for ICT had reduced to RM118.98 million in 10th MP (Table 4.4). The MGS funding has been contracted to RM6.65 million. The fund supported 7 projects (all completed) which had led to 23 intellectual properties. The fund under 10th MP focused more on human capital development and supporting the company's operations. MSC Malaysia Customise Incentive (MCI) is established to support companies in the form of tax incentives. Strategic Funding for ICT and MSC Pre Seed Fund were not endowed in 10th MP.

Table 4.4 Funding Allocation and Approved Projects under 9th MP and 10th MP

	9 th MP					
	Approved Fund (RM million)	Approved Projects	Completed Projects	IPR	Publication	Awards
Strategic Funding for ICT	111.59	18	12	28	0	0
MCI	.	.	.	.	.	.
MGS	100.55	70	69	259	11	46
MSC Pre Seed Fund	48.38	334	285	0	0	0
	10 th MP					
	Approved Fund (RM million)	Approved Projects	Completed Projects	IPR	Publication	Awards
Strategic Funding for ICT	.	.	.	.	.	.
MCI	112.33	24	1	2	0	0
MGS	6.65	7	7	23	0	0
MSC Pre Seed Fund	.	.	.	.	.	.

Note: Projects under MCI are not related to "R, D and C". The fund is used for human capital development and supporting company operations in the form of tax incentives (not grants). Projects under Strategic Funding for ICT grants are generally not related to "R, D and C". It is used for human capital development and supporting company operations.

Source: MOSTI, Report of Achievement Evaluation Study and Impact of R,D&C MOSTI program under 10th MP Report

Malaysia intends to prioritise the use of innovative technology to extract value. The aim is to foster inclusive development and help those in the laggard segments to increase the use of technology. Likewise, it is targeted to incentivise business individuals to digitalise their business operations to create an e-commerce revenue channel for their businesses and expand their online presence. There are a number of grants and supports from the government in promoting the adoption of technologies under IR 4.0. These include:

- 1) Promotions to develop data centre industry such as allocation of RM1.8 billion to step up national cyber security, to establish cybersecurity and IoT security guideline for IR 4.0 and IR 4.0 blueprint to expedite the implementation of HSBB at key industrial areas.
- 2) There are dedicated government agencies to lead industrial digitalisation and integration processes. Malaysian Investment Development Authority (MIDA) is endowed to provide High Impact Fund- a matching grant to attract investments of selected companies as they are capable in driving IR 4.0 technologies. The government has approved RM1 billion for domestic investment strategic fund initiative under 11th MP.

- 3) Allocation of RM3 billion for Industry Digitalisation Transformation fund with a subsidised 2% interest rate under Bank Pembangunan Malaysia Berhad. This fund is used to help industrial owners to develop or acquire technologies of IR 4.0.
- 4) Allocation of RM2 billion for Business Loan Guarantee Scheme (SJPP) to help SMEs in modernising (automating) their manufacturing operations.

These initiatives are critical in ensuring that Malaysia takes the opportunities that IR 4.0 provide. Box 4.1 illustrates the windows of opportunities that IR 4.0 has for Malaysia.

Box 4.1 Is the IR 4.0 a Window of Opportunity for ASEAN Economies?

It is noted that the arrival of the IR 4.0 is perceived as the window of opportunity for ASEAN members to achieve high-income status. Riding the wave of IR 4.0 with capital investment (both local and abroad) would enable ASEAN to upgrade their infrastructures and manufacturing capacities. However, some doubts that such anticipation and maintenance of IR 4.0 can amplify the issues of middle income trap the ASEAN members are facing. The new wave of technological innovations (3D printing, AI, etc.) will rewrite the rules of manufacturing and lead low-cost labour advantaged economies unattractive and irrelevant. The IR 4.0 can also subsequently lead the cost of automation to plummet to re-shore manufacturing activities in ASEAN back to the developed world. If IR 4.0 to happen, global supply value chains are expected, by some, to become flat. Therefore, whether IR 4.0 can be the window of opportunity depends on the readiness an economy in adopting the technologies under IR 4.0. The ASEAN members attained vary levels of industrialization. However, Malaysia is reasonably more advanced compared to other economies. Given Malaysia's strong presence in ICT manufacturing as well as the ability to capitalise technologies under IR 4.0 through various initiatives, it is expected that Malaysia can use IR 4.0 as the windows of opportunities. Indeed, there are enabling institutions endowed to consistently drive upgrading of research infrastructure and skills provision that Malaysia could leverage on.

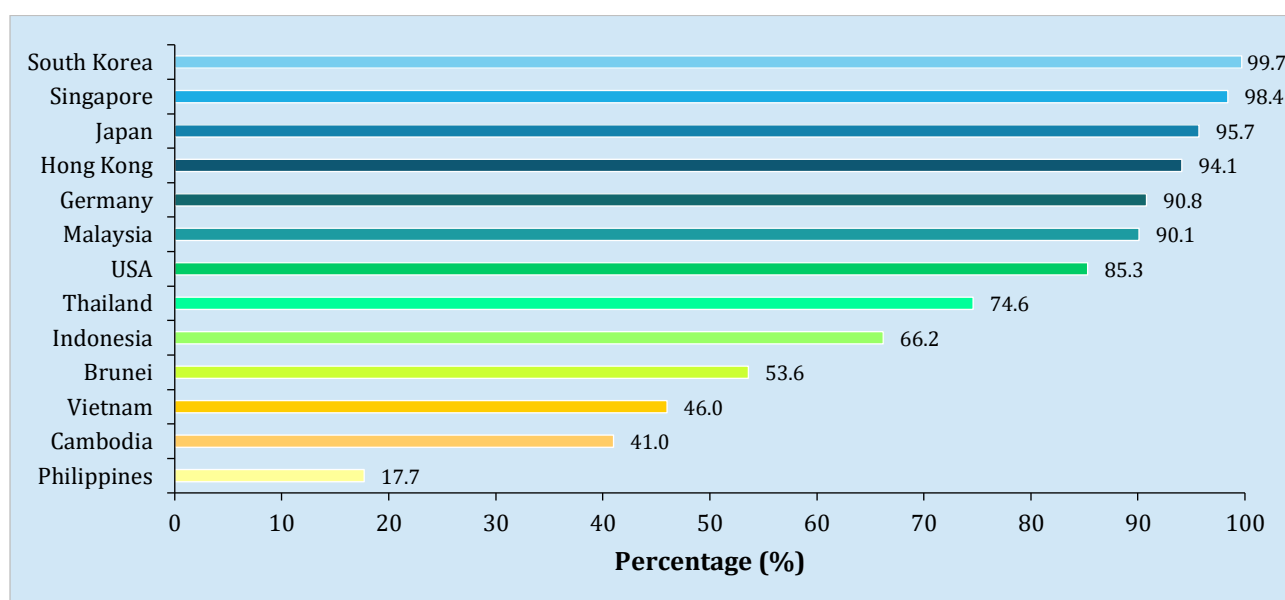
Source:

Lee, K., Wong, C. Y., Intarakumnerd, P., & Limapornvanich, C. (2019). Is the Fourth Industrial Revolution a window of opportunity for upgrading or reinforcing the middle-income trap? Asian model of development in Southeast Asia. *Journal of Economic Policy Reform*, forthcoming.

Wong, C. Y., & Fung, H. N. (2019). Caught-In or Breaking-Free from the Middle-Income Trap: The Case of Malaysia. *Seoul Journal of Economics*, 32(1), 1-22.

4.5 International Comparison

Malaysia's commitment in advancing ICT infrastructure and public access to internet is laudable. It attained 90.1% in terms of proportion of households with internet access at home (Figure 4.13). This achievement is comparable to that of many advanced countries such as Japan (95.7%), Germany (90.8%) and the USA (85.3%). Some countries in the region are comparatively lagging such as the Philippines (17.7%), Vietnam (46%), Cambodia (41%) and Brunei (53.6%).

Figure 4.13 Proportion of Households with Internet Access at Home, 2018

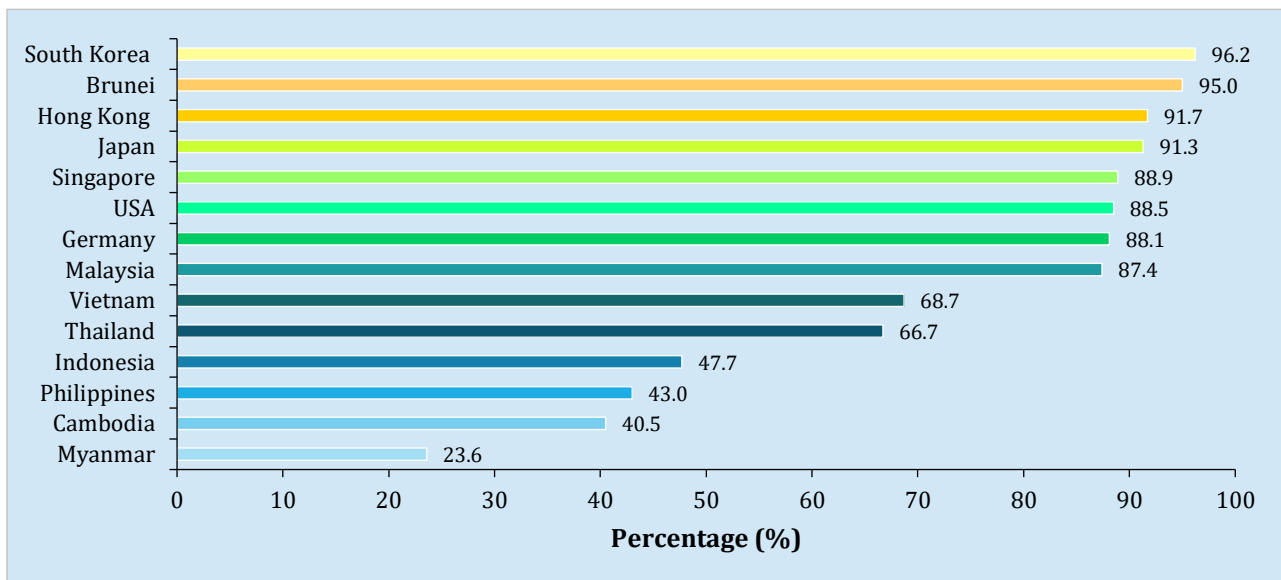
Source: ITU, International Telecommunication Union

In term of percentage of individuals using the internet (Figure 4.14), Malaysia at 87.4%, is comparable to that of developed countries such as the USA (88.5%), Germany (88.1%) and Singapore (88.9%). Countries such as Cambodia (40.5%), Myanmar (23.6%), Vietnam (68.7%), the Philippines (43%), Thailand (66.7%) and Indonesia (47.7%) are performing relatively behind.

In terms of international internet bandwidth per internet user, Malaysia is lagging behind many countries (Figure 4.15). Hong Kong (3,721.80), Singapore (616.53), Germany (145.99), United States (70.97), Thailand (54.79), Japan (48.64), South Korea (45.18), Brunei (39.93) and Myanmar (28.67) are performing better than Malaysia (27.17). Malaysia nonetheless performed way above Vietnam (20.75), Cambodia (16.31), Indonesia (6.23) and China (5.00).

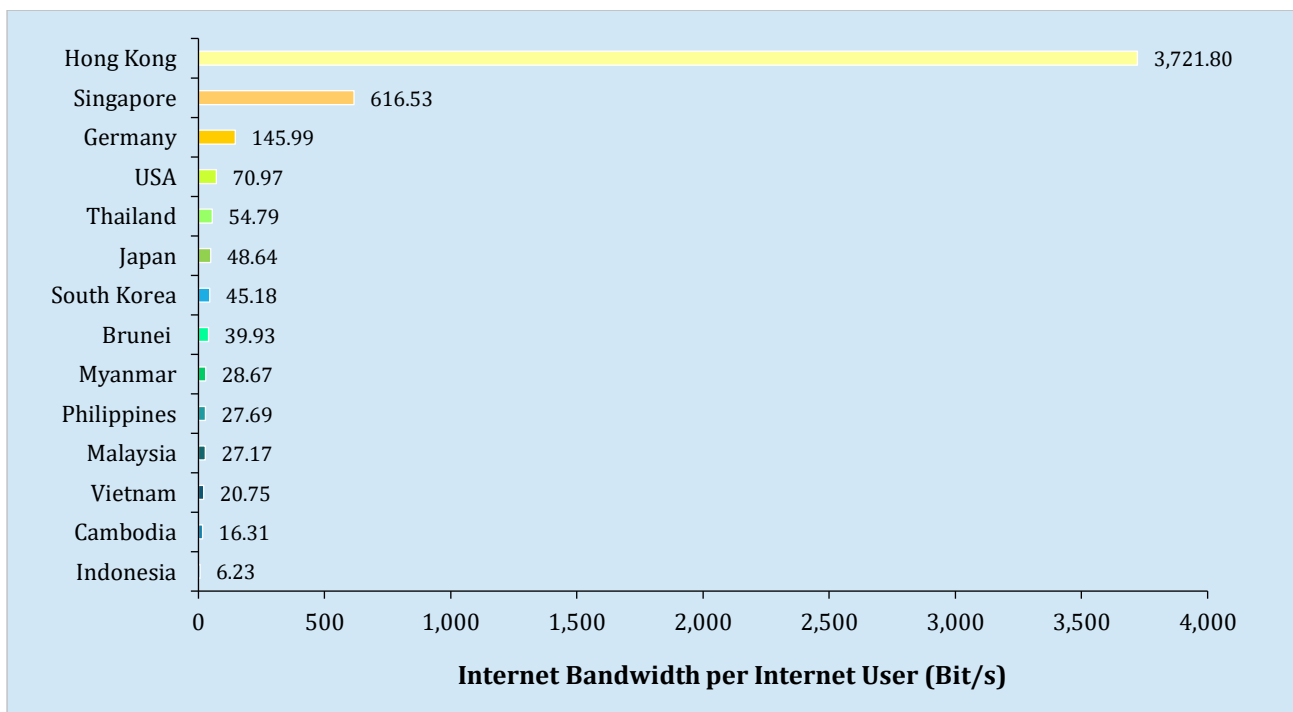
Malaysia's underperformance in bandwidth per user is attributed to the high broadband prices in the market which does not allow more users from different income segments to adopt broadband package of higher bandwidth. Malaysian government has been enforcing the Mandatory Standards for Access Pricing (MSAP) to significantly reduce the broadband prices. On top of that, the government also allocated RM1 billion for National Fibre Connectivity Plan to advance the public broadband infrastructure.

Figure 4.14 Percentage of Individuals using the Internet, 2018



Source: ITU, International Telecommunication Union

Figure 4.15 International Internet Bandwidth per Internet User (Bit/s), 2016



Source: World Bank

4.6 Summary

Malaysia is committed to advance the ICT infrastructure and public access to internet. There is funding for industrial research and adoption of technologies under IR 4.0 and policy to reduce the broadband prices in the market with various efforts to appropriate ICT for economic growth and development. All these measures are commendable. Malaysia stands out as one of

the performing nations in term of proportion of households with internet access at home and percentage of individuals using the internet. The ICT industry contributed about 18.5% to the national economy in 2018 and the MSC programme has generated 182,538 jobs in the economy. The adoption rates of broadband for internet access and cellular telephone have reached above 100 per 100 inhabitants. However, the digital infrastructure development progress has led to digital divide. Underdeveloped states such as Kelantan, Kedah, Pahang and Sabah are performing at 58.2%, 59.6%, 59.7% and 59.8% respectively in terms of household computer access in 2019. They are performing way behind to that of advanced states such as Selangor (86.2%) and Penang (76.9%). In terms of international internet bandwidth per internet user, Malaysia's performance lags many developed countries. In addition, addressing cyber security issues is critical. Other critical policy implications are enabling institutions to drive upgrading of research infrastructure and skills provision, closing the digital divide between developed and underdeveloped states via attracting investment opportunities, providing funding and executing incentive measures to (re)energise industry and human workforce in ICT. Malaysia achieved impressively in many of the ICT related indicators. It is hoped that the pursuit of upgrading via technologies of IR 4.0 would propel Malaysia's competitiveness.

5

**R&D INVESTMENT
AND
RESEARCH
WORKFORCE**

CHAPTER 5: R&D INVESTMENT AND RESEARCH WORKFORCE

5.1 Introduction

The NSTIP 2021-2030 envisions the scientific and social R&D advancements and commercialisation for national socio-economic transformation and inclusive growth. The policy targets the Malaysia's GERD to be at least 3.5% of GDP by 2030 and 50% of R&D to be in experimental development. This chapter assesses the progress of Malaysia in terms of R&D investment and research workforce. The findings will inform policy makers on the nation's progress and gaps in achieving the performance targets determined in the NSTIP.

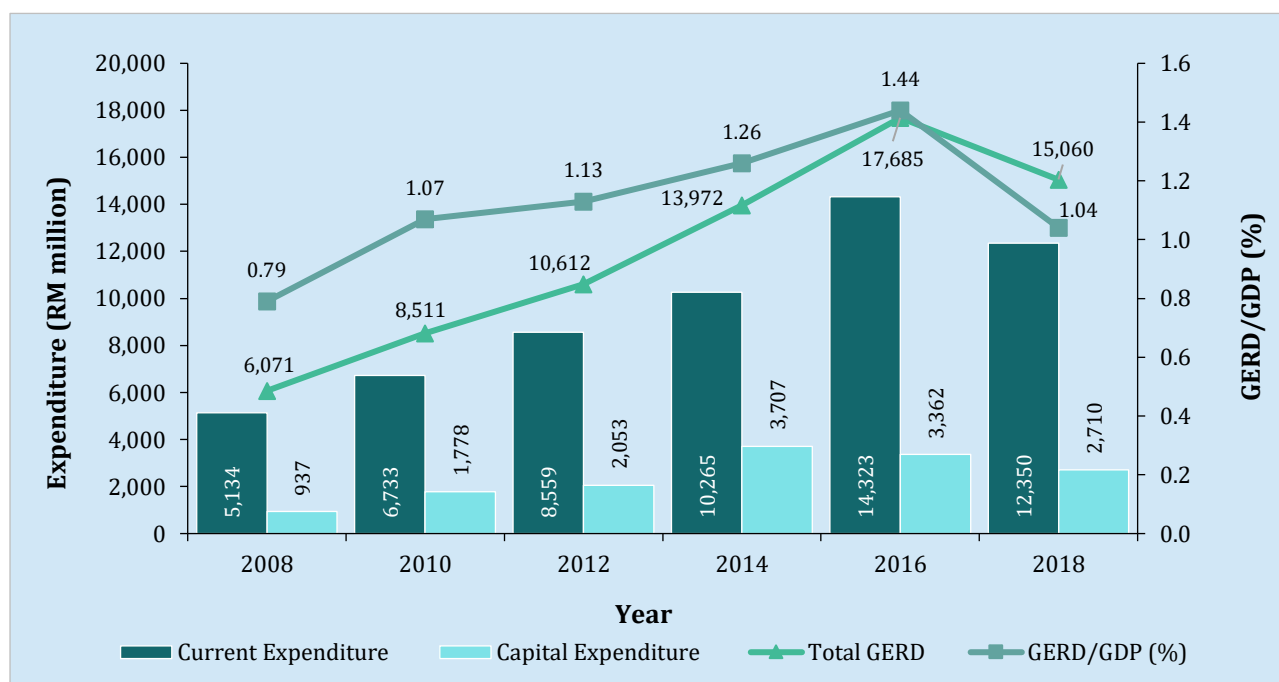
5.2 R&D Investments

5.2.1 Expenditure on R&D

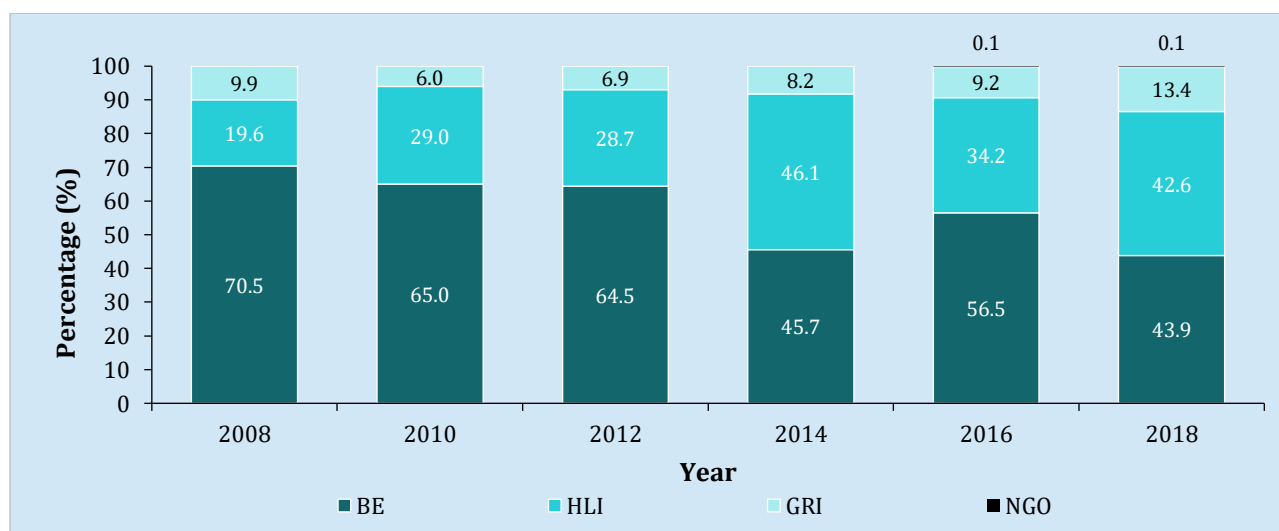
GERD measures the expenditure on current and capital items that are associated to R&D activities during a specific period. GERD, as a proportion of GDP, indicates the direct R&D intensity of a nation. Both R&D expenditure and R&D intensity are two essential indicators used to gauge resources devoted to STI development worldwide. Figure 5.1 shows that Malaysia's GERD was on the upward trend during the period of 2008-2016. In 2016, Malaysia's GERD reached RM17,685 million which was the country's highest ever expenditure on R&D.

A similar impressive development was observed in GERD/GDP ratio in which Malaysia recorded 1.44% in 2016. However, in 2018 there was a sharp decrease in both GERD and its ratio to GDP. In 2018, Malaysia's GERD was at RM15,060 million whereas GERD/GDP ratio was recorded at 1.04%. This indicated a decrease of 14.8% and 27.8%, respectively. In terms of type of expenditure, current expenditure has continued to remain the main R&D expenditure in comparison to capital expenditure. Box 5.1 illustrates Malaysia's GERD/GDP ratio contraction in comparison with others.

As Figure 5.2 shows, HLI, GRI and BE were the three main sectors that contributed to R&D spending in Malaysia. During 2008-2018, BE was the main contributor in comparison to HLI and GRI except for the year 2014 in which HLI was slightly ahead of BE in terms of R&D spending. Malaysia's efforts in increasing the technological capabilities of firms especially SMEs are somewhat curtailed by a significant decrease in terms of BERD between 2008 and 2018, decreasing from 70.5% to 43.9%.

Figure 5.1 GERD in Malaysia, 2018

Source: National Survey of R&D in Malaysia 2019

Figure 5.2 GERD by Sector, 2008-2018

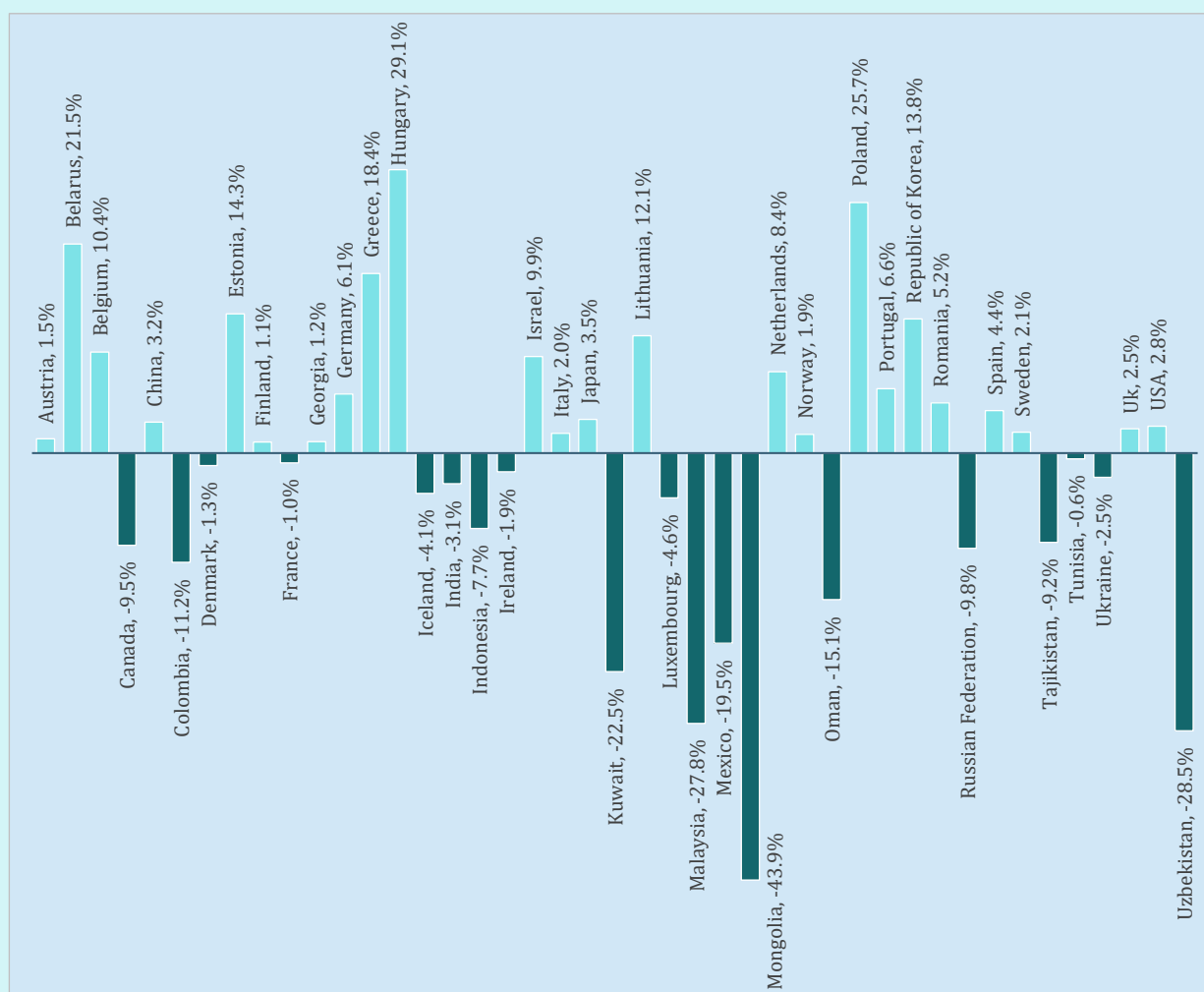
Source: National Survey of R&D in Malaysia 2019

Note: Data on NGO is not available before 2016

Box 5.1 Global GERD as a Percentage of GDP (2016-2018)

Bank Negara Malaysia (BNM) reported that “In 2016, the Malaysian economy continued to face considerable external and domestic headwinds. While some of the impact of earlier domestic shocks gradually dissipated during the year, growth performance was affected by the materialisation of new risks and ongoing adjustments to external shocks that have impacted the economy since end-2014 (BNM, 2017:16)”; and “Concurrently, business and consumer sentiments were affected by a confluence of global and domestic factors, including the heightened volatility in financial markets and the significant underperformance of the ringgit (BNM, 2017:3)”.

Malaysia, as illustrated in figure below, is one of the countries that has suffered a highest decline in GERD/GDP ratio during the tumultuous years due to the external shocks. Notably, many countries continued to increase their R&D investments.



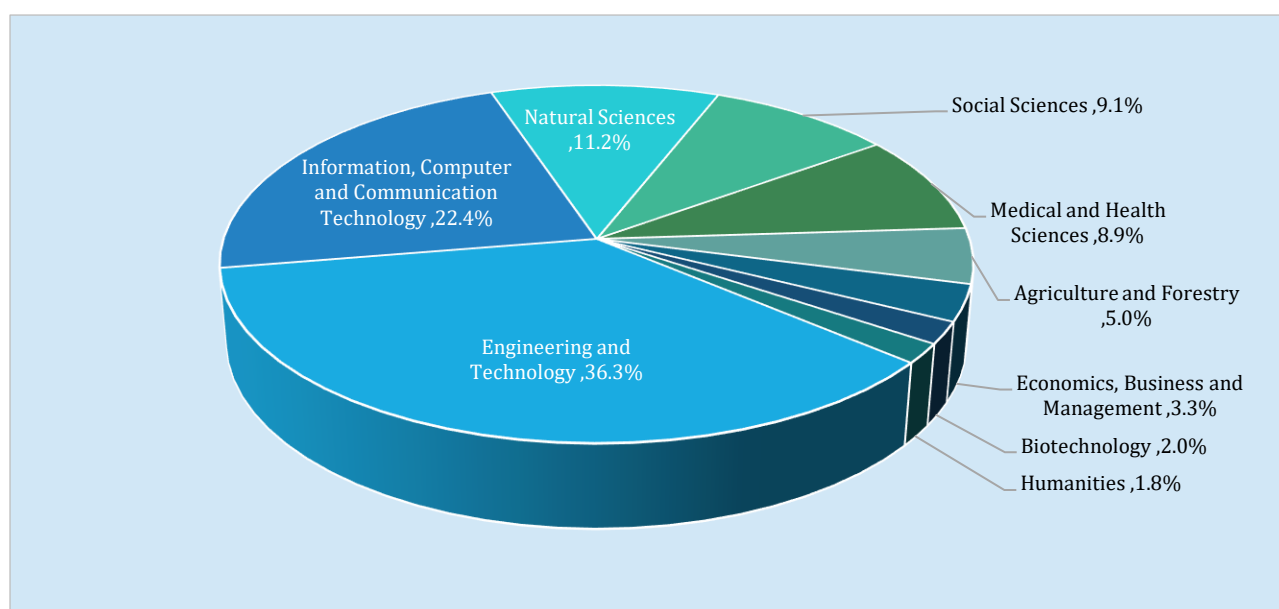
Source: Data extracted from UIS.Stat (http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&lang=en), dated 19 Sep 2020

5.2.2 Expenditure by Types of Activity

In 2018, Engineering and Technology (36.3%); and Information, Computer and Communication Technology (22.4%), and Natural Sciences (11.2%) were three major FOR that contributed the most to R&D spending in Malaysia (Figure 5.3). These were followed by the fields of Social

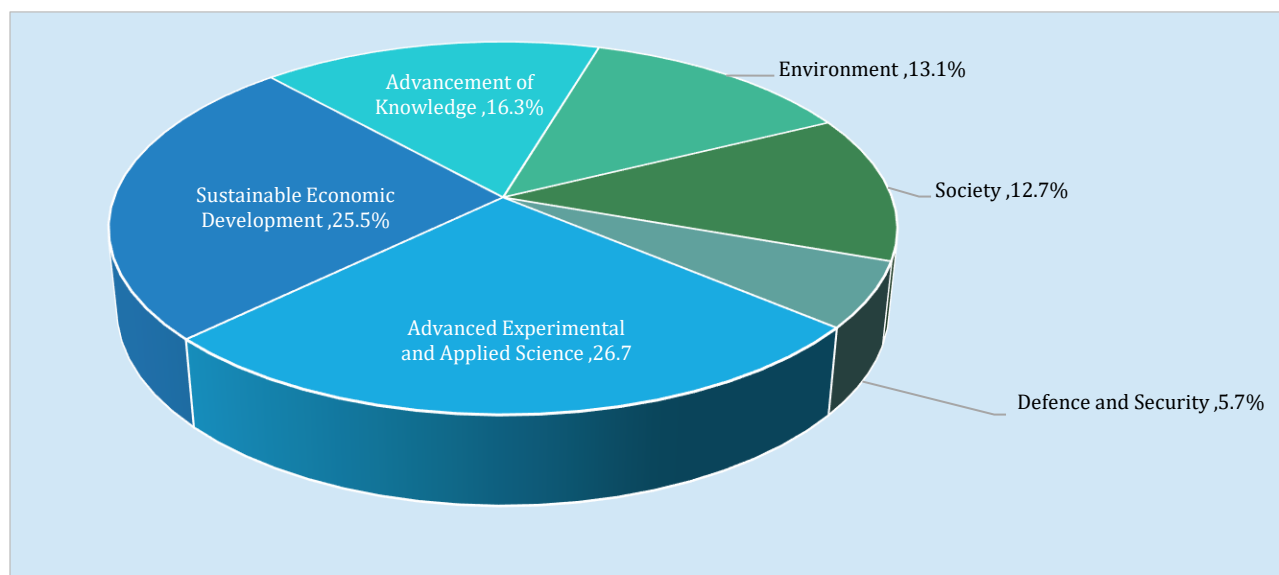
Science; Medical and Health Sciences; and Agriculture and Forestry in the range of 5.0%-9.1%. The contribution of Economics, Business and Management; Biotechnology; and Humanities were not significant – in the range of 1.8% - 3.3%. In terms of SEO, as illustrated in Figure 5.4, about half of the R&D expenditure was related to the Advanced Experimental and Applied Science (26.7%) and Sustainable Economic Development (25.5%). These were followed by Advancement of Knowledge (16.3%); Environment (13.1%); Society (12.7%); and Defence and Security (5.7%). Figure 5.5 provides more detailed account on Malaysia's R&D expenditure according to National Priority Area (NPA). The top three NPAs in terms of GERD were Medical and Healthcare (13.9%); Transportation and Urbanisation (11.3%); and Cybersecurity (10.1%).

Figure 5.3 GERD by FOR, 2018



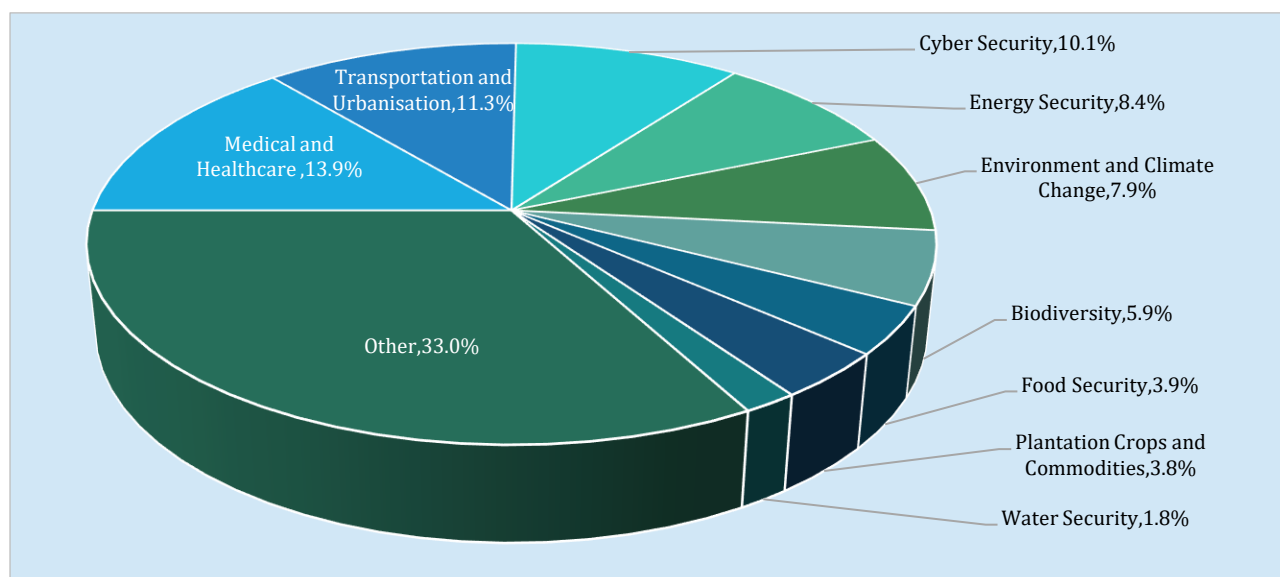
Source: National Survey of R&D in Malaysia 2019

Figure 5.4 GERD by SEO, 2018



Source: National Survey of R&D in Malaysia 2019

Figure 5.5 GERD by NPA, 2018



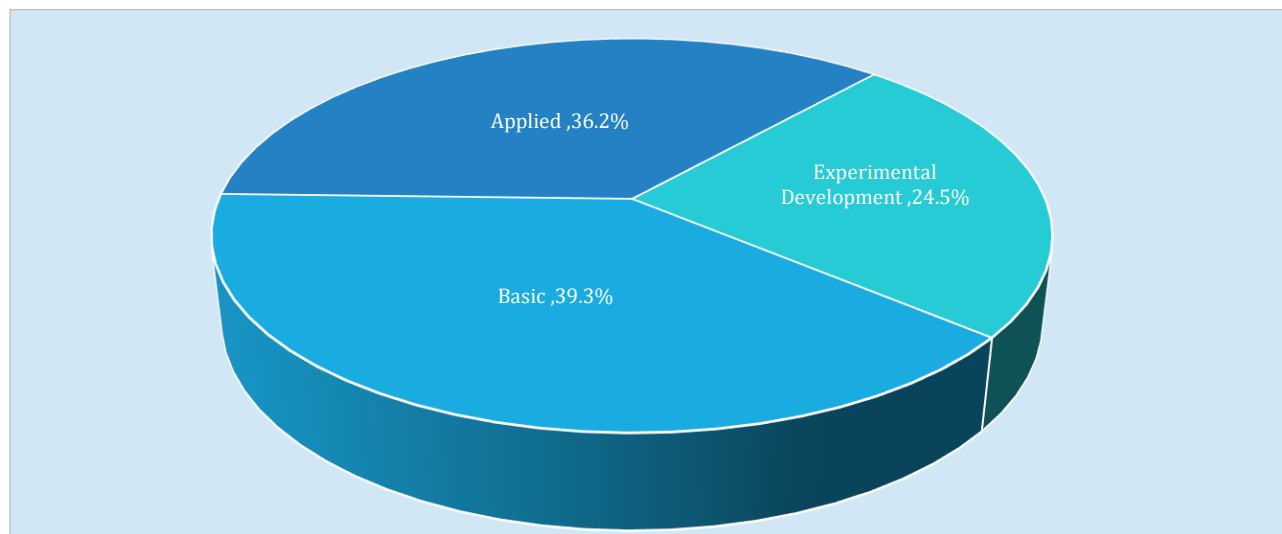
Source: National Survey of R&D in Malaysia 2019

5.2.3 GERD by Types of Research and Sector

Basic Research, Applied Research and Experimental Development are three types of R&D activities. Figure 5.6 exhibits equitable distribution of R&D expenditure among these three types of R&D – 39.3% for Basic Research, 36.2% for Applied Research, and 24.5% for Experimental Development. However, increasing the capabilities of R&D commercialisation, requires Malaysia to increase the share of Experimental Development in overall national R&D expenditure. Figure 5.7 illustrates each sector's performance according to type of research. Due to the nature of these institutions and enterprises, BEs seem to generally focus on Basic and

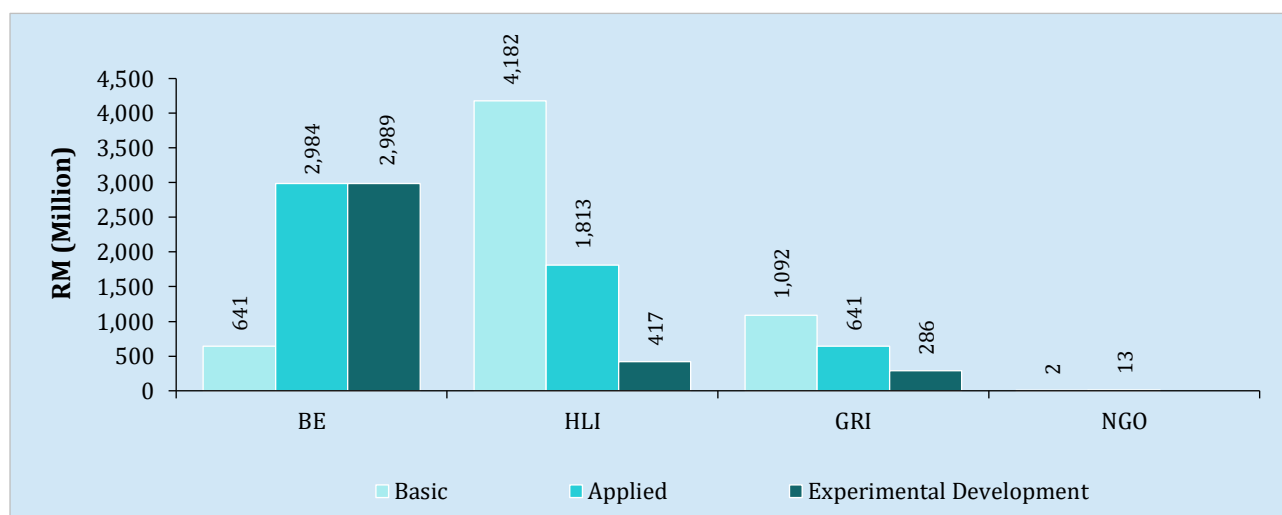
Applied Research whereas HLIs were mainly engaging in Basic Research. The trend of research for GRIs is similar to the HLIs in which they were more focused on Basic Research.

Figure 5.6 GERD by Type of Research, 2018



Source: National Survey of R&D in Malaysia 2019

Figure 5.7 Type of Research by Sectors, 2018



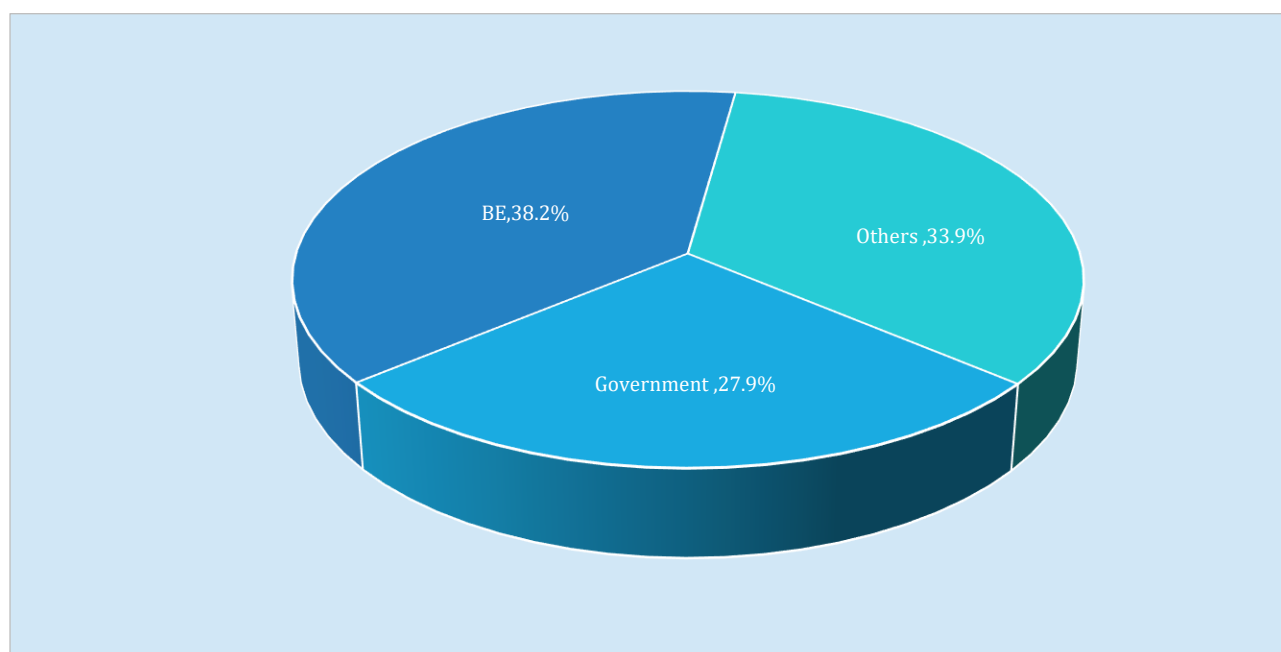
Source: National Survey of R&D in Malaysia 2019

5.2.4 Sources of R&D Funds

R&D funds are normally made available by Government (e.g. federal government R&D funds, state or local government funds, and specific ministries), BE (e.g. public funds from corporations and quasi-corporations owned by government units such as Government Link Companies (GLCs), private money from corporations and quasi-corporations) and Others (e.g. other private sectors and NGOs fund). In 2018, the BE contributed 38.2% and it was the biggest share in R&D expenditure. Government's share was at 27.9% which was ranked behind BE and

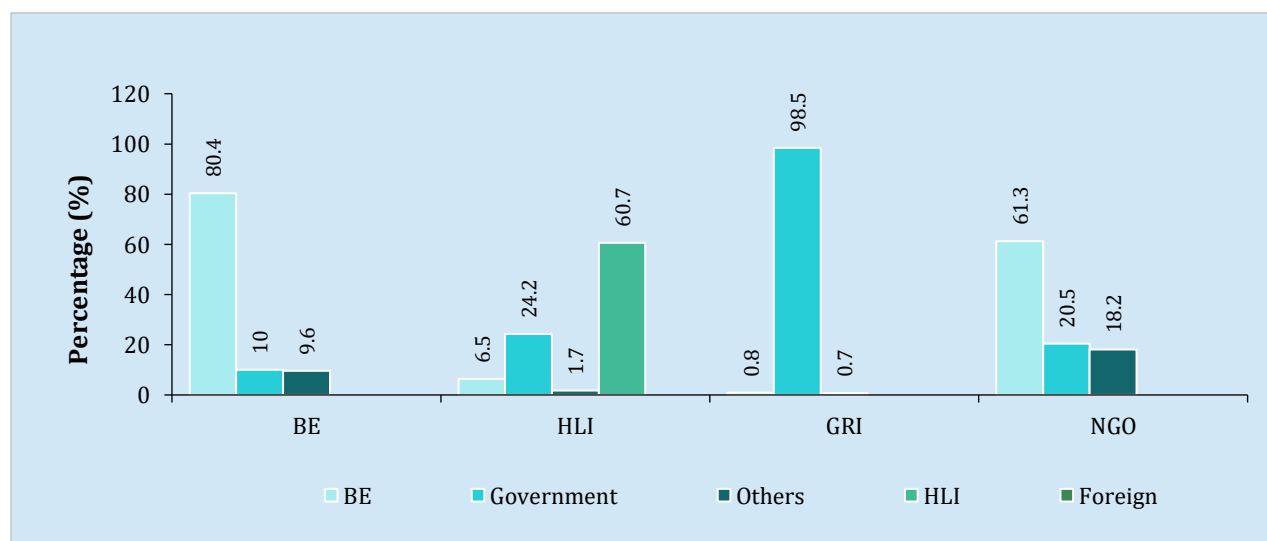
Others (Figure 5.8). Figure 5.9 details sources of R&D funding by sector. BE self-funded 80.4% of their R&D whereas funds from government (10.0%) and Others (9.6%) were limited. In comparison to other sectors, HLI has more sources of R&D funds, in which internal fund (60.7%) was the main source of R&D funding. This is followed by Government (24.2%), Foreign (6.9%), BE (6.5%) and Others (1.7%). For GRI, almost all their R&D funds were from Government (98.5%), and funds from BE (0.8%) and Others (0.7%) were almost insignificant. On the other hand, 61.3% funds for NGO comes from BE and followed by Government (20.5%) and Others (18.2%).

Figure 5.8 Source of R&D Fund, 2018



Source: National Survey of R&D in Malaysia 2019

Figure 5.9 Source of R&D Funds by Sectors, 2018

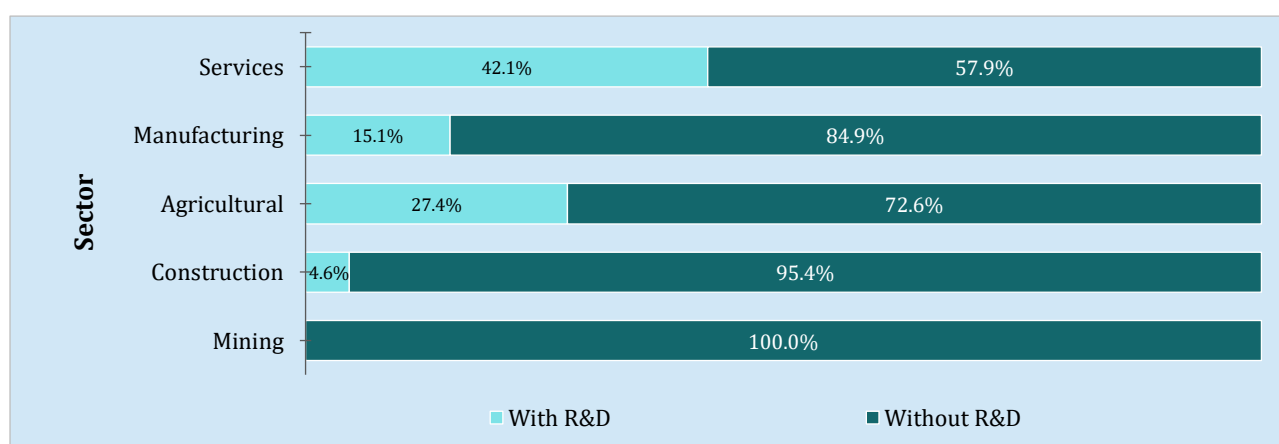


Source: National Survey of R&D in Malaysia 2019

5.2.5 BERD: Industrial Classification, Size, Ownership, Research Method

Figure 5.10 reports the percentage of firms undertaking R&D activities. Services sector has the highest rate of R&D-active BE at 42.1%. This was followed by Agricultural (27.4%), Manufacturing (15.1%) and Construction (4.6%). There was no R&D-active BE reported for Mining sector. In terms of sectoral contribution to the total BERD, Services and Manufacturing contributes 55.2% and 40.1% respectively⁴ (Figure 5.11). In respect to BE with R&D by firm size, the small BE has the highest percentage of firms performing R&D (35.5%) and this was followed by the micro BE (33.3%). The medium and large BEs reported having 24.2% and 22.9% of their members active in R&D in 2018 (Figure 5.12). Nevertheless, in terms of R&D expenditure the large BE contributed the largest share to BERD in Malaysia accounting for 69.1% (RM3,179.8 million) of the total spending. This was followed by the medium (16.8%; RM 773.08 million), small (13.2%; RM607.4 million) and micro (0.9%; RM41.42 million) (Figure 5.13). Overall, BERD in Malaysia in 2018 was mainly contributed by in-house R&D by majority foreign owned large BEs (Table 5.1).

Figure 5.10 BE with R&D Activities by Economic Sector, 2018

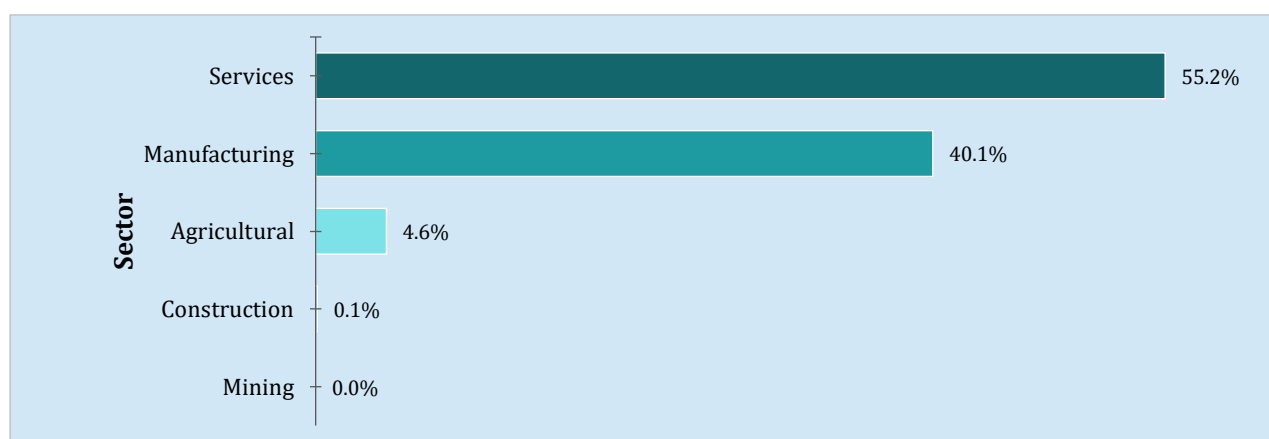


Note: Based on available data provided by 2,542 firms responded to survey. The data does not cover firms from secondary list of MDEC and Bionexus. The classification of industry is based on Malaysia Standard Industrial Classification 2008 (MSIC 2008), and derived from survey question A(1) – Main activity of the company.

Source: National Survey of R&D in Malaysia 2019.

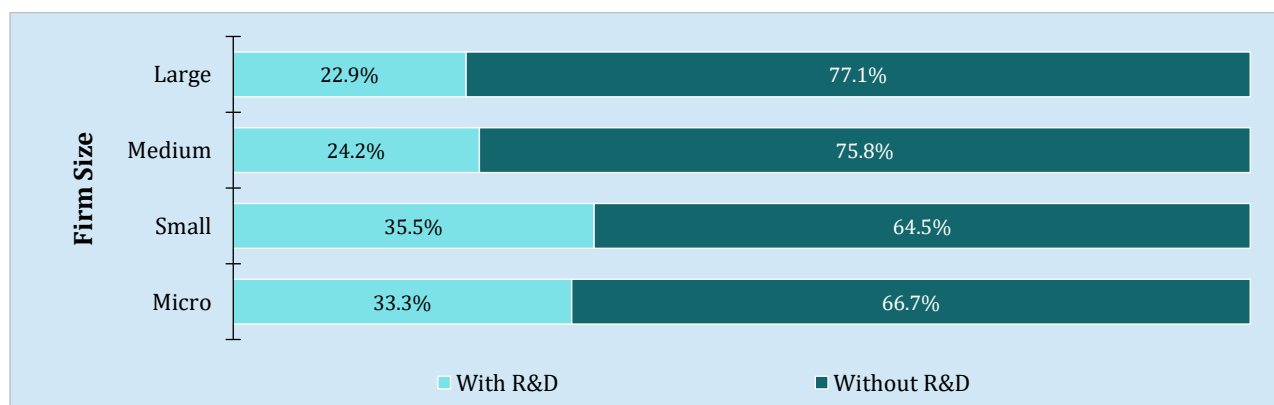
⁴ The percentage is calculated from 675 firms who have conducted R&D activities amounting to RM 4,757.89 million. The data do not cover firms from secondary list given some limited information on sector classification and size.

Figure 5.11 BERD by Economic Sector (%), 2018



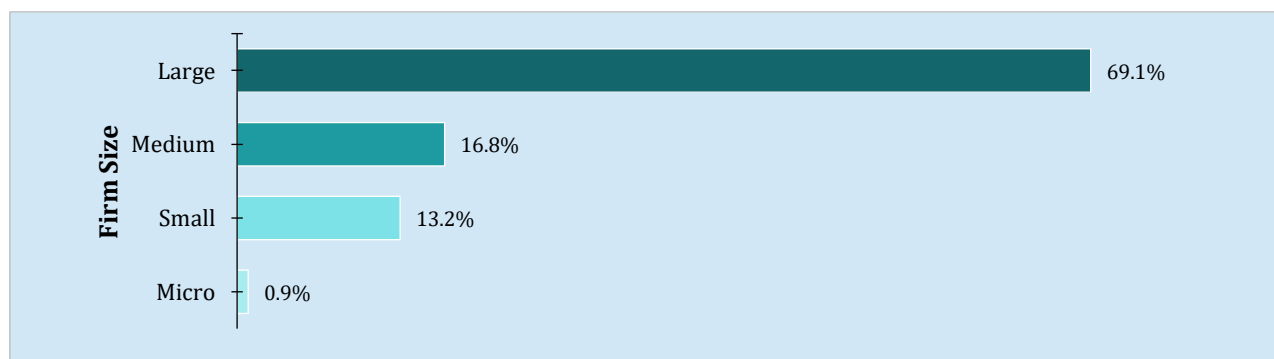
Note: Based on available primary data provided by 675 firms conducted R&D activities in 2018 with total R&D expenditure= RM4,757.89 million. The data does not cover firms from secondary list of MDEC and Bionexus. The classification of industry is based on Malaysia Standard Industrial Classification 2008 (MSIC 2008), and derived from survey question A(1) – Main activity of the company.
Source: National Survey of R&D in Malaysia 2019

Figure 5.12 BE with R&D Activities by Firm Size, 2018



Note: Based on available data provided by 2,336 firms responded to survey. The data does not cover firms from secondary list of MDEC and Bionexus. The classification of industry size is based on National Entrepreneur and SME Development Council (NESDC) definition, and derived from survey question A(1) – Main activity of the company and survey question A(3) – Total number of full-time employee in 2018.
Source: National Survey of R&D in Malaysia 2019

Figure 5.13 BERD by Firm Size, 2018



Note: Based on available data provided by 661 firms conducted R&D activities in 2018 with total R&D expenditure = RM4,601.67 million. The data does not cover non-response firms from secondary list of MDEC and Bionexus. The classification of industry size is based on NESDC definition, and derived from survey question A(1) – Main activity of the company and A(3) – Total number of full-time employee in 2018
Source: National Survey of R&D in Malaysia 2019

Table 5.1 BERD by Size, Ownership and Research Method, 2018

Measures	Percentage (%)
<i>Size of Enterprise</i>	
- Large	69.1
- Medium	16.9
- Small	13.2
- Micro	0.9
<i>Type of Ownership</i>	
- Majority Local Owned	39.8
- Majority Foreign Owned	59.9
- Equal Ownership (50:50)	0.2
<i>Research Method</i>	
- In-house R&D	84.9
- Outsourced R&D	15.1

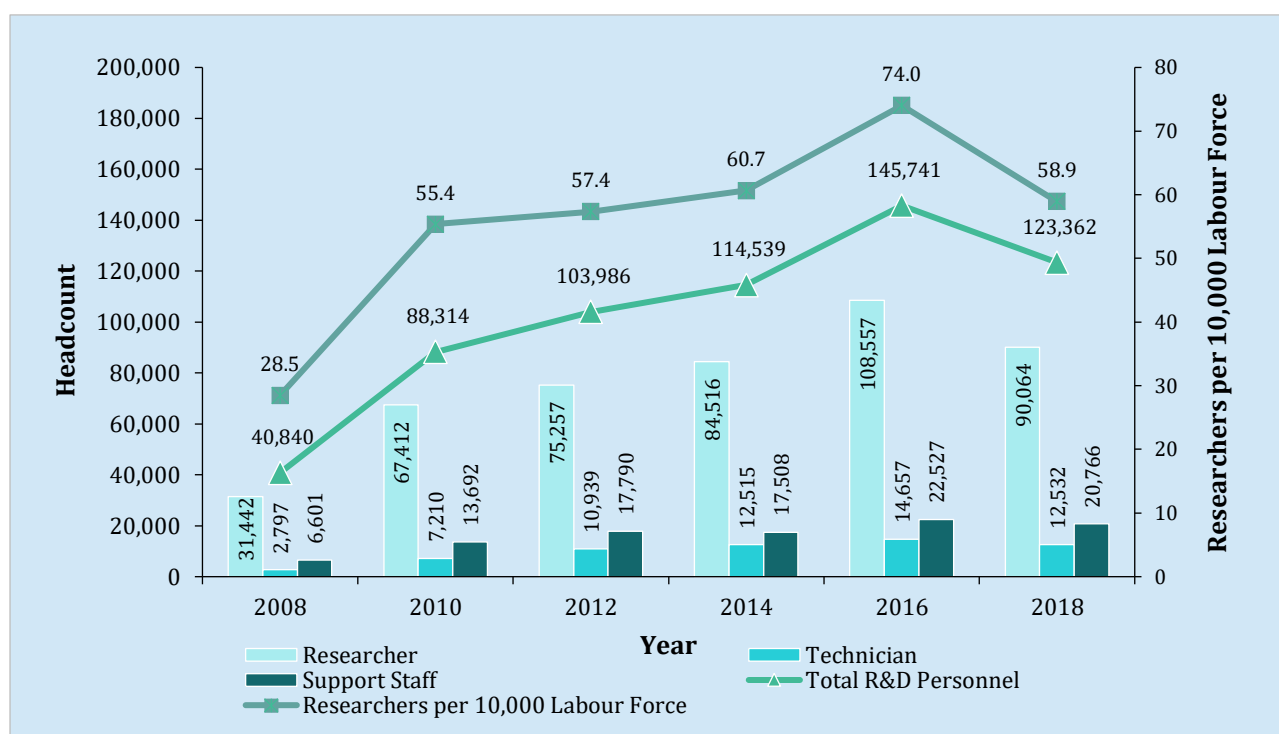
Source: Data from National Survey of R&D in Malaysia 2019

5.3 Research Workforce

5.3.1 Researchers Headcount by Qualifications, 2006-2011

Figure 5.14 shows the number of R&D personnel and ratio of researchers to 10,000 labour force. An upward trend is observed from 2008-2016 but recording a significant decline in 2018. Comparing 2016 and 2018, a 15.4% decrease in total number of R&D personnel from 145,741 persons to 123,362 persons is recorded. Likewise, researchers per 10,000 labour force decreased by 20.4% from 74.0 to 58.9. In 2018, R&D personnel in Malaysia was made up of 90,064 researchers (73.0%), 12,532 technicians (10.2%), and 20,766 support staff (16.8%). This composition has been consistent over the years.

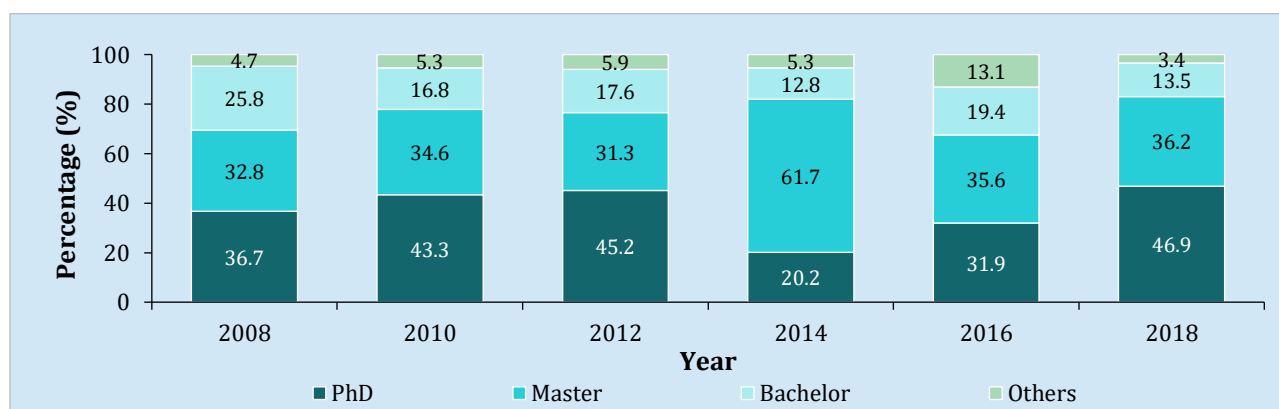
Figure 5.14 R&D Personnel and Researchers per 10,000 Labour Force 2008-2018



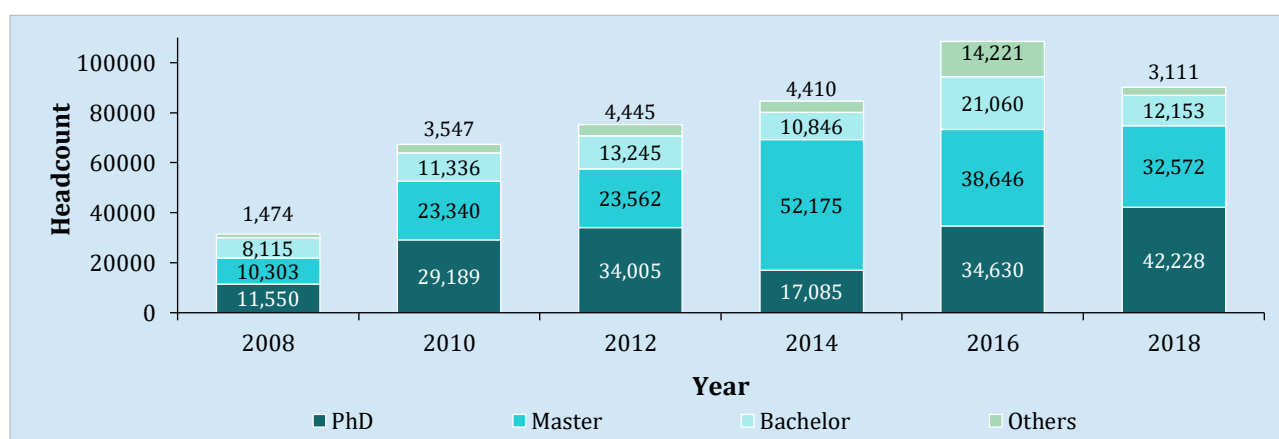
Source: National Survey of R&D in Malaysia 2019

Figure 5.15 shows the proportion of researchers by qualification in Malaysia. Except in 2014, researchers with PhD qualification were the largest group of R&D workforce in Malaysia. This was followed by researchers with Master and Bachelor's degrees. In 2018, researchers with PhD qualifications constituted 46.9% of total, 36.2% with Master qualifications, 13.5% Bachelor qualifications, and 3.4% researchers with other qualifications. Figure 5.16 provides the headcount of researchers by qualification during the period 2008-2018.

Figure 5.15 Proportion of Researchers by Qualification, 2008-2018



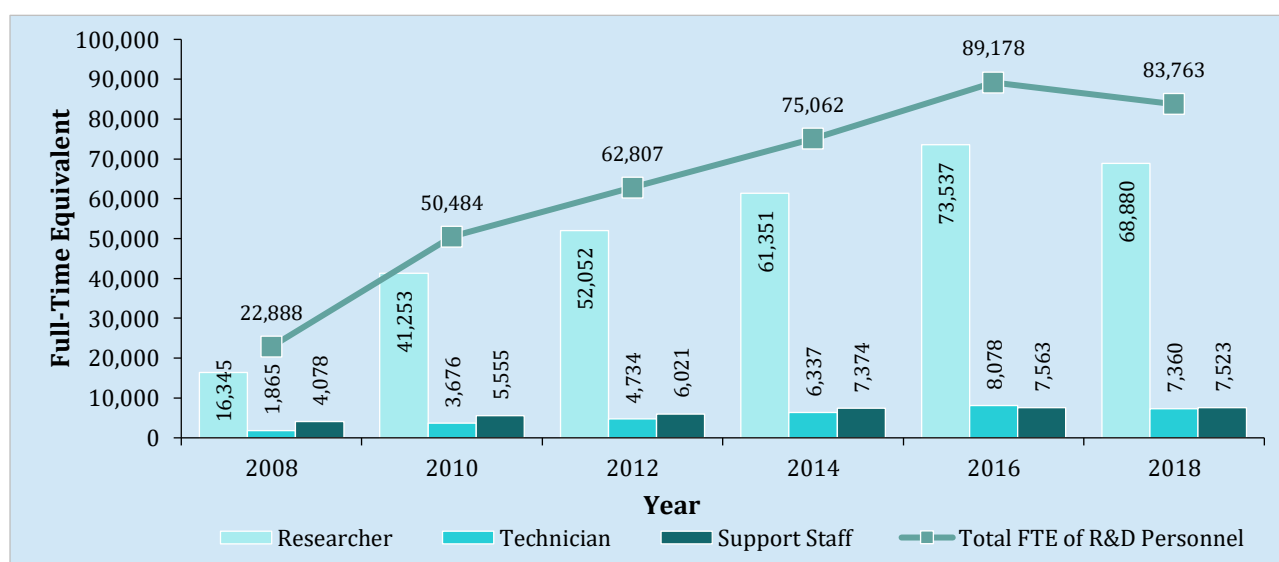
Source: National Survey of R&D in Malaysia 2019

Figure 5.16 Headcount of Researchers by Qualification, 2008-2018

Source: National Survey of R&D in Malaysia, 2019

5.3.2 Full-Time Equivalent of R&D Personnel

Full time-equivalent (FTE) of R&D personnel denotes the volume of time that a researcher dedicates to R&D related activities during a specific period. As shown in Figure 5.17, similar to other indicators, FTE of R&D personnel experienced a decline in 2018. The recorded decline was 6.1%, that is, from 89,178 in 2016 to 83,763 in 2018. The decline was found in all the three groups of research personnel – Researcher, Technician, and Support Staff.

Figure 5.17 Full-Time Equivalent of R&D Personnel, 2008-2018

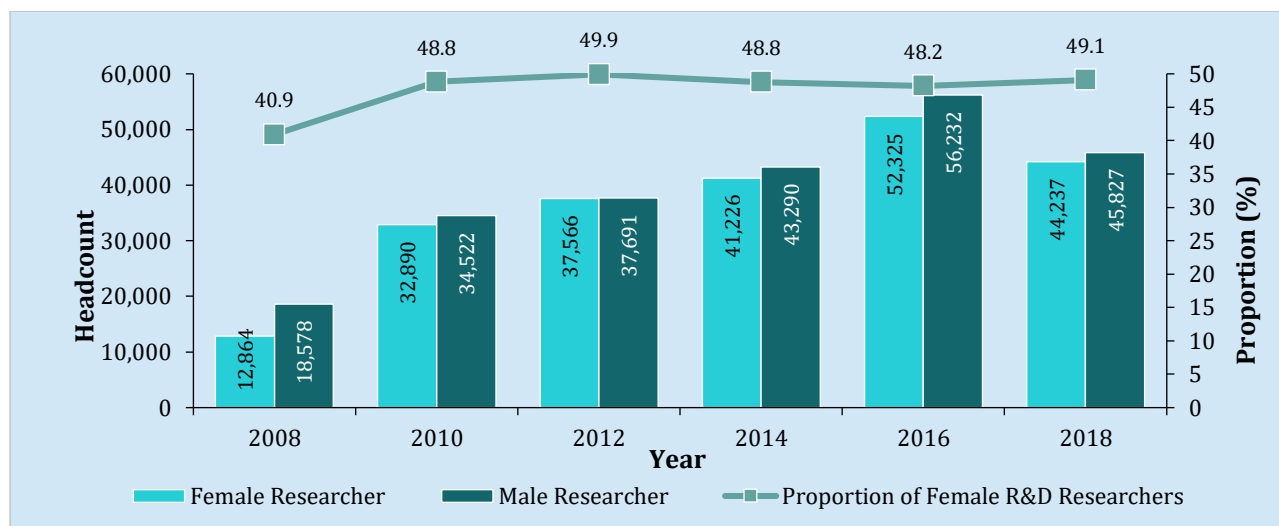
Source: National Survey of R&D in Malaysia 2019

5.3.3 Researchers by Gender

Figure 5.18 shows that the ratio of male to female researchers is approaching the ideal figure of 50:50. In fact, the ratio has remained rather steady in the range of 48.2% (2016) and 49.9%

(2012). In 2018, the proportion of female researchers to the total number of researchers was 49.1%. The performance signifies the commitment to increase female participation in STI.

Figure 5.18 Headcount of Researchers by Gender, 2008-2018

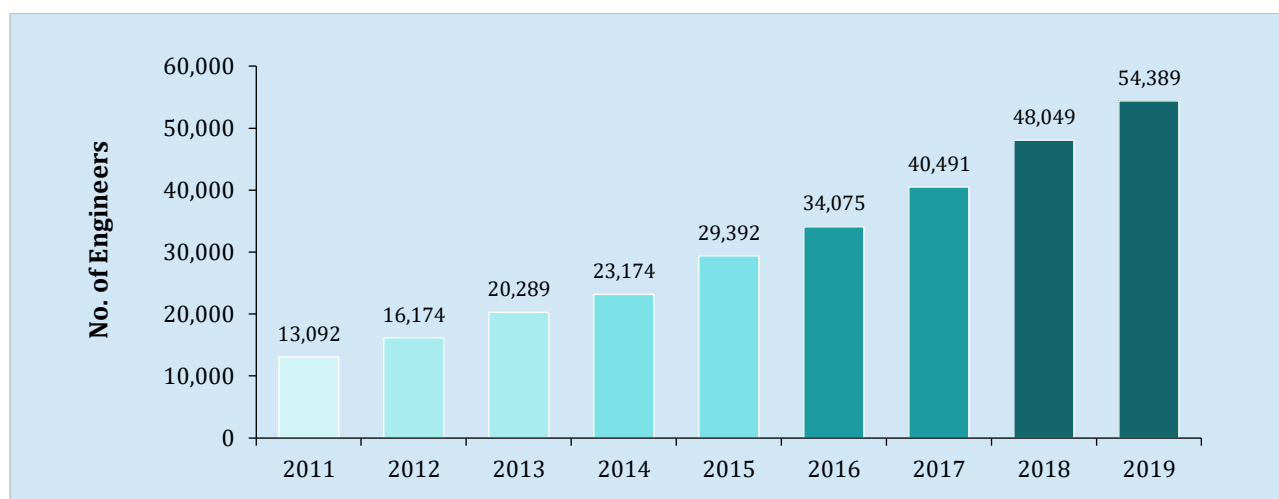


Source: National Survey of R&D in Malaysia 2019

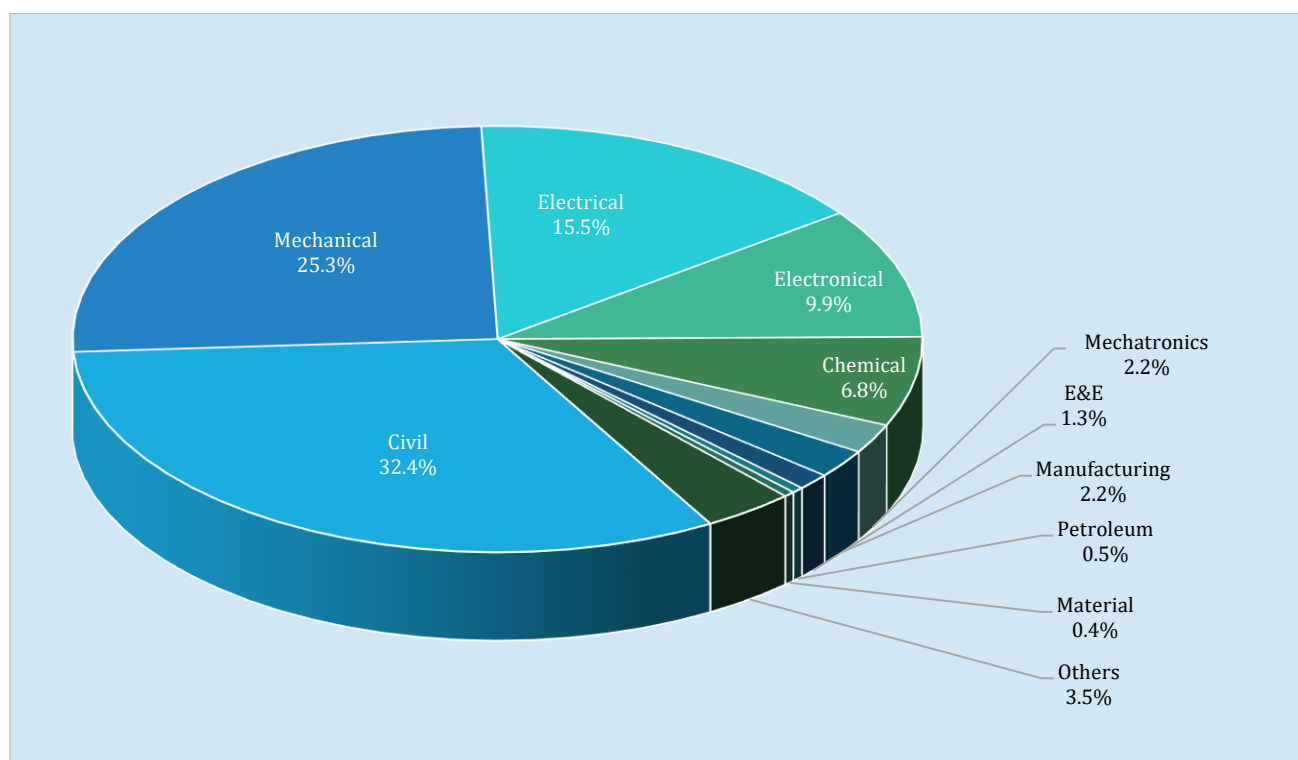
5.3.4 Registered Engineers

Figure 5.19 shows the growth in number of registered engineers in Malaysia from 2011-2019. Significantly, the number of registered engineers has increased fourfold since 2011. The registered engineers by fields are illustrated in Figure 5.20. The highest percentage of engineers was registered in the field of Civil (32.4%), followed by Mechanical (25.3%) and Electrical (15.5%).

Figure 5.19 Number of Registered Engineers, 2011-2019



Source: The Institution of Engineers, Malaysia

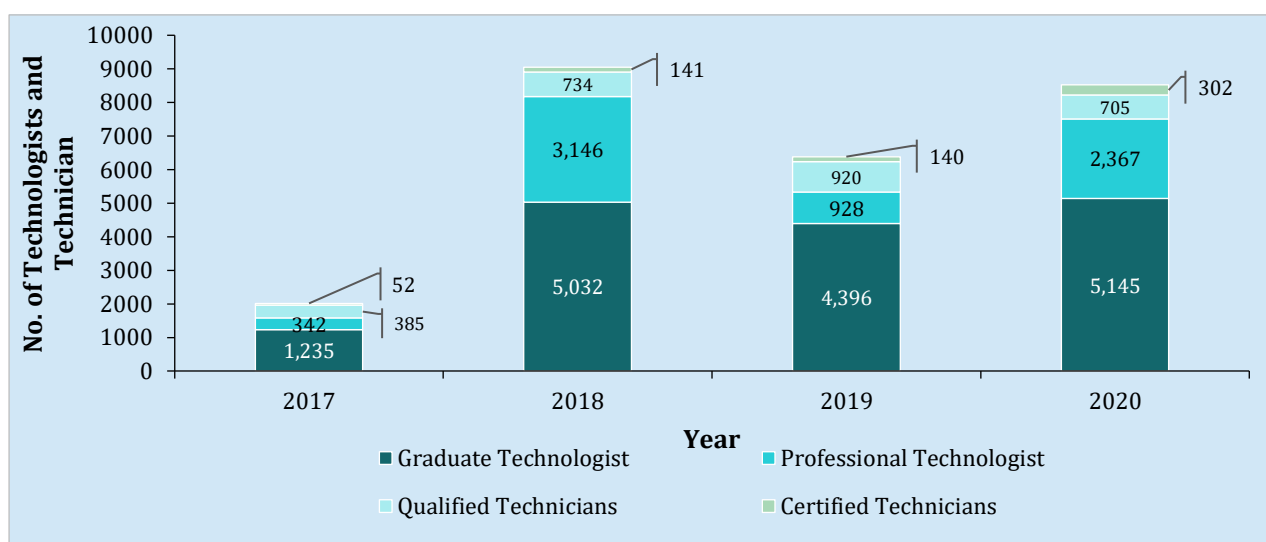
Figure 5.20 Registered Engineers by Field (as of end 2019)

Source: The Institution of Engineers, Malaysia

5.3.5 Registered Technologists and Technicians

Figure 5.21 shows the number of registered technologists and technicians in Malaysia from 2017 to November 2020. The four categories of technologists and technicians comprise, namely graduate technologists, qualified technicians, certified technicians and professional technologist. The total number of the registered technologists and technicians increased from 2,014 persons to 8,519 persons, a threefold increase, during the 4 years period. Graduate technologist is the largest group of registered technologists and technicians in Malaysia. This is followed by professional technologist and qualified technicians. Figure 5.22 provides details on the registered technologists and technicians by fields in Malaysia as of November 2020. The largest group of registered technologists and technicians are in electrical and electronics (E&E) (24.1%) followed by IT (15.3%), building and construction technology (15.0%), manufacturing and industrial technology (14.6%), and oil and gas technology (3.4%).

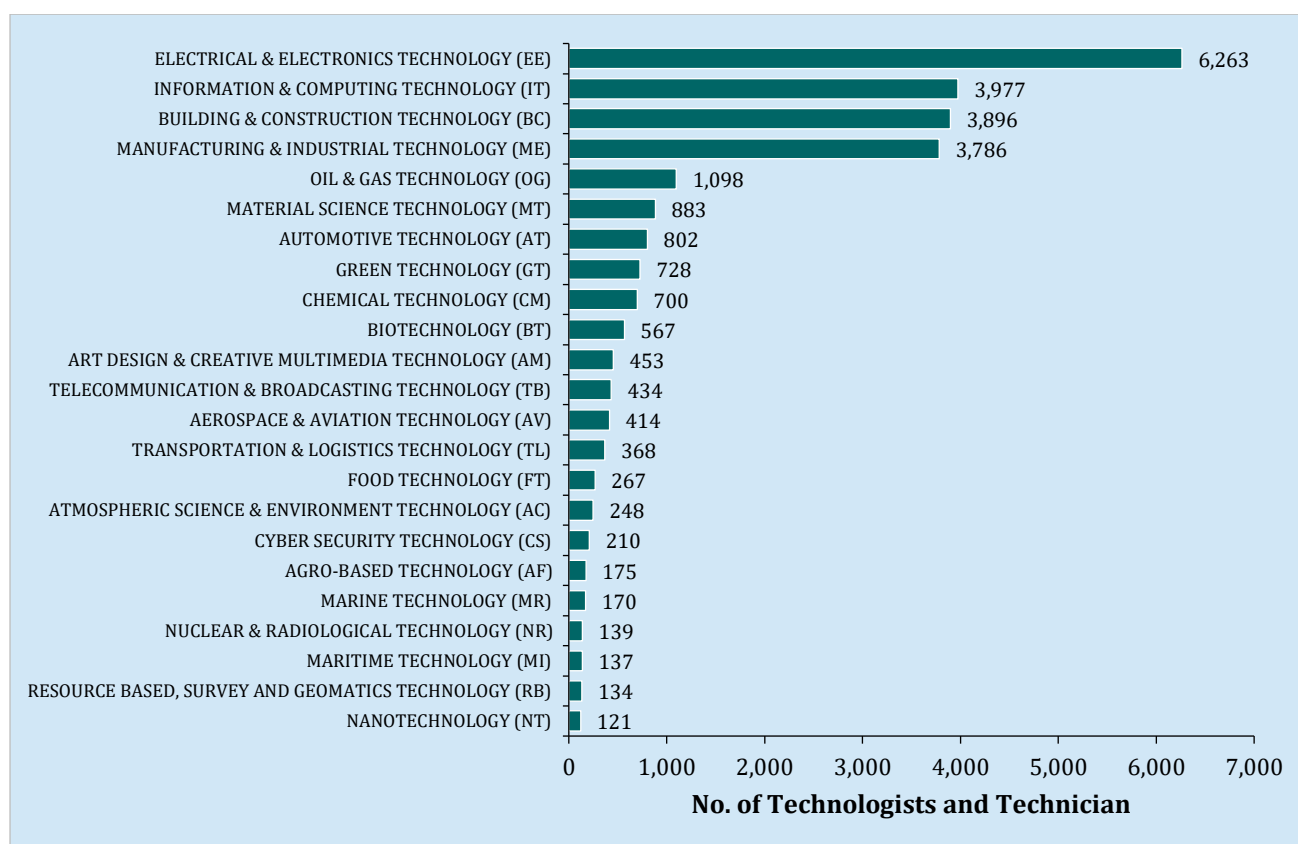
Figure 5.21 Registered Technologists and Technicians, 2017-2020



Note: Data for 2020 is up to November.

Source: Malaysia Board of Technologists

Figure 5.22 Registered Technologist and Technicians by Fields (as of Nov 2020)

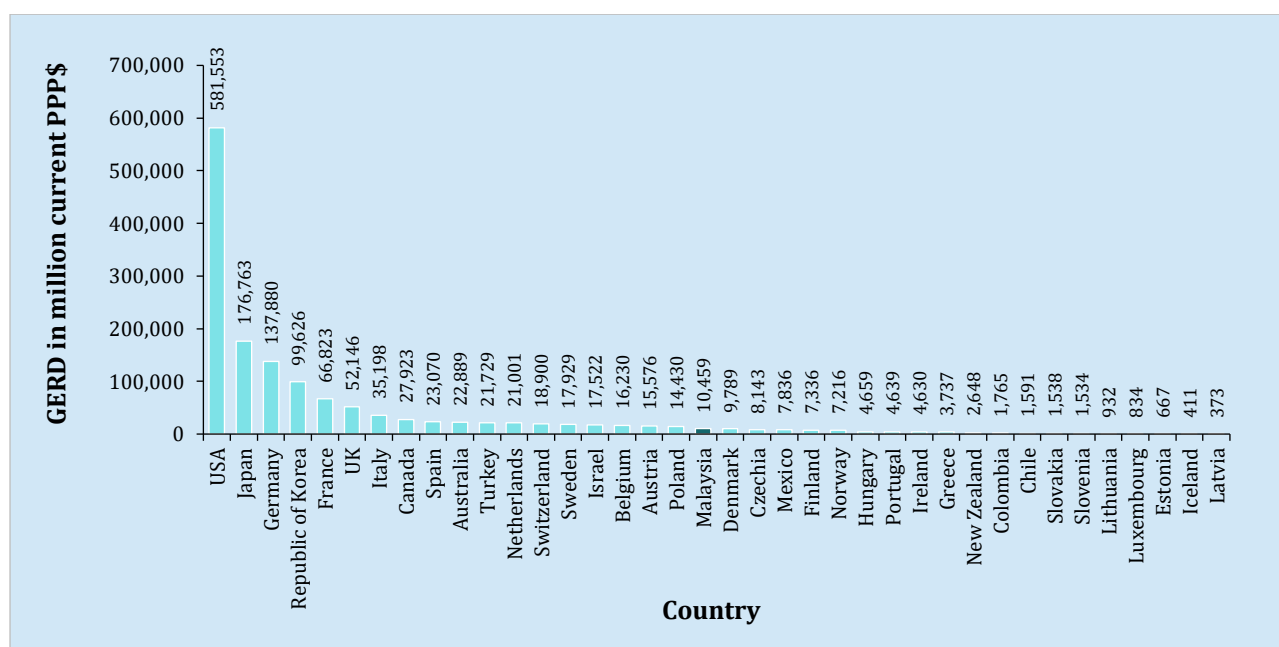


Source: Malaysia Board of Technologists

5.4 International Comparison

Figure 5.23 shows Malaysia's GERD in 2018 in comparison to OECD countries (for 2017) whereas Figure 5.24 provides the percentage of GERD/GDP. In terms of GERD, Malaysia is ranked far behind the top OECD nations such as USA, Japan and Germany. As for GERD/GDP ratio, Israel and Republic of Korea were among the leading OECD countries in terms of R&D intensity. Malaysia (with 1.04%) was below the World's average (1.72%) and Asia (Eastern & South-eastern) region's average (2.13%). Malaysia was just slightly above the average of Asia (South-eastern) (0.97%). Figure 5.25 shows the performance of BERD/GERD ratio for Malaysia and OECD countries. Malaysia (43.9%) is currently below the OECD average of 60.11%. Israel, Republic of Korea and Japan are the leading three countries based on this indicator. On the other hand, Malaysia's investments in higher education expenditure on R&D as percentage of GERD was 42.6% which places Malaysia ahead of many OECD countries. Malaysia was just behind of Latvia, Mexico, Chile and Estonia (Figure 5.26).

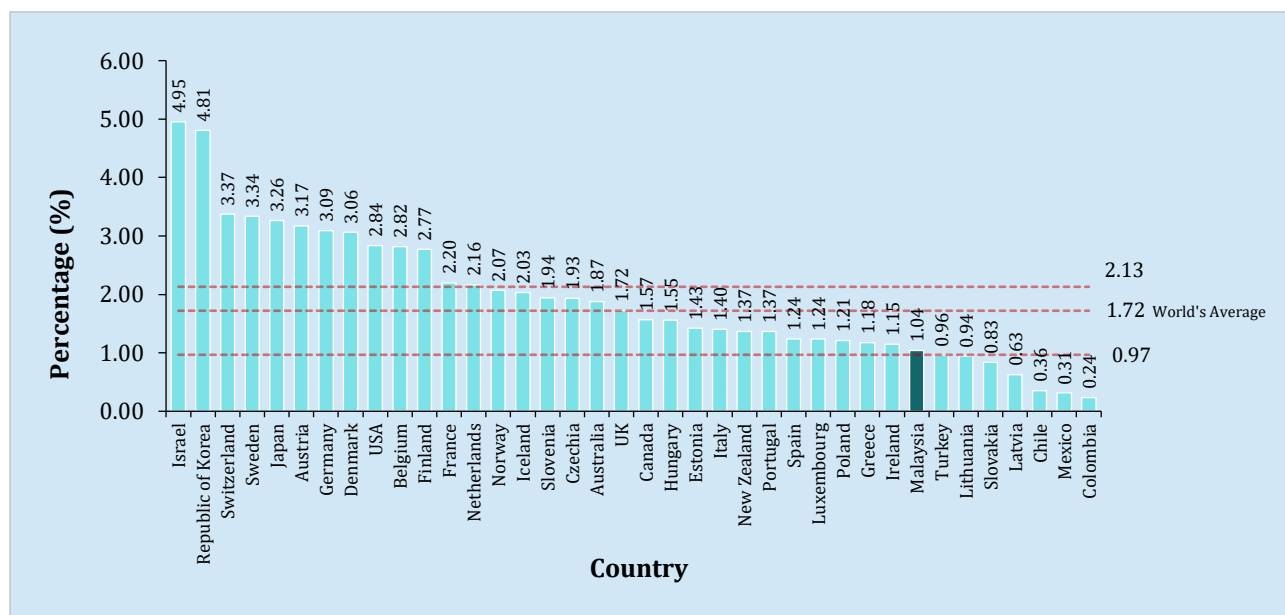
Figure 5.23 GERD by Country



Note: Data for year 2018; except Australia, Chile, New Zealand, Switzerland, Turkey for year 2017. Data for Malaysia from National Survey of R&D in Malaysia 2019.

Source: UNESCO UIS.Stat (28 October 2020) (<http://data.uis.unesco.org/>)

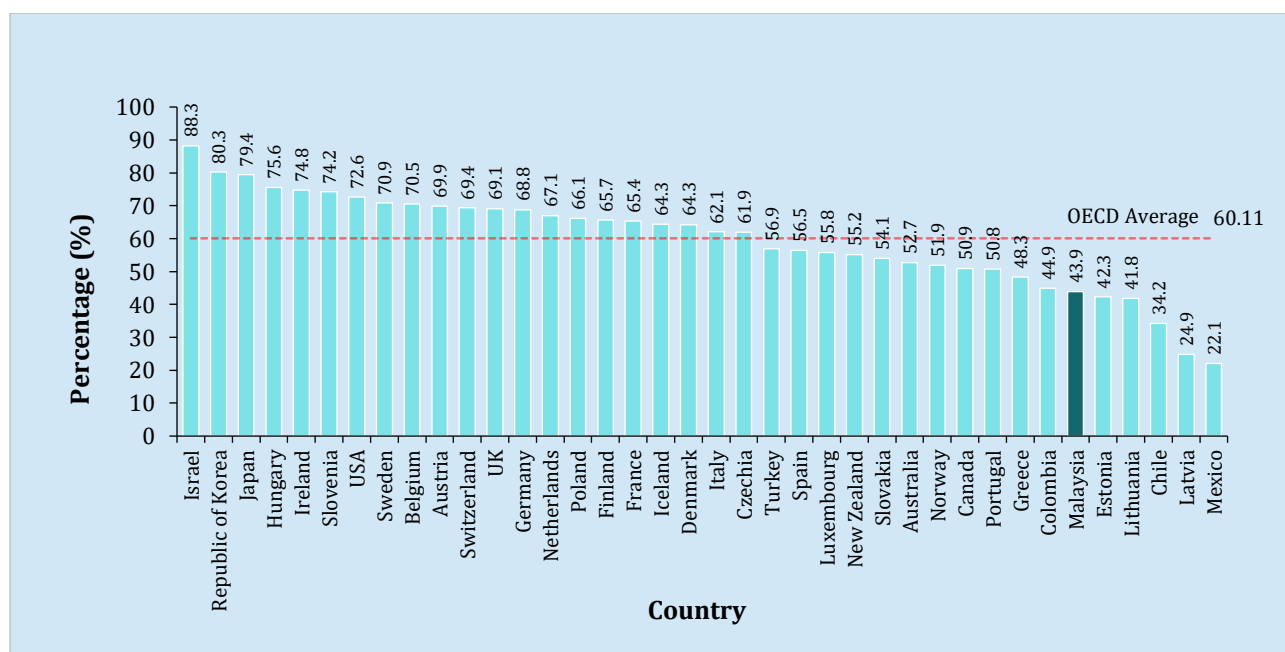
Figure 5.24 GERD/GDP Ratio by Country



Note: Data for year 2018; except Australia, Chile, New Zealand, Switzerland, Turkey for year 2017. Data for Malaysia from National Survey of R&D in Malaysia 2019.

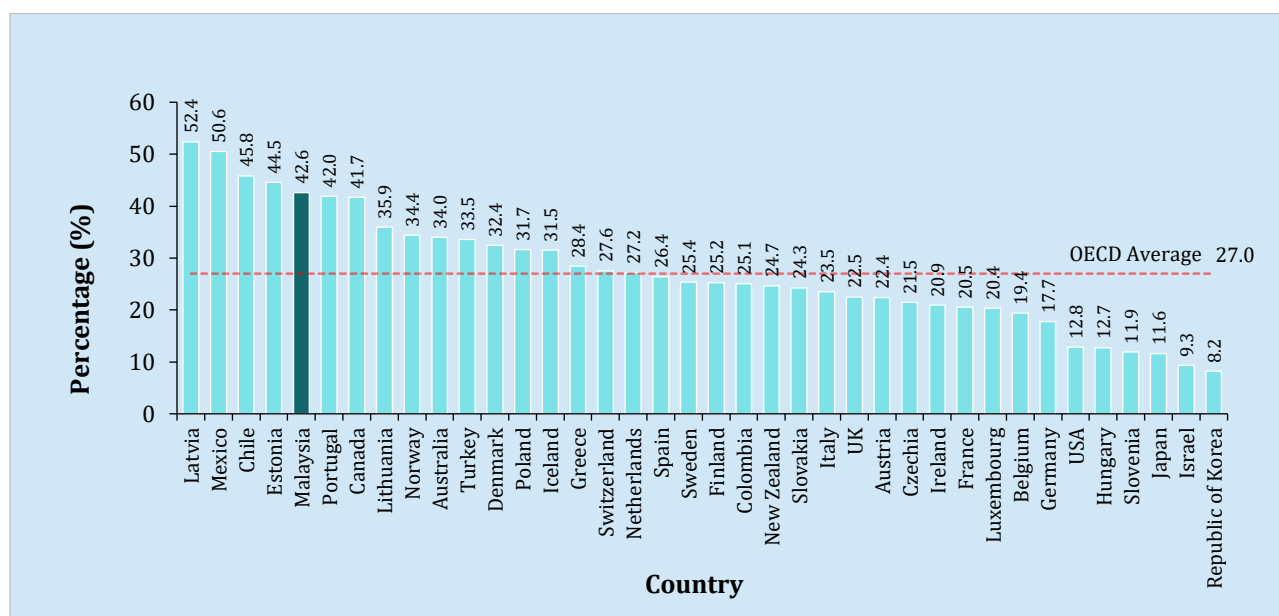
Source: UNESCO UIS.Stat (28 October 2020) (<http://data.uis.unesco.org/>)

Figure 5.25 BERD/GERD Ratio by Country



Note: Data for year 2018; except Australia, Chile, New Zealand, Switzerland, Turkey for year 2017. Data for Malaysia from National Survey of R&D in Malaysia 2019.

Source: UNESCO UIS.Stat (28 October 2020) (<http://data.uis.unesco.org/>)

Figure 5.26 Higher Education Expenditure on R&D as Percentage of GERD

Note: Data for year 2018; except Australia, Chile, New Zealand, Switzerland, Turkey for year 2017. Data for Malaysia from National Survey of R&D in Malaysia 2019.

Source: UNESCO UIS.Stat (28 October 2020) (<http://data.uis.unesco.org/>)

5.5 Summary

Malaysia experienced a downward trend in R&D investments during 2016-2018 which was reflected by the decline in the country's performance in GERD and GERD/GDP ratio. In 2018, Malaysia's GERD/GDP ratio was recorded at 1.04% compared to 1.44% in 2016. The decline was mainly due to the significant decrease in BERD. This sharp decline has disrupted the tremendous growth trend of Malaysia's GERD/GDP ratio since 2008. In fact, such downward trend has seriously affected Malaysia's efforts to achieve its GERD to at least 2.0% of GDP in 2020. In 2018, BE was the main contributor to GERD in comparison to HLI and GRI. Engineering and Technology; and Information, Computer and Communication Technology, and Natural Sciences were the three major FORs that contributed the most to R&D spending. In terms of SEO, about half of the R&D expenditure is related to the Advanced Experimental and Applied Science and Sustainable Economic Development. The top three NPAs in terms of GERD are Medical and Healthcare; Transportation and Urbanisation; and Cybersecurity. Overall, BERD in Malaysia in 2018 was mainly contributed by in-house R&D by majority foreign owned large BEs.

In 2016, Malaysia has met the target of the ratio of researchers per 10,000 workforces to be at least 70. However, Malaysia was unable to sustain this performance when the ratio declined to 58.9 in 2018. FTE of R&D personnel experienced a decline in 2018. In terms of qualification of researcher, researchers with PhD qualification was the largest group of R&D workforce in Malaysia. The proportion of female researchers to the total number of researchers stands 49.1% in 2018. Globally, Malaysia's investments in higher education expenditure on R&D as percentage of GERD was ranked third compared to OECD countries. However, there is still more

room for improvement for Malaysia in terms of GERD, ratio of GERD/GDP and percentage of BERD/GDP in comparison to OECD countries.

6

PUBLIC R&D INVESTMENT: MAJOR GRANTS AND PROGRAMMES

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

6.1 Introduction

This chapter provides an overview on the performance the various public R&D grants, industry and commercialisation funds, loans and venture capitals, and STI tax incentives during the 10th MP and 11th MP. Public grants, programmes and incentives are the most used mechanisms to foster and support R&D and innovation activities within National Innovation Systems. These interventions are instrumental to ensure R&D and innovation activities amongst private and public sector, as well as society as a whole, take place adequately. This is particularly important for new and highly uncertain R&D areas, and fields that do not offer promising prospects for profits but important for national and societal benefits.

6.2 R&D Grants

6.2.1 MOSTI

The main R&D grants offered by MOSTI in 10th MP were ScienceFund, TechnoFund and InnoFund, while Dana R&D, SMART Fund and GO-Fund were the main MOSTI's R&D grants in 11th MP (Table 6.1). In 10th MP, MOSTI approved 1,478 ScienceFund projects, which was the highest compared to the other two grants. In terms of the total value of approved projects, the total value of TechnoFund was RM492.37 million and this was the highest among MOSTI R&D grants. In 11th MP, Dana R&D has the highest number of approved projects with a total of 77 approvals. However, in terms of total value of approvals, SMART Fund was the highest with RM116.77 million. The total approvals of MOSTI R&D grants, both in terms of number and number of projects, has experienced a sharp decline in 11th MP in comparison to 10th MP.

Table 6.1 Main MOSTI R&D Grants, 2011-2020

Grants / Programmes	10 th MP		11 th MP	
	Amount (RM million)	Number of projects approved	Amount (RM million)	Number of projects approved
ScienceFund	307.04	1,478	-	-
TechnoFund	492.37	176	-	-
InnoFund	22.53	83	-	-
Dana R&D	-	-	15.16	77
SMART Fund	-	-	116.77	69
GO-Fund	-	-	17.45	61
TOTAL	821.94	1,737	149.38	207

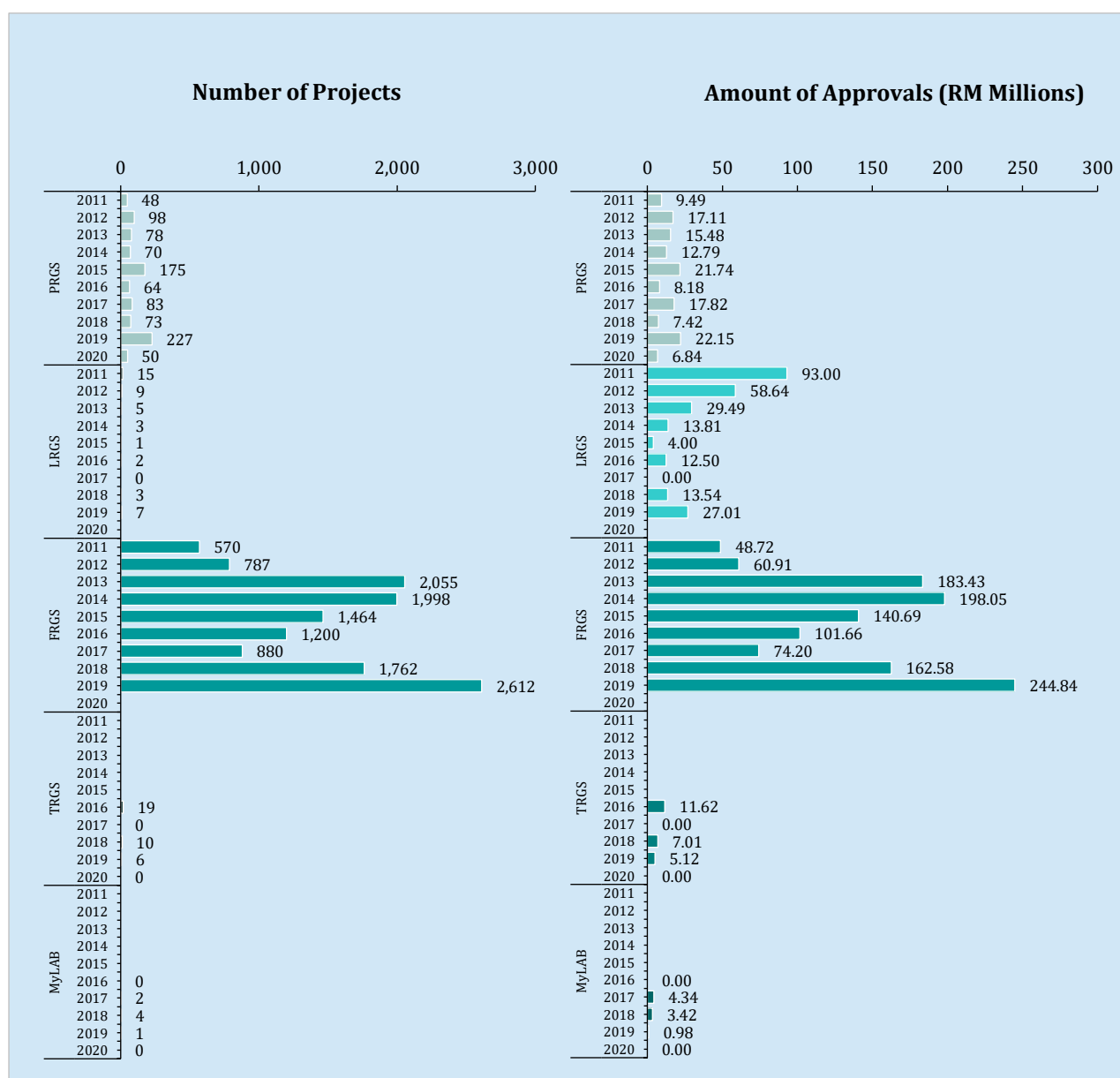
Note: SMART Fund comprises of SMART Fund, TechnoFund, special allocation for agencies, National Science, Technology and Innovation Policy, and flagship. GO-Fund comprises of InnoFund, Facilities Fund and International Collaboration.

Source: Status of achievement R,D&C grants for 9th MP, 10th MP and 11th MP until 31 July 2020. Fund Division, Ministry of Science, Technology and Innovation

6.2.2 Ministry of Higher Education (MOHE)

MOHE provides grants to support basic and applied research activities among researchers in public and private HLIs. These include Fundamental Research Grant Scheme (FRGS), Prototype Research Grant Scheme (PRGS), Long Term Research Grant Scheme (LRGS), Trans-disciplinary Research Grant Scheme (TRGS) and Malaysia Laboratories for Academia-Business Collaboration (MyLAB) (Figure 6.1). FRGS is the major MOHE's R&D grant both in expenditure and number of approved projects. As of September 2020, MOHE has approved 6,874 FRGS projects (RM631.80 million) in 10th MP, and 6,454 FRGS projects (RM583.28 million) in 11th MP. This was followed by PRGS with 469 projects (RM76.61 million) in 10th MP and 497 projects (RM62.41 million) in 11th MP; and LRGS with 33 projects (RM198.94 million) in 10th MP and 12 projects (RM53.05 million) in 11th MP. TRGS and MyLAB were two newly awarded grant schemes since 2016.

Figure 6.1 Main MOHE R&D Grants, 2011-2019



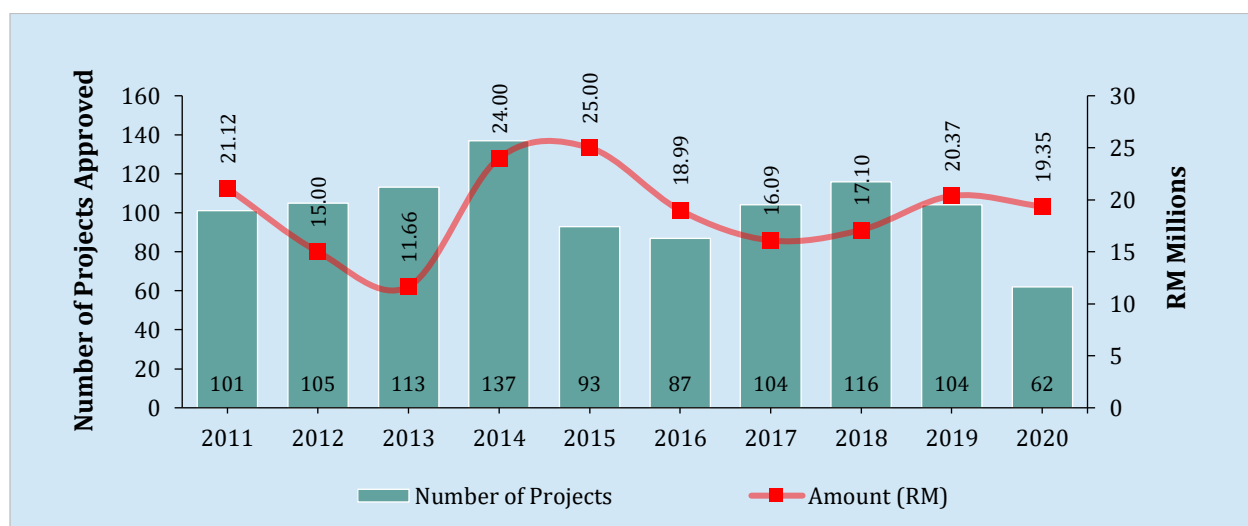
Note: Data as of September 2020. Approvals for year 2020 not available except for PRGS.

Source: MOHE, Malaysia

6.2.3 Ministry of Health (MOH)

MOH provides MOH Research Grant (MRG) to support research projects which are in accordance with the national and MOH's priorities. MRG is only awarded to MOH staff and for projects that involve collaboration with non-MOH researchers, with the principal investigator of the project being the MOH staff. In 2011-2020, MOH has approved 1,022 MRG projects amounting to RM188.68 million (Figure 6.2). Similarly, 549 projects (RM96.78 million) and 473 projects (RM91.90 million) were approved in 10th MP and 11th MP, respectively. Box 6.1 illustrates a successful project of MOH.

Figure 6.2 MRG, 2011-2020



Note: Data as of September 2020

Source: MOH, Malaysia

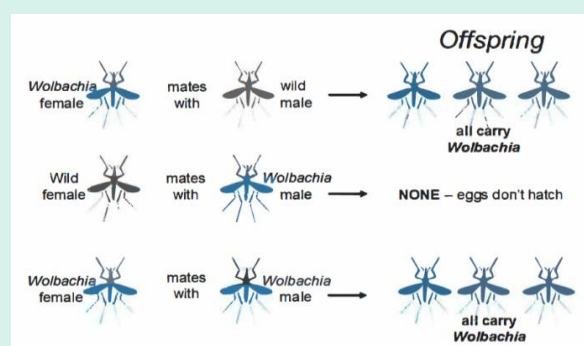
Box 6.1 MRG Project on Wolbachia Strategy to Reduce Dengue Cases

Project on “Field Evaluation on the impact of *Wolbachia* infected *Aedes aegypti* on dengue and chikungunya transmission” is funded by MRG with the main objective to replace wild *Aedes aegypti* – dengue-transmitting mosquito populations with populations that are unable to transmit dengue, Zika or chikungunya viruses to people. The project is expected to be completed by 2021 and the outcomes from the R&D are anticipated to reduce dengue cases in dengue hotspots by 60-80%. The Ministry of Health Malaysia has adopted the innovative *Wolbachia* replacement strategy – a dengue control approach as a policy in their dengue control programme. Community acceptance rate was favourable and community participated voluntarily in the releases.



Visit to mass-rearing of *Wolbachia* mosquitoes production facility by Dr. Takeshi Kasai, WHO Regional Director for The Western Pacific

Source: National Institutes of Health (NIH), MOH



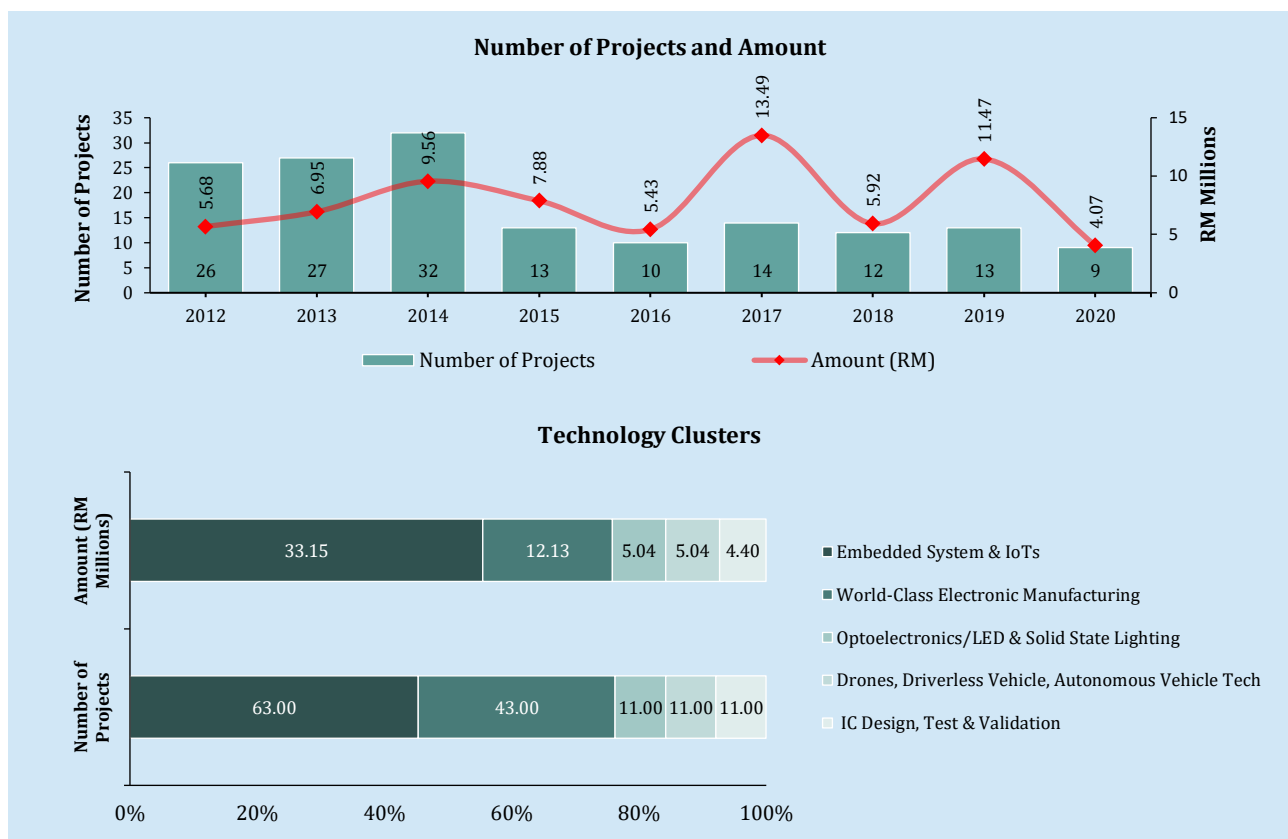
The 101 of *Wolbachia* Strategy

6.2.4 Collaborative Research in Engineering, Science and Technology

Collaborative Research in Engineering, Science and Technology (CREST) is an industrial-driven collaborative platform between academic and industry for market-driven R&D and talent development in the E&E sector. CREST R&D Grant focuses on the following technology clusters:

Optoelectronics/LED and Solid-State Lighting; Embedded System & Internet of Things; IC Design, Test & Validation; Advance Materials & Packaging; World-Class Electronic Manufacturing; and Drones, Driverless vehicle and Autonomous Vehicle Technology. A total of 156 projects with a total value of RM70.45 million were approved by CREST during 2012-2020 (Figure 6.3). The number of projects approved was in the range of 9-14 in 2015-2020, which was relatively lower compared to 2012-2014. The value of approved projects varied and did not exhibit consistent trend. The main technology clusters that received the most funding were Embedded System & IoTs and World-Class Electronic Manufacturing.

Figure 6.3 CREST R&D Grant, 2012-2020



Note: Data as of September 2020
Source: CREST

6.3 Industry and Commercialisation Funds

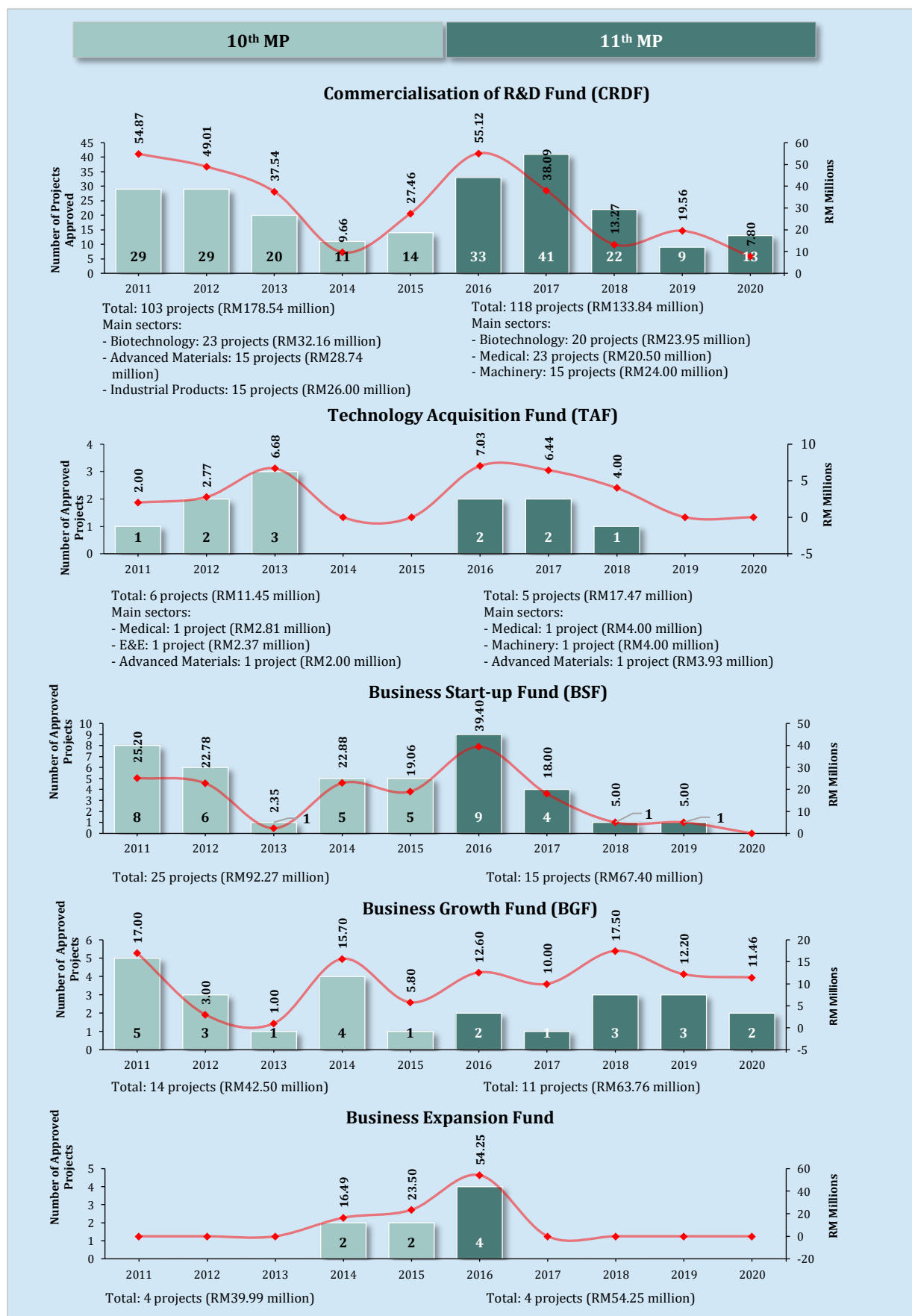
6.3.1 Malaysian Technology Development Corporation

In 2011-2017, Malaysian Technology Development Corporation (MTDC) provided several funds to support Malaysian companies in technology commercialisation, technology adaptation and business growth, namely CRDF, Technology Acquisition Fund (TAF), Business Start-up Fund (BSF), Business Growth Fund (BGF) and Business Expansion Fund (Figure 6.4). A total of 103 CRDF projects (RM178.54 million) and 118 CRDF projects (RM133.84 million) have been approved in 10th MP and 11th MP respectively. The top-three project fields in 10th MP were Biotechnology, Advanced Materials and Industrial Products while in 11th MP the tops fields

were Biotechnology, Medical and Machinery. Relatively, the number of approved TAF projects were lower compared to CRDF. Only 6 projects (RM11.45 million) and 5 projects (RM17.47 million) were approved for TAF in 10th MP and 11th MP respectively.

MTDC has approved 25 projects (RM92.27 million) under BSF in 10th MP and the number declined to 15 approved projects (RM67.40 million) in 11th MP. As for BGF, although the number of approved projects has reduced from 14 projects in 10th MP to 11 projects in 11th MP, the amount of fund has increased from RM42.50 million to RM63.76 million. On the other hand, the number of Business Expansion Fund approved projects was relatively low. Only 4 projects were approved in 10th MP and 11th MP respectively. Generally, several funds such as CRDF and BSF have more approved projects in the beginning of the plans.

Figure 6.4 Funds under MTDC, 2011-2020



Note: Data as October 2020
Source: MTDC

6.3.2 BioeconomyCorp Fund

Malaysian Bioeconomy Development Corporation Sdn Bhd (BioeconomyCorp) provides Biotechnology Commercialisation Fund 2.0 (BCF 2.0) to facilitate on-going commercialisation of bio-based products and services as well as provide assistance in expanding applicants' existing bio-based businesses among the BioNexus Status companies. BCF 2.0 received a total allocation of RM 10.0 million each for 2016 and 2017 (Table 6.2). In 2017, two projects were approved with a total amount of RM6.6 million. This was the only year a successful application recorded during 2016-2020. At the same time, BioeconomyCorp received a total of RM35.0 million for Bioeconomy Transformation Programme (BTP), in which RM25.0 million was received in the 10th MP and RM10.0 million in the 11th MP. All the allocation was fully committed in funding 6 BTP projects in 2013-2017 (Table 6.3).

Table 6.2 Biotechnology Commercialisation Fund 2.0, 2016-2020

Year	Allocation (RM million)	Number of Project	Amount (RM million)
2016	10.0	0	0.0
2017	10.0	2	6.6 ^a
2018	0.0	0	0.0
2019	0.0	0	0.0
2020	0.0	0	0.0

Note: ^a 2 applications were approved but 1 applicant had declined the offer. The successful applicant however had decided to reduce their commitment for the BCF 2.0 Programme from RM3.0 million to RM2.0 million; data as of September 2020

Source: Malaysian Bioeconomy Development Corporation Sdn Bhd

Table 6.3 Bioeconomy Transformation Programme, 2013-2017

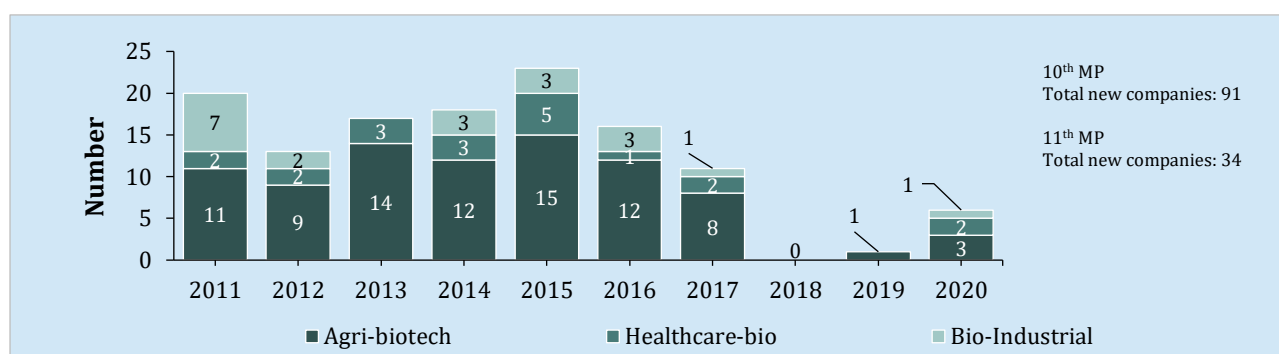
Year	Allocation (RM million)	Number of Project	Amount (RM million)
2013	25.0	0	0.0
2014	0.0	0	0.0
2015	10.0	3	11.9
2016	0.0	2	14.4
2017	0.0	1	8.7

Note: Data as of September 2020

Source: Malaysian Bioeconomy Development Corporation Sdn Bhd

BioeconomyCorp awards BioNexus status to qualified international and Malaysian biotechnology companies that participate and undertake value-added biotechnology activities. BioNexus Status companies enjoy incentives and privileges contained within the BioNexus Bill of Guarantees. Figure 6.5 shows a total of 125 new BioNexus companies have been approved during 2011-2020 with the highest number in the sub-sector of Agri-biotech (85). This is followed by companies in Healthcare-bio and Bio-industrial with 20 companies for each sub-sector. Notably, the number of new approved companies has significantly decreased from 91 companies in 10th MP to only 34 companies in 11th MP.

Figure 6.5 New Approved BioNexus Companies, 2011-2020

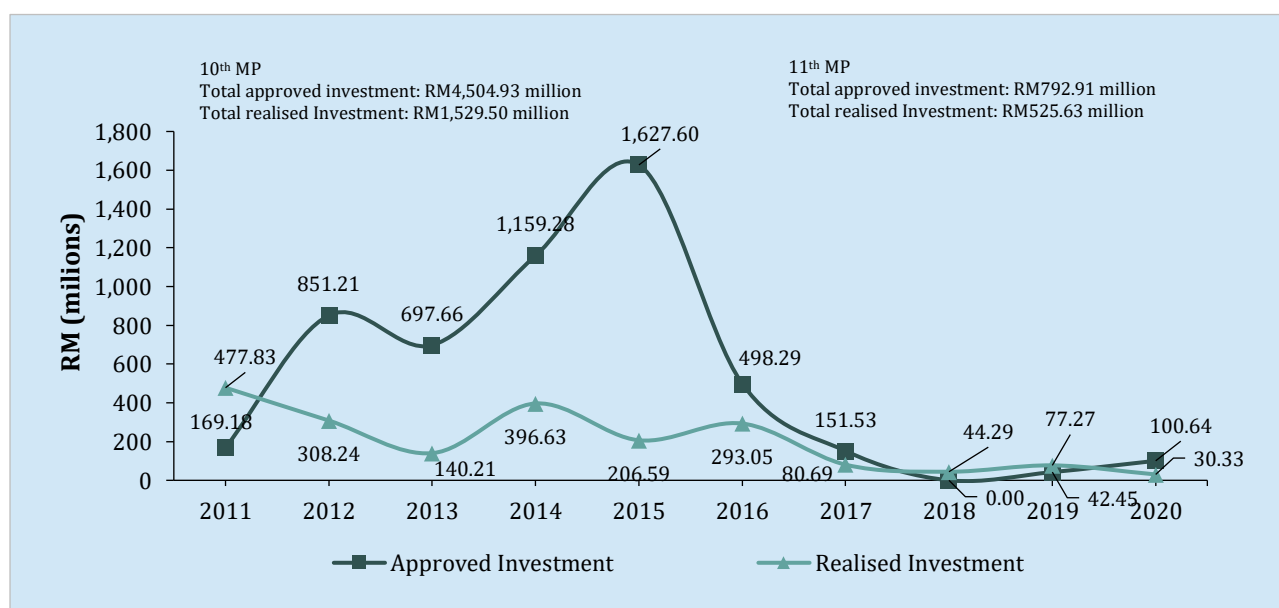


Note: Data as of June 2020

Source: Malaysian Biotechnology Corporation Sdn Bhd

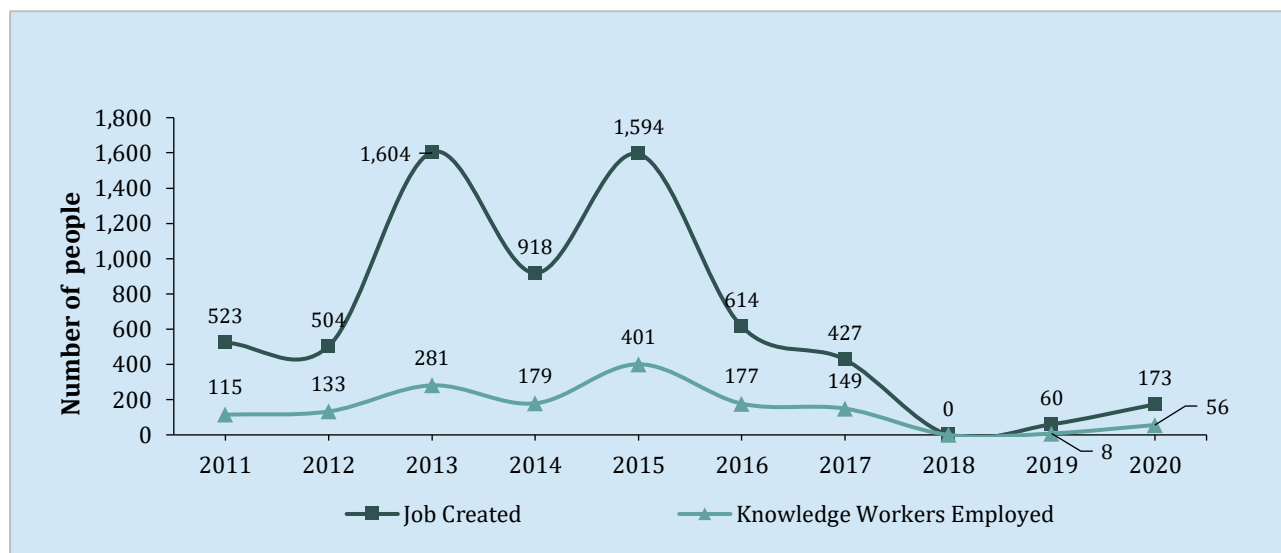
Total approved investment dropped from RM4,504.93 million (in 10th MP) to RM792.91 million (in 11th MP); while the total realised investment declined from RM1,529.50 million (in 10th MP) to only RM525.63 million (in 11th MP) (Figure 6.6). The same downward trend is observed in terms of the number of jobs created and knowledge workers employed by BioNexus companies during the same period (Figure 6.7). The total number of jobs created declined from 5,143 person (in 10th MP) to 1,274 persons (in 11th MP); while knowledge workers employed declined from 1,109 persons (in 10th MP) to only 390 persons (in 11th MP). Total R&D expenditure dropped from RM473.80 million (in 10th MP) to RM336.10 million (in 11th MP). Nonetheless, there was an encouraging growth in terms of revenue of BioNexus companies in which the total revenue has increased from RM5,728.69 million (in 10th MP) to RM6,374.59 million (in 11th MP) (Figure 6.5).

Figure 6.6 Approved and Realised Investment by BioNexus Companies, 2011-2020



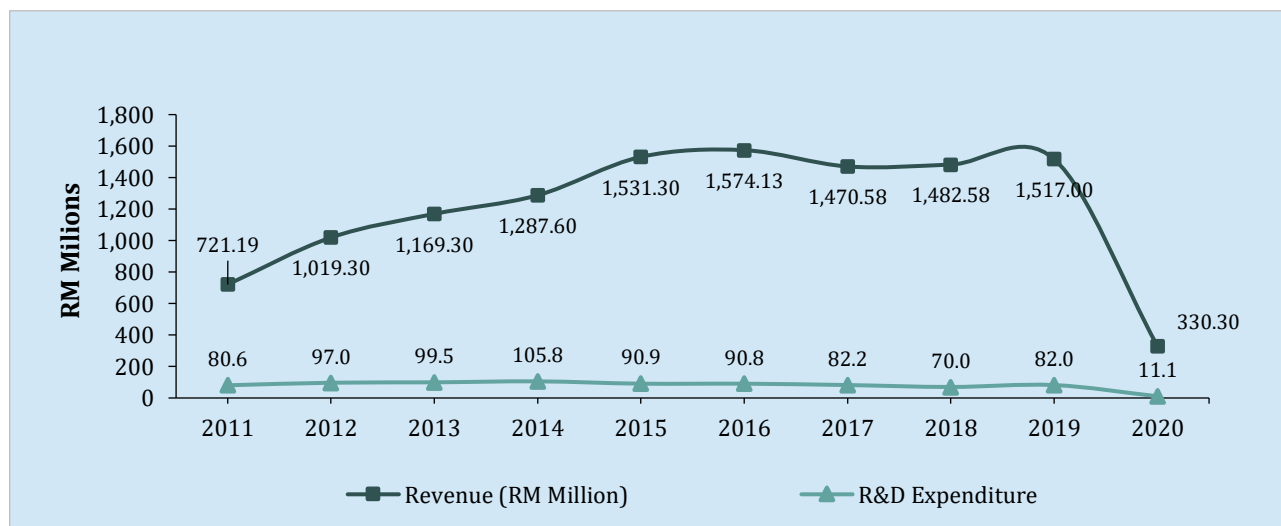
Note: Data as of June 2020

Source: Malaysian Bioeconomy Development Corporation Sdn Bhd

Figure 6.7 Jobs Created and Knowledge Workers by BioNexus Companies, 2011-2020

Note: Data as of June 2020

Source: Malaysian Bioeconomy Development Corporation Sdn Bhd

Figure 6.8 R&D Expenditure and Revenue of BioNexus Companies, 2011-2020

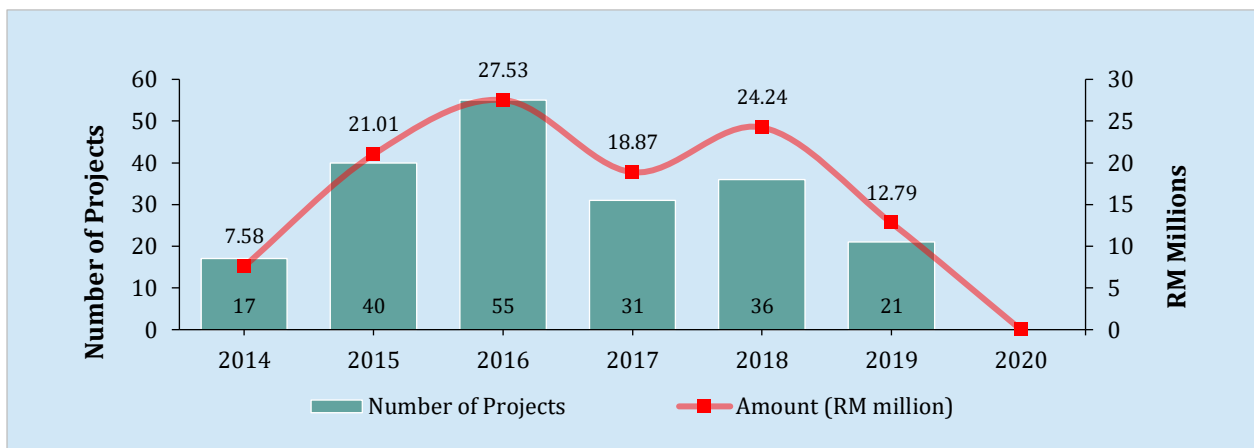
Note: Data as of June 2020

Source: Malaysian Bioeconomy Development Corporation Sdn Bhd

6.3.3 PlaTCOM Ventures

As a consultancy company and technology commercialisation platform, PlaTCOM Ventures Sdn. Bhd. provides HIP2 Concept to Commercialisation Gap Fund (CCGF) to support Malaysian SMEs, start-ups and specific projects (as identified from time to time by PlaTCOM) from universities and research institutions in developing and commercialising new technologies. Figure 6.9 shows the performance of CCGF in 2014-2020. A total of 200 projects with total amount of RM112.02 million have been approved during 2014-2020. As of September 2020, there was no project approved in 2020.

Figure 6.9 HIP2 Concept to Commercialisation Gap Fund, 2014-2020



Note: Data as September 2020

Source: PlatCOM Ventures Sdn. Bhd

6.3.4 Malaysia Venture Capital Management Berhad

AXIATA Digital Innovation Fund (ADIF) was launched in 2015. The fund is a collaborative effort between Axiata Group Bhd and Malaysia Venture Capital Management Bhd (MAVCAP) that aims to build up the capabilities of local digital companies, especially bumiputera companies, in becoming successful regional and international players. The target sectors are e-commerce, location-based services, big data analytics, IoT, traditional to cloud services, Fintech and other innovative companies. Table 6.4 shows the performance of ADIF in 2015-2020. MAVCAP has committed RM20.00 million to the total fund size of RM80.40 million. There were 17 investee companies with the total invested amount of RM54.93 million. At the same time, MAVCAP has committed to 11 venture capital funds as listed in Table 6.5. The highest committed fund by MAVCAP was ECM Straits Fund I in 2014 and Gobi Fund III in 2015.

Table 6.4 AXIATA Digital Innovation Fund, 2015-2020

MAVCAP Commitment (RM)	Fund Size Amount (RM)	Number of Investee Companies	Invested Amount (RM)
20,000,000	80,400,000	17	54,934,249

Note: Data as September 2020

Source: MAVCAP

Table 6.5 MAVCAP Venture Capital Fund, 2013-2020

Year (and Fund)	MAVCAP Commitment (RM)*	Fund Size Amount (RM)*	Number of Investee Companies	Invested Amount (RM)
2013 (500 Startups III)	10,719,150	369,536,949	677	364,241,944
2014 (ECM Straits Fund I)	107,562,500	215,125,000	12	132,481,091
2014 (500 Durians)	34,420,000	108,727,216	122	98,015,752
2015 (Gobi Fund III)	107,562,500	515,869,750	30	263,374,263
2016 (Gobi MAVCAP Asean Superseed Fund)	20,148,512	60,600,000	21	46,042,375
2017 (500 Durians II)	21,620,075	226,424,500	104	138,192,243
2017 (Meranti Asean Growth Fund)	86,050,000	482,740,500	15	296,201,448
2018 (Vynn Capital Emergence Fund)	12,907,500	24,524,250	5	13,208,675
2019 (Lunex Ventures)	4,302,500	18,048,987	12	6,170,073
2020 (Asia Greentech Fund I)	43,025,000	86,050,000	0	0
2020 (Superseed Fund II)	13,500,000	30,375,000	0	0

Note: Data as September 2020; Exchange rate USD1 = RM4.3025 as at 31.3.2020
Source: MAVCAP

6.3.5 Malaysia Debt Ventures Berhad

Malaysia Debt Ventures Berhad (MDV) is wholly owned by the Ministry of Finance Inc. Malaysia and it has been operating since 2003. MDV finances ICT, biotechnology and green energy projects. In this respect, Intellectual Property Financing Scheme (IPFS) assists SMEs for easier access to credit through their IP assets. Companies are allowed to use their IPRs as an alternative source of collateral to obtain funding in securing additional investments for technology capabilities development. The fund is administered by Malaysia Debt Venture (DVC). Table 6.6 indicates that a total of 17 projects amounting to RM50.27 million were approved during 2014-2016. Out of these approved projects, 12 of the projects (RM36.69 million) have been successfully executed (Table 6.6). At the same time, in collaboration with MOSTI, BiotechCorp and EPU, MDV provides Bumiputera, Biotechnology & Bio-Industry Development Fund (B3DF) to enhance Bumiputera's participation in the biotechnology and bio-industry sector. However, only one B3DF project with the value of RM5.00 million has been approved in 2016 (Table 6.7).

In addition, MDV provides RMK10-Pre-Commercialisation Financing – a special financing scheme for early stage and/or pre-commercialise companies in technology focus sectors such as ICT, biotechnology and green energy. The scheme aims to enhance the technology financing ecosystem and improve Malaysia's commercialisation rate, focusing on underserved financing space for commercialisation requirements. The scheme is the collaboration between MDV and MOF Inc. Berhad and Table 6.8 shows the performance of the schemes for the periods of 2012-2019.

Table 6.6 Intellectual Property Financing Scheme, 2014-2016

Year	Projects Approved ^[1]		Projects Executed ^[2]	
	Number of Projects	Amount (RM)	Number of Projects	Amount (RM)
2014	10	32,640,000	8	29,440,000
2015	6	16,130,000	3	5,750,000
2016	1	1,500,000	1	1,500,000
TOTAL	17	50,270,000	12	36,690,000

Note: ^[1] Based on the actual approval after pre-screening of applications; including the ones approved but later cancelled/rejected (not yet activated). ^[2] Based on financing facilities which are being actually executed/activated upon approval. Data as September 2020

Source: MDV

Table 6.7 Bumiputera, Biotechnology & Bio-Industry Development Fund, 2016

Year	Projects Approved ^[1]		Projects Executed ^[2]	
	Number of Projects	Amount (RM)	Number of Projects	Amount (RM)
2016	1	5,000,000	1	5,000,000

Note: ^[1] Based on the actual approval after pre-screening of applications; including the ones approved but later cancelled/rejected (not yet activated). ^[2] Based on financing facilities which are being actually executed/activated upon approval. Data as September 2020.

Source: MDV

Table 6.8 RMK 10 - Pre-Commercialisation Financing, 2012-2019

Year	Projects Approved ^[1]		Projects Executed ^[2]	
	Number of Projects	Amount (RM)	Number of Projects	Amount (RM)
2012	4	8,400,000	2	5,300,000
2013	7	20,370,000	3	10,700,000
2014	9	19,600,000	6	11,500,000
2015	6	16,000,000	4	8,000,000
2016	1	2,200,000	0	0
2017	1	1,000,000	1	1,000,000
2018	8	11,175,000	6	6,975,000
2019	1	650,000	1	650,000

Note: ^[1] Based on the actual approval after pre-screening of applications; including the ones approved but later cancelled/rejected (not yet activated). ^[2] Based on financing facilities which are being actually executed/activated upon approval. Data as September 2020

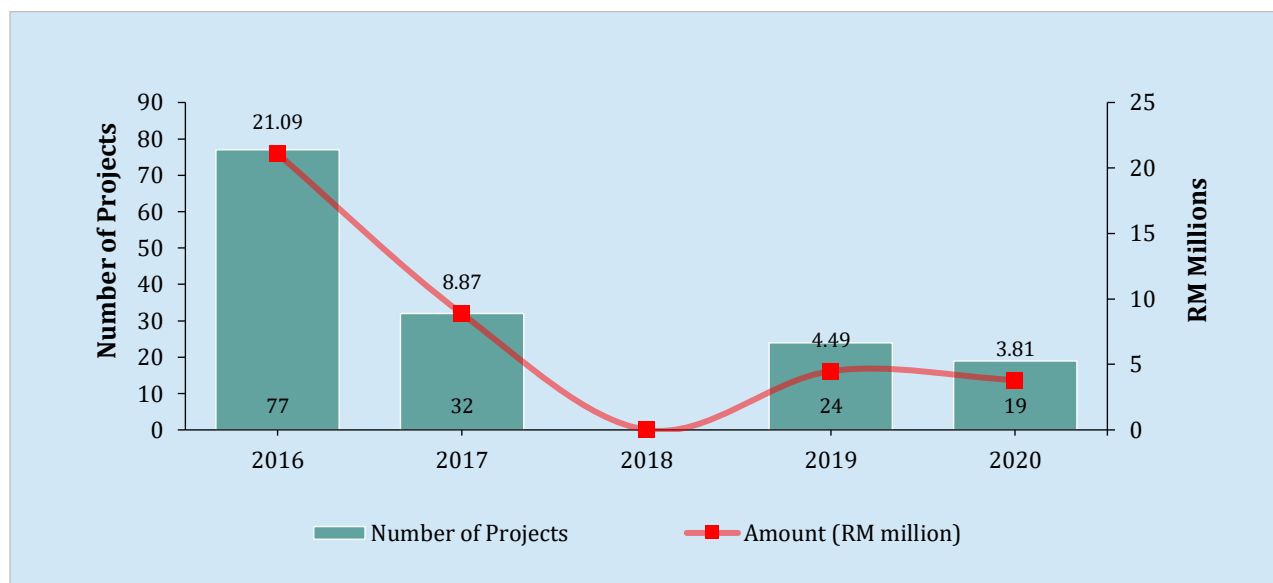
Source: MDV

6.3.6 Malaysia Social Innovation Fund

Malaysia Social Innovation Fund (MySI) is an initiative by MOSTI to improve the well-being of the community in rural areas using existing technology to meet social needs. MySI aims to improve the well-being of the community giving priority to the B40 group through the implementation of innovative local R&D technology application projects that have been developed and ready to be implemented sustainably. In 2016-2020, a total of 152 MySI projects

with a value of RM38.26 million have been approved (Figure 6.10). Box 6.2 illustrates one of the successful MySI projects.

Figure 6.10 MySI, 2016-2020



Note: Data as of October 2020

Source: MOSTI, Malaysia

Box 6.2 MySI Project on LED EX-LiT Solar Street Light.

A research team from Technology Park Malaysia received MySI in 2016 to develop and disseminate LED EX-LiT Solar Street Light for local communities. The main objectives of the project were to introduce solar energy-based street lighting technology to the community, and provide a better lighting system to the villagers. This six-month project was also to support the government's efforts to promote locally developed products with elements of green technology. The project has successfully reduced the crime rate in the project areas by 30%.

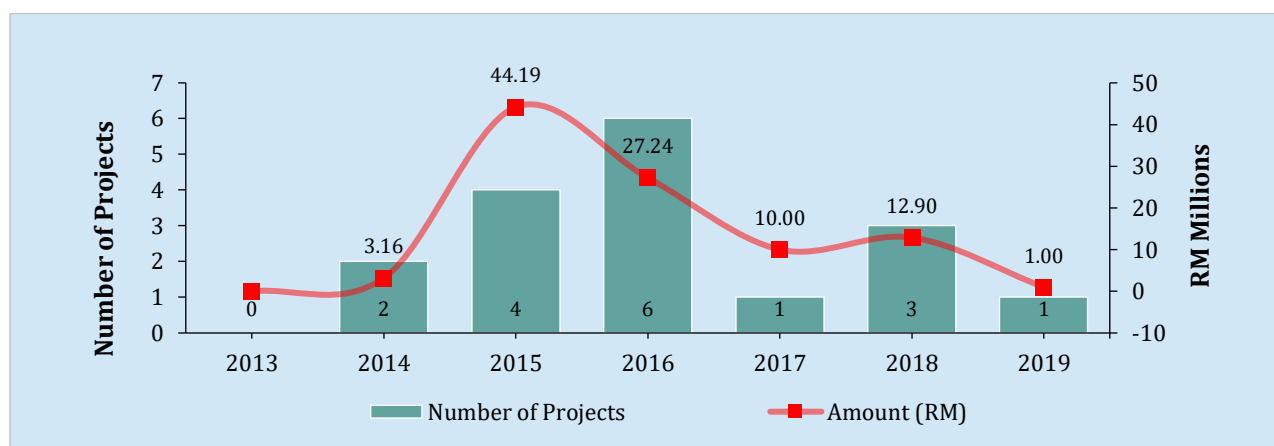


The launch of LED solar street lights at Kampung Hailan Jetty, Tangga Batu, Melaka

Source: Technology Transfer and Commercialisation of R&D Division, MOSTI

6.3.7 Kumpulan Modal Perdana Sdn. Bhd.

Kumpulan Modal Perdana Sdn. Bhd. provides E&E Fund – a venture capital fund focusing on investing into growing companies with high growth visibility within the E&E space. This venture capital fund invests on deep technology companies that have high growth visibility within the E&E and in renewable energy or green technology sectors. Figure 6.16 shows that a total of 17 projects valued RM98.49 million have been approved during 2013-2019 (Figure 6.11).

Figure 6.11 E&E Fund, 2013-2019

Note: Data as of September 2020

Source: Kumpulan Modal Perdana Sdn. Bhd.

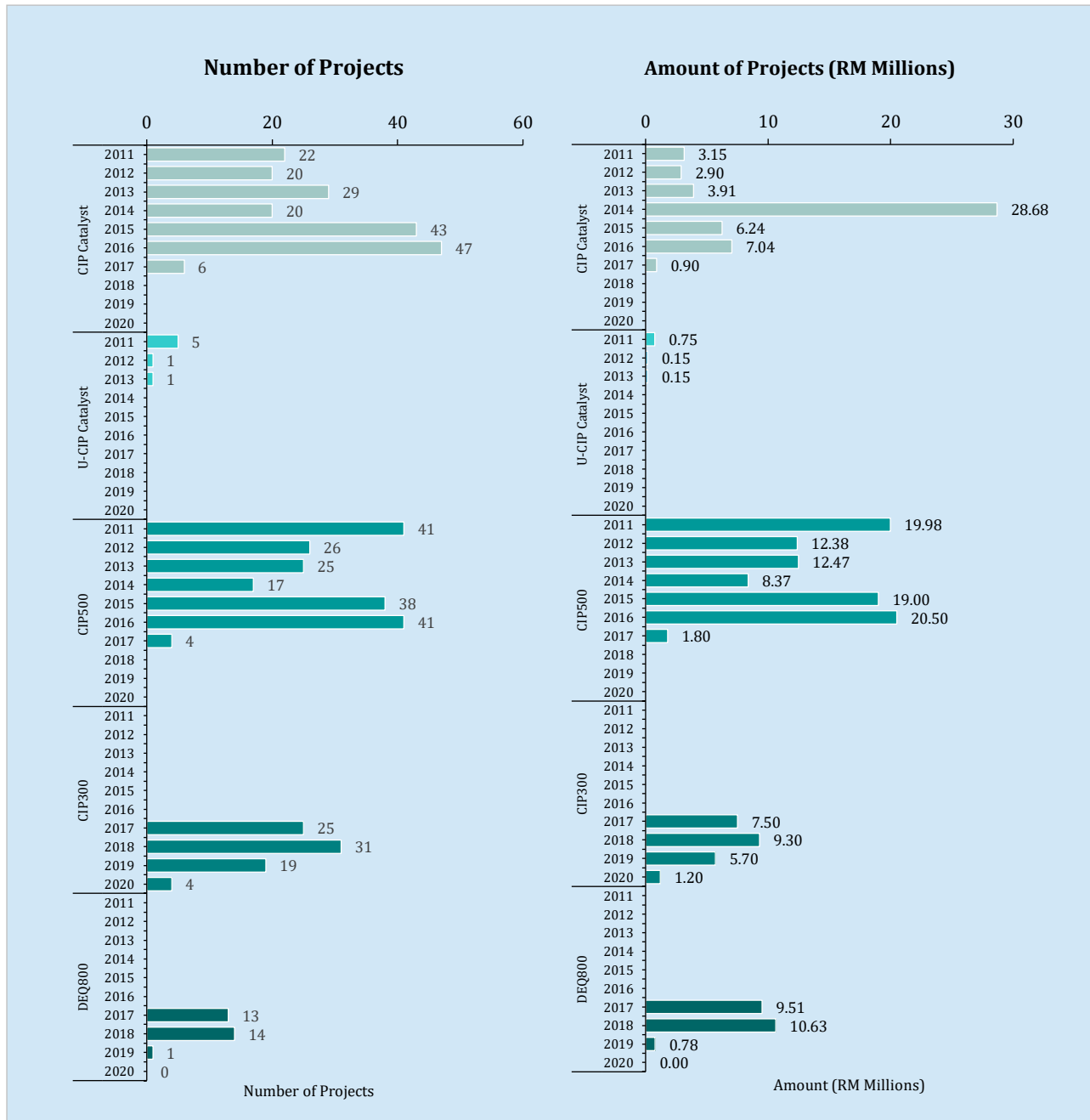
6.3.8 Cradle Fund Sdn. Bhd.

Seed financing (or seed funding or seed capital) is the early-stage funding to support newly established innovative technology companies and ventures. The fund is primarily used to support essential expenses such as company operation, market research and the creation of prototype. Cradle Fund Sdn. Bhd. provides several seed capital or CIPs, namely CIP Catalyst, U-CIP Catalyst, CIP500, CIP300 and Direct Equity 800 (DEQ800). Figure 6.12 shows the performance of these funds in terms of number and value of projects approved during 2011-2020. During 2011-2017, CIP500 (with total 192 approved projects, RM94.50 million) and CIP Catalyst (with total 187 approved projects, RM52.82 million) were the two main programmes offered by Cradle Fund Sdn. Bhd. CIP300 and DEQ300 were newly launched programmes since 2017. From 2017-2020, CIP300 (with total 79 approved projects, RM23.70 million) has the higher number and value of approved projects in comparison to DEQ800 (with total 28 approved projects, RM20.92 million) as of September 2020.

Cradle Fund Sdn. Bhd. also provides Coach and Growth Programme (CGP) and Angel Tax Incentives (ATI) in 2018-2020 (Table 6.9). CGP is a public-private partnership programme bringing together key players in the entrepreneurial ecosystem to nurture and grow existing entrepreneurs via coaching. A total of 212 projects valued at RM6.84 million have been approved in 2018-2019. On the other hand, ATI aims to bridge the early-stage investment gap by encouraging qualified individual investors to invest in early-stage technology start-ups in Malaysia. Only one ATI project amounting RM400,000 has been approved in 2018-2020. CIP Ignite (i), CIP Ignite (ii) and CIP Accelerate are new funding programmes that provides a conditional grant and value-added assistance to technology start-ups, local SMEs or spin-off companies from universities and research institutes. CIP Ignite (i) is for deep tech companies at Technology Readiness Level (TRL) 5 to 7; CIP Ignite (ii) is for non-deep tech companies at TRL 8 to 9; while CIP Accelerate is for deep tech companies at TRL 8-9 and with market

validated product via paying customer. In 2020, Cradle has approved 7 CIP Ignite (ii) projects (RM3.50 million) and 4 CIP Accelerate projects (RM8.00 million).

Figure 6.12 Cradle Funds, 2011-2020



Note: Data as of September 2020.

Source: Cradle Fund Sdn. Bhd.

Table 6.9 Cradle Programmes and Incentives, 2018-2020

Type of Programmes	2018		2019		2020	
	No. of Projects	Amount (RM)	No. of Projects	Amount (RM)	No. of Projects	Amount (RM)
CGP	104	3,339,209	0	0	108	3,496,940
Angel Tax Incentive	1	400,000	0	0	0	0
CIP Ignite (i)	-	-	-	-	0	0
CIP Ignite (ii)	-	-	-	-	7	3,500,000
CIP Accelerate	-	-	-	-	4	8,000,000

Note: Data as of September 2020.

Source: Cradle Fund Sdn. Bhd.

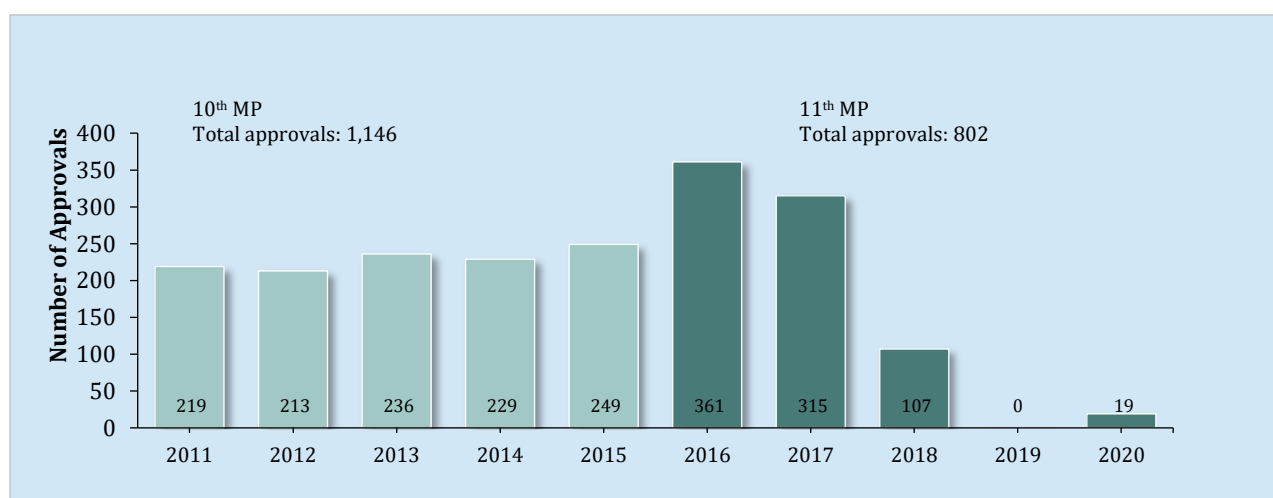
6.4 STI Tax Incentives

6.4.1 MSC Malaysia Status and Research Incentive

MSC Malaysia status is a recognition given by the Government of Malaysia through MDEC for ICT establishments in the country. Being awarded MSC Malaysia Status, an enterprise is given access to exclusive incentives to increase their competitiveness in IT industry. These incentives are in forms of, among others, pioneer status privilege with tax exemption, investment tax allowance, R&D grants, duty-free importation of multimedia equipment and IP protection. The number of applications and approvals have declined drastically since 2018. There were 1,146 companies awarded MSC Status in 10th MP compared 802 companies in 11th MP (Figure 6.13).

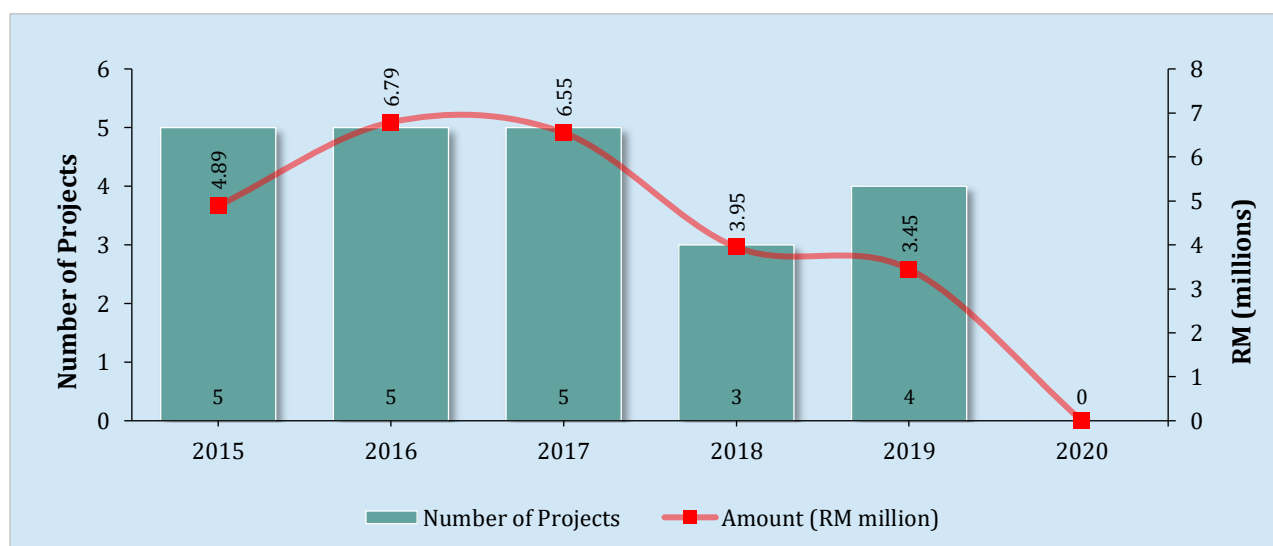
MDEC also provides Research Incentive Scheme for Enterprises (RISE) to enhance technology absorption and allow local companies to hire experienced researchers to be based locally at a competitive cost. The incentive also allows local companies to set up R&D centres that focus on high value-added activities. MDEC approved 22 RISE projects during 2015-2020 accounting for RM25.63 million (Figure 6.14). Data shows that the number of approved projects to be in the range of 3-5 projects during 2015-2019. There is no approved project in 2020 (as of September 2020).

Figure 6.13 MSC Malaysia Status, 2011-2020



Note: *cases presented at approval committee; data as of 23 September 2020
Source: MDEC

Figure 6.14 MDEC Research Incentive Scheme for Enterprises, 2015-2020



Note: *cases presented at approval committee; data as of 23 September 2020
Source: MDEC

6.4.2 MIDA R&D Investment Incentives

MIDA offers various tax incentives to promote industry participation in undertaking R&D related activities. These incentives cover pioneer status with income tax exemption, investment tax allowance and infrastructure allowance. Those eligible companies or activities are: Contract R&D Company, R&D Company, In-House R&D, Pre-packaged R&D, and R&D Status Company. Table 6.10 provides information on MIDA R&D investment incentives in terms of the number of new projects approved, number of employments generated and capital investments for the periods of 2011-2019.

MIDA approved 84 new projects during 2011-2020. The highest number of approved projects was during 10th MP with 57 projects. The number decreased to only 27 projects in 11th MP. Overall, R&D Contract (35 projects) and R&D Status (24 projects) were the main approved projects. In respect to employment, a higher number of employment was recorded in 10th MP (2,200) compared to 11th MP (1,388). R&D Status projects contribute the most to the total employment (1,177). In terms of capital investments, the projects have attracted RM1,625.07 million investment in which RM874.20 million (or 53.79%) was recorded in 10th MP and RM750.87 million (or 46.21%) in 11th MP. Out of the total investment, RM888.97 million (or 54.70%) was contributed by domestic investors, while RM736.10 million (or 45.30%) was provided by foreigners. R&D Contract and R&D Inhouse projects have contributed the biggest share in 10th MP and 11th MP, respectively.

Table 6.10 MIDA R&D Investment Incentives, 2011-2019

Number New Approved Projects					
	R&D Company	R&D Contract	R&D Inhouse	R&D PrePackaged	R&D Status
10 th MP	1	28	4	10	14
11 th MP	3	7	6	1	10
Number of Employment					
	R&D Company	R&D Contract	R&D Inhouse	R&D PrePackaged	R&D Status
10 th MP	11	470	107	796	816
11 th MP	49	302	666	10	361
Capital Investments (RM million)					
	R&D Company	R&D Contract	R&D Inhouse	R&D PrePackaged	R&D Status
10 th MP	14.57	330.00	82.27	310.68	136.68
11 th MP	25.39	189.78	356.50	31.44	147.76

Note: Data as of September 2020

Source: Malaysian Investment Development Authority

6.5 Issues and Challenges

National R&D Survey 2019 indicates that the top three types of R&D incentives received by BEs are R&D grant/matching grant, pioneer status and income tax exemption. The top three main issues reported by the BEs during the grant and incentive application were mainly related to the lack of information and accessibility on R&D incentives, unclear definition of R&D incentives, and the unclear application procedures. For BEs that did not take advantage of government R&D incentives, they perceived the existing R&D incentives not to suit their needs. Like those BEs that received public funding supports, among other common reasons for not utilising the R&D incentives were lack of information, not aware of the incentive and complicated process. At the same time, HLIs, GRIs and NGOs reported that they suffered from insufficient government funding as one of the top limitations in their R&D activities. Thus, it is crucial to review the public funding system as to streamline and enhance the management of the funding system. Likewise, the managerial capabilities of BEs in grant management should also be strengthened.

Meanwhile, there was a significant decrease in terms of number and amount of R,D&C projects approved in the 11th MP in comparison to 10th MP. This was particularly obvious in the grants and programmes provided by MOSTI, and performance of BioNexus companies and MSC Malaysia Status. Government should ensure investments in R,D&C are sustainable even during economic uncertainties.

6.6 Summary

Malaysia's public funding schemes consists of grants, loans and incentives in supporting R,D&C projects. There are numerous funding schemes managed and coordinated by the respective ministries and their agencies within the funding ecosystem. MOSTI, MOHE, MOH and CREST are the main ministries and organisations responsible for R&D grants, while MTDC, BioeconomyCorp, PlaTCOM Ventures, MAVCAP, MDV, MySI, Kumpulan Modal Perdana Sdn. Bhd., and Cradle Fund Sdn. Bhd. are playing important roles in supporting industry development and commercialisation. Meanwhile, there are STI tax incentives – such as MSC Malaysia status and research incentives, as well as MIDA R&D investment incentives, available for firms that made investments in key national priority areas. Although Government is always supportive in fostering and promoting R,D&C, there was a significant decrease in terms of amount and number of projects approved in the 11th MP.

7

INNOVATION IN MANUFACTURING AND SERVICES

CHAPTER 7: INNOVATION IN MANUFACTURING AND SERVICES SECTORS**7.1 Introduction**

Innovation is fundamental to socio-economic growth. Firms and industries compete on the basis of innovation. A critical issue is the nature of the relationship between investments in resources, like R&D and realized innovative output and how innovation subsequently affects performance in terms of enhanced competitiveness as well as improved productivity. Through an understanding of these and other related issues pertaining to innovation Malaysia can shape and steer its innovation policies to ensure the continued dynamism of its manufacturing and services sectors. The MASTIC undertook the first National Survey of Innovation (NSI) in 1994, targeting the manufacturing sector in Malaysia to establish the level of innovation activities. Since then, seven more surveys have been conducted, and in the 2005 – 2008 survey the services sector in Malaysia was included. The latest NSI-2018 covers innovation activities over the period 2015 – 2017. This chapter reports the findings of the 2018 survey and compares the innovation activities across manufacturing and services sectors. It addresses the following key aspects: (1) Overview of innovation in the Malaysian manufacturing and services sectors; (2) Innovation activities in the manufacturing and services sectors; (3) Objectives and effects of innovation; (4) Resources for innovation activities; (5) IP and Protection; (6) Factors hampering Innovation Activities; (7) IR 4.0; and (8) International Comparison. Comparisons of the survey results must be treated with caution owing to changes, among others, in the composition of the respondents.

7.2 Overview of Innovation in the Malaysian Manufacturing and Services Sectors

The NSI-2018 examined a total of 2,020 companies with 717 enterprises (or 35.5% of total) from the manufacturing sector and 1,303 companies (64.5%) from the services sector. The following sections describe the profile of innovative companies in both the manufacturing and services sectors including types of ownership, size of enterprises, annual sales turnover, innovation activities and expenditure on innovation activities.

7.2.1 Innovative and Non-Innovative Companies

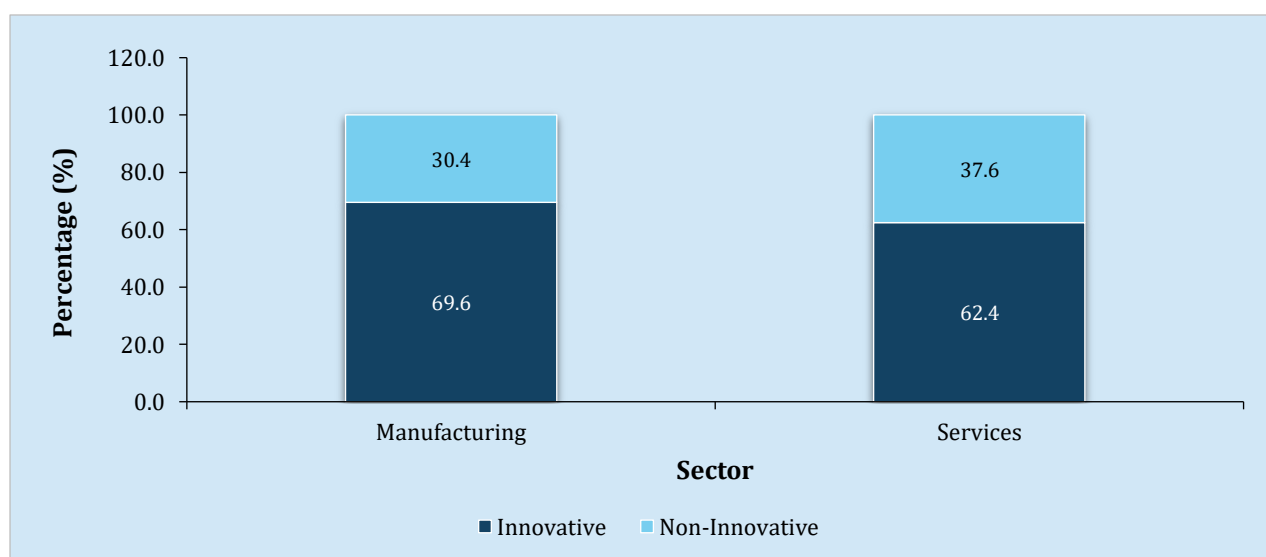
The NSI-2018 survey revealed that 65.0% of the respondents can be categorized as innovative companies while 35.0% are non-innovative companies. By comparison, in 2015, 72.0% of the companies surveyed were innovative companies, while 28.0% were non-innovative companies (Table 7.1).

Table 7.1 Innovative and Non-Innovative Companies, 2015 and 2018

Companies	2015		2018	
	Number of Companies	Percentage (%)	Number of Companies	Percentage (%)
Innovative	1,213	72.0	1,312	65.0
Non-Innovative	472	28.0	708	35.0
TOTAL	1,685	100	2,020	100

Source: National Survey of Innovation 2018

At a sectoral level, 69.6% of the manufacturing firms reported that they are innovative while 62.4% reported the same for the services sector. Likewise, 30.4% of the manufacturing firms are non-innovative while 37.6% of the services sector reported to be non-innovative (Figure 7.1).

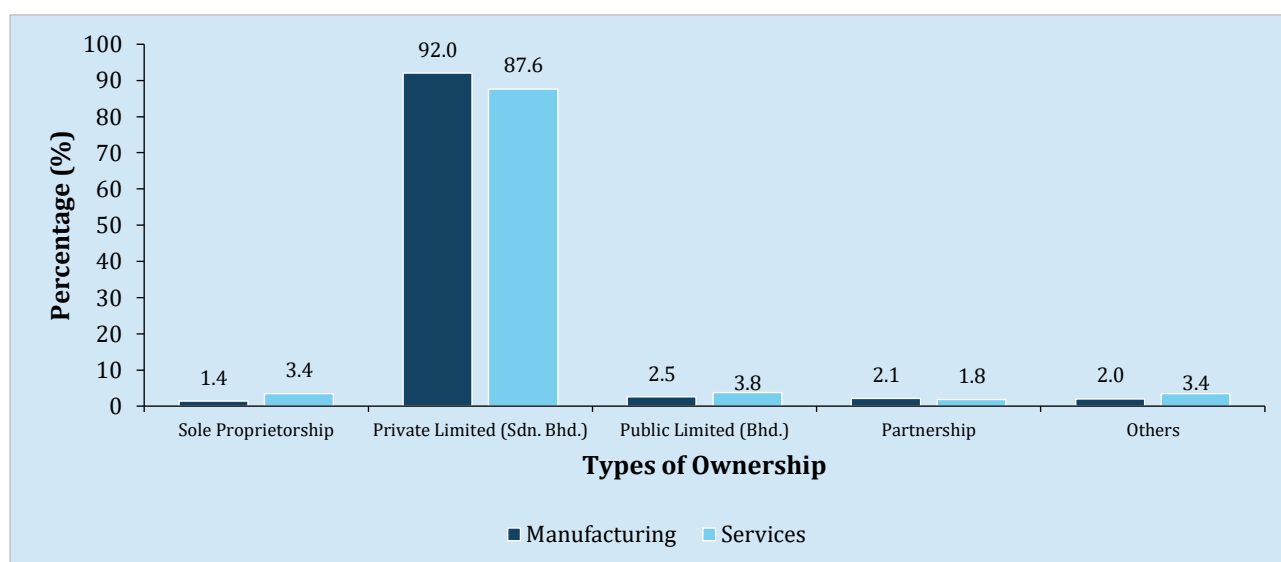
Figure 7.1 Innovative and Non-Innovative Enterprises Based on Business Sectors

Source: National Survey of Innovation 2018

7.2.2 Profile of Innovative Companies

The characteristics of the companies under examination can be described from various aspects. Both sectors exhibit similar pattern of ownership with Private Limited establishments constituting the highest proportion. This type of enterprise ownership represents 92.0% of the manufacturing sector, and 87.6% in the services sector. The rest of the companies are sole proprietorship, public limited companies or under partnership (Figure 7.2).

Figure 7.2 Types of Ownership of Companies by Sectors



Source: National Survey of Innovation 2018

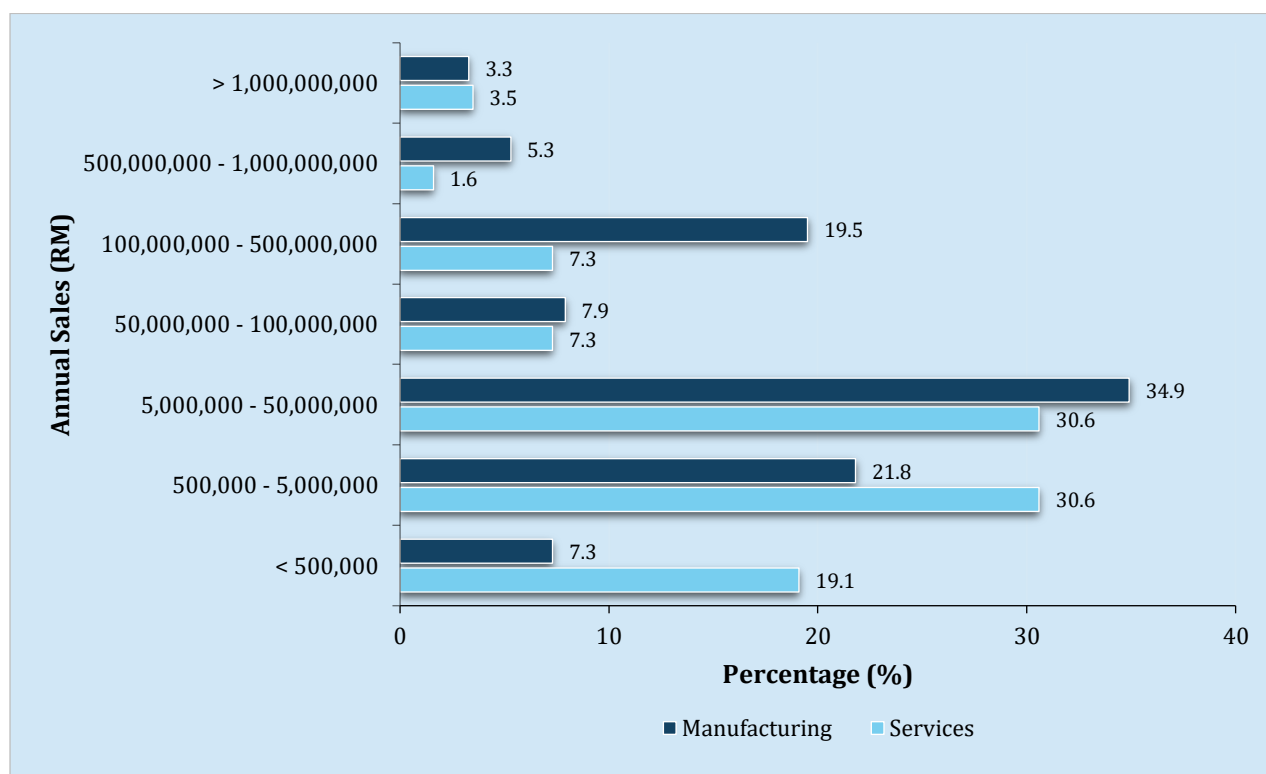
In terms of size of enterprise based on definition as used by NESDC, small and medium-sized companies represent almost 73% of the companies in the manufacturing sector and 78% in services sector (Table 7.2).

Table 7.2 Company Size by Sector, 2015 and 2018

Size of Company	2015		2018	
	Manufacturing (%)	Services (%)	Manufacturing (%)	Services (%)
Small	78.0	93.4	35.2	43.8
Medium	14.7	3.8	37.5	34.5
Large	7.3	2.8	27.3	21.7
TOTAL	100	100	100	100

Source: National Survey of Innovation 2018

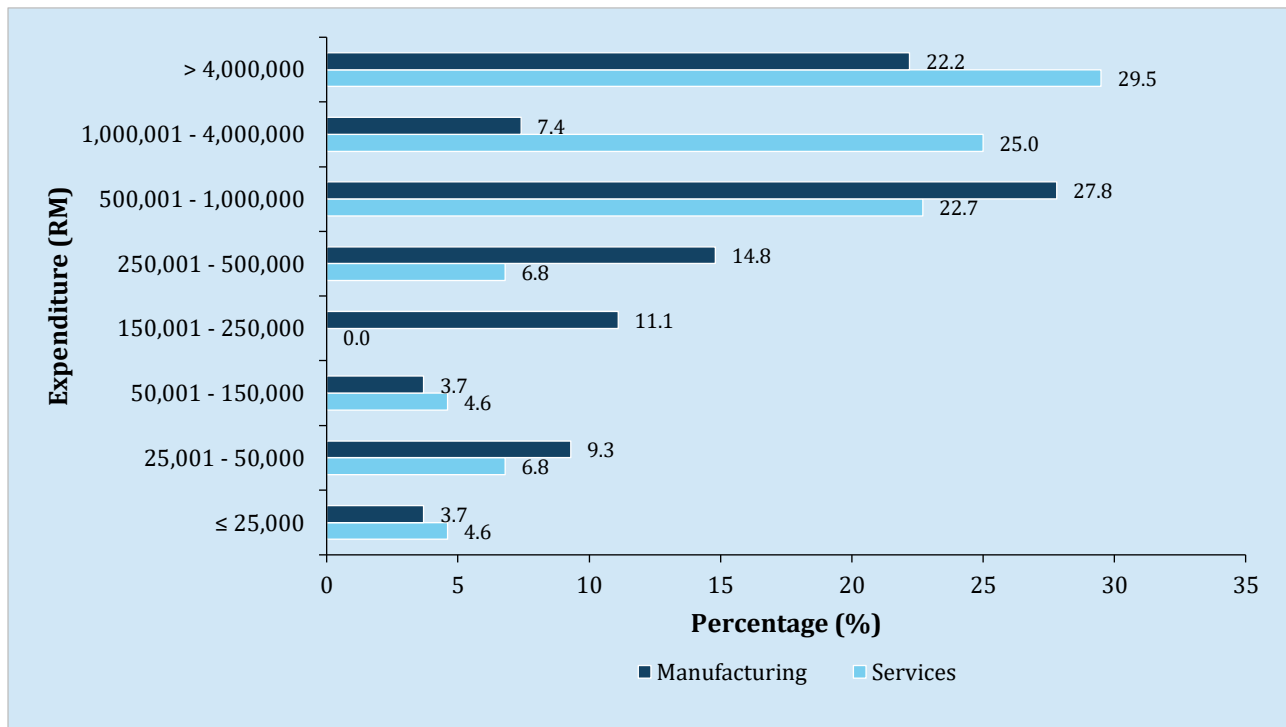
More than 70.9% and 50.3% of the companies in both the manufacturing and services sectors respectively have recorded annual sales of more than RM5 million. It is revealed that 3.3% and 3.5% of the surveyed companies in both the manufacturing and services sectors respectively have annual sales exceeding RM1 billion. The proportion of companies in the manufacturing sector (28.1%) which have achieved annual sales greater than RM100 million is more than double that of companies in the services sector (12.4%) (Figure 7.3).

Figure 7.3 Enterprise Annual Sales by Sector

Source: National Survey of Innovation 2018

Figure 7.4 reveal the details of expenditures on innovation incurred by the enterprises in the manufacturing and services sectors during the survey period. A significant proportion of firms in both the manufacturing (22.2%) and services (29.5%) sectors expended more than RM4 million on innovation-related activities. This contrasts with the small proportion (less than 2%) of such high spending firms in NSI-2015. Another distinctive feature is the very small proportion of firms engaged in minimal expenditure of RM25,000 or less on innovation as compared to the significantly higher proportion (greater than 29%) recorded in NSI-2015. The innovation-related expenditure patterns of firms in both sectors underscore the growing importance attached to innovation as a competitive tool as compared to the earlier survey.

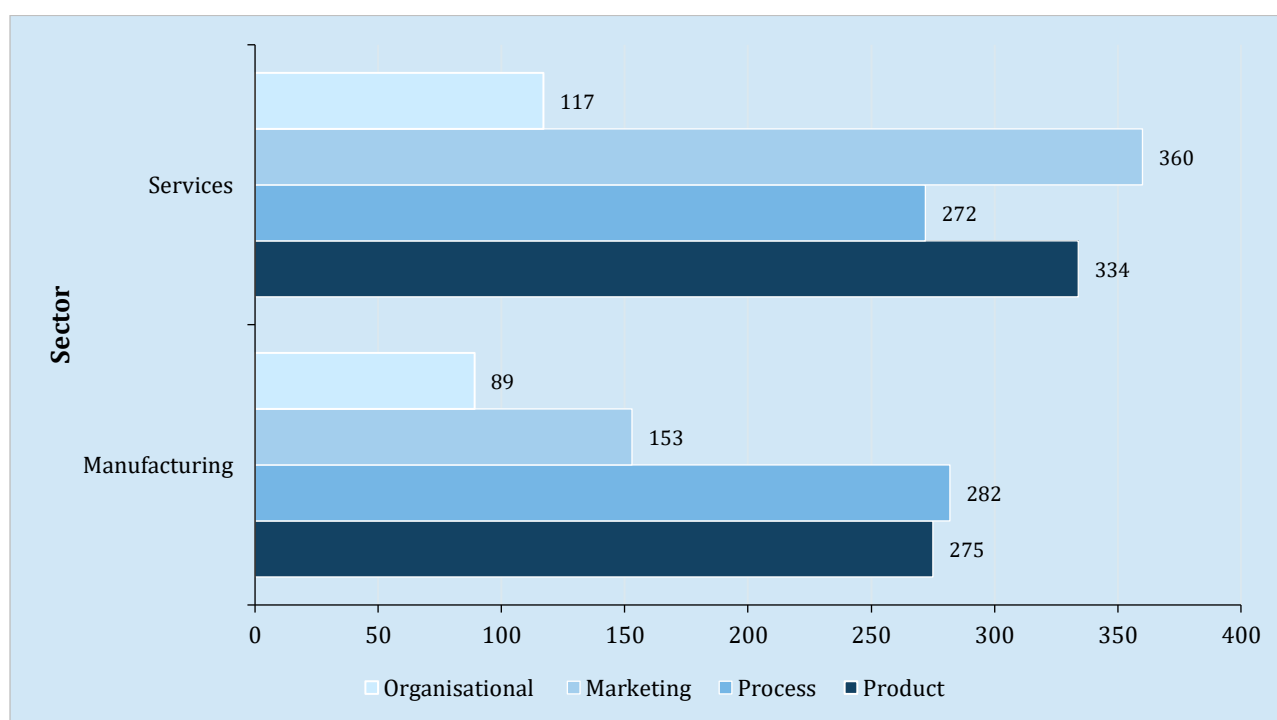
Figure 7.4 Innovation Expenditure of Companies by Sectors



Source: National Survey of Innovation 2018

7.3 Innovation Activities in the Manufacturing and Services Sectors

The NSI-2018 examined four types of innovation activities, namely, product; process; marketing; and organisational innovation. Figure 7.5 depicts the categorisation of innovation activity by type and sector. Marketing innovations, as expected, appear prominent in the services sector. In the services sector, marketing innovation tops the innovation activities followed by product, process and organisational innovation. In contrast, the manufacturing sectors focus is on process, product, marketing and organisational innovation respectively. The next section describes the innovation activities by types in more detail.

Figure 7.5 Categorization of Innovation Activities Based on Type and Business Sector

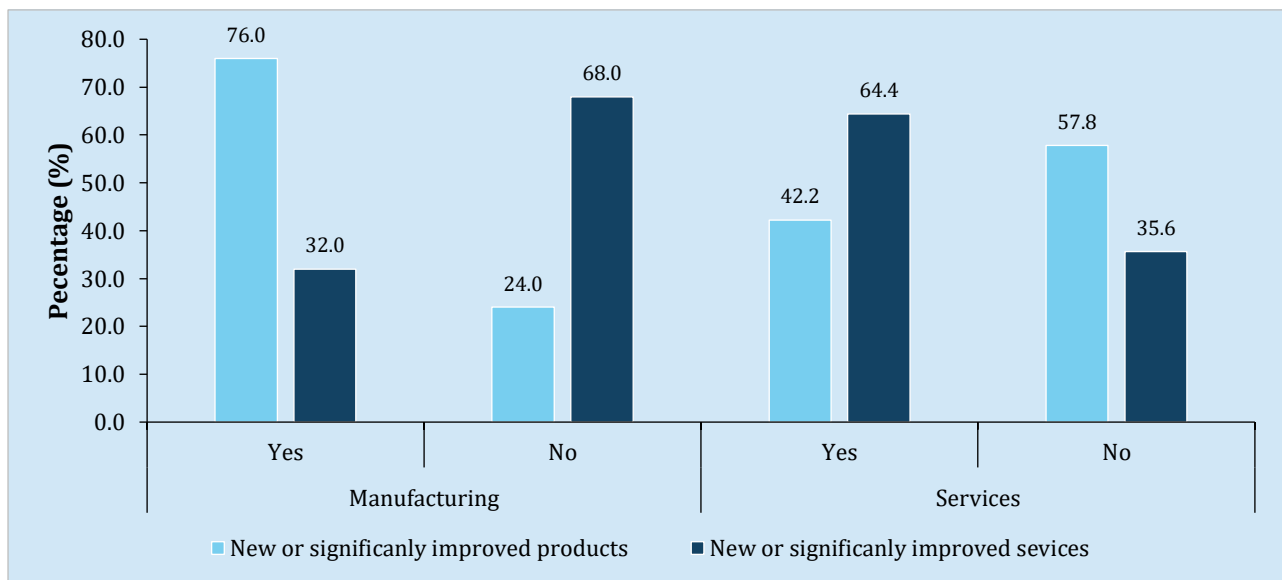
Source: National Survey of Innovation 2018

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” (Oslo Manual 2005). Most of the product innovations (76.0%) in the manufacturing sector comes from new or significantly improved products. On the other hand, the services sector reports more innovations in the new or significantly improved services variety (64.4%) as illustrated in Figure 7.6.

The innovations can be classified as new to the world, new to the market or new to the company. Most of the product innovations are new to the company as well as new to the market for both the manufacturing and services sectors. A significant proportion of the respondents in either sector (25.5% in manufacturing and 16.2% in services) have indicated that their product innovations are new to the world – far more than the below 1% reported in NSI-2015 for the same category of product innovation (Figure 7.7). This sharp increase suggests, among others, that companies are becoming more competent and confident in launching new products. Box 7.1 describes the efforts by a local company in introducing a new product for the oil and gas pipeline maintenance sector. The NSI-2018 survey reveals that there is no marked difference in the introduction of new or significantly improved products and services across size of enterprise. Additionally, the survey reports that closed innovation represents the main method for development of new or significantly improved products or services.

Figure 7.6 Product Innovation Based on Business Sectors



Source: National Survey of Innovation 2018

Box 7.1 Creating Impacts in Business through Innovations – Eureka Efektif Sdn Bhd

Eureka Efektif Sdn Bhd has established their presence as one of the preferred pipeline maintenance solutions providers in the oil and gas industry. When Eureka first started their business, the focus was more on representing foreign enterprises exclusively in Malaysia. It was not until 2010 to 2015 that the enterprise started having their own field service people to assist all these foreign partners until it reached a time when the foreign partners started sending only their tools and one of their specialists while the rest of the services were conducted by Eureka's people.

Not satisfied with just servicing products from foreign suppliers, Eureka embarked on manufacturing their very own version of cleaning pigs in their factory in Bangi. The process of planning, designing, preparing for the manufacturing plan, and testing the production of the product took almost a year. Personnel experienced in material polyurethane were hired to come out with the formulation, selection of the raw material, and the machine. The company's indigenously developed product has gone on to capture almost 70% of the Malaysian market share for this product.

Because they understood the business very well, the enterprise had not opted for the premium design, but had stuck to a design that could cater to most of their oil and gas clients. The design for both the mechanical specification and equipment were invented based on the PETRONAS technical standards, and of course the team's own experience. The technical team worked closely with machinery suppliers before deciding on which machines to purchase. This decision had saved them from buying the wrong machines that could not be utilised. After the manufacturing set up was completed, the enterprise immediately worked on getting the product certified by ISO 9001, which was granted in 2015. PETRONAS as one of their main clients came to audit Eureka in December 2015 and was satisfied with their product.

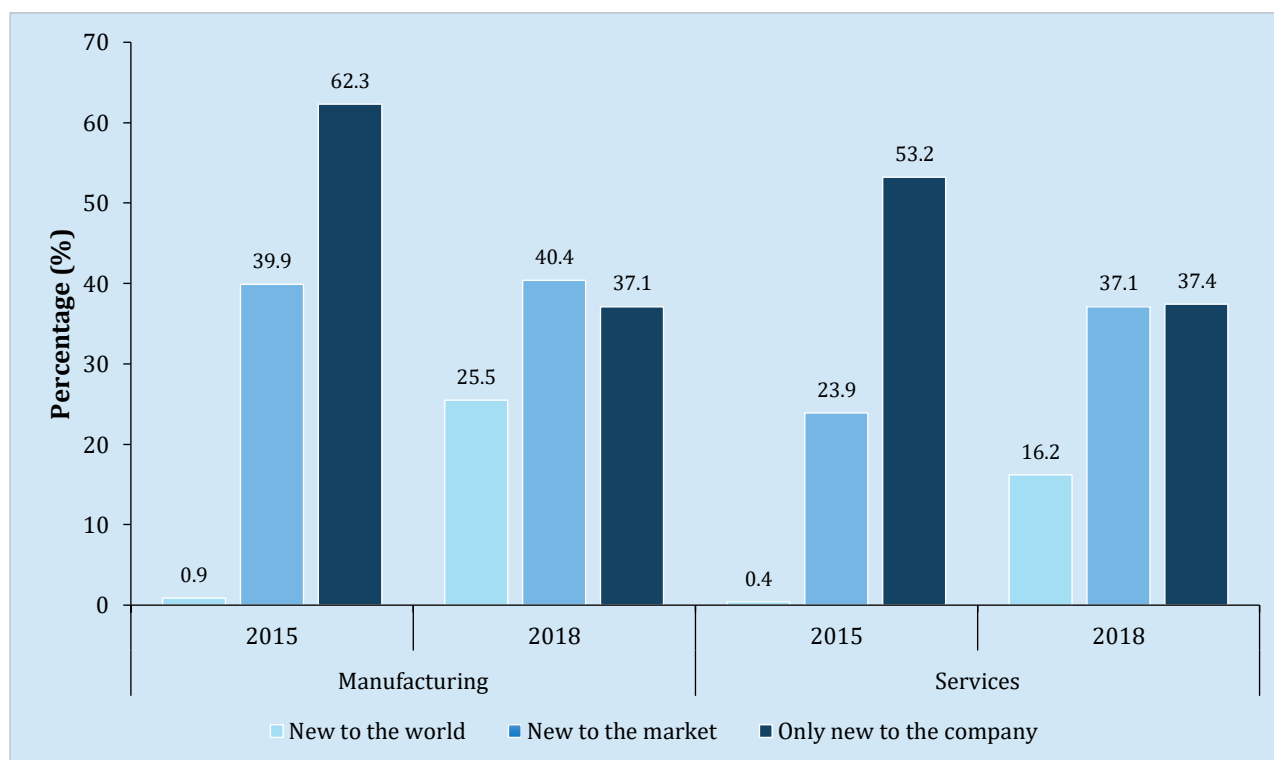
By 2016-2017, the design team in Eureka had started designing a more specialised type of pig - the dewaxing pig - which was designed to remove the wax and scale in the pipelines. This invention had the brush-like and tungsten stud to remove the hard wax and scale from the pipeline. In developing this enhanced version of the product, the enterprise had also worked with the local universities including giving out grants for students to do research on their behalf.

When the enterprise started to expand, the need for an automated system especially one that allowed data capturing was crucial. In addition to the ERP system, Eureka was also moving towards using automated machines to ensure better accuracy and efficiency in meeting their clients' demands. As the intention was to export internationally, the move from a semi-automatic factory to a fully automated one was also considered as necessary. Over time, Eureka has developed sufficient capabilities to provide total pipeline pigging solutions to clients including those from abroad.

Developing technological capabilities is not automatic. Neither is it effortless. Instead, it requires much investments in developing human capital as well as intensive learning from external sources. Eureka has demonstrated that local companies, with commitment, conviction and adequate support, are able to elevate their technological competencies to be on par with their competitors.

Source: Adapted from National Survey of Innovation, 2018

Figure 7.7 Novelty of Product Innovation by Sector 2015 and 2018

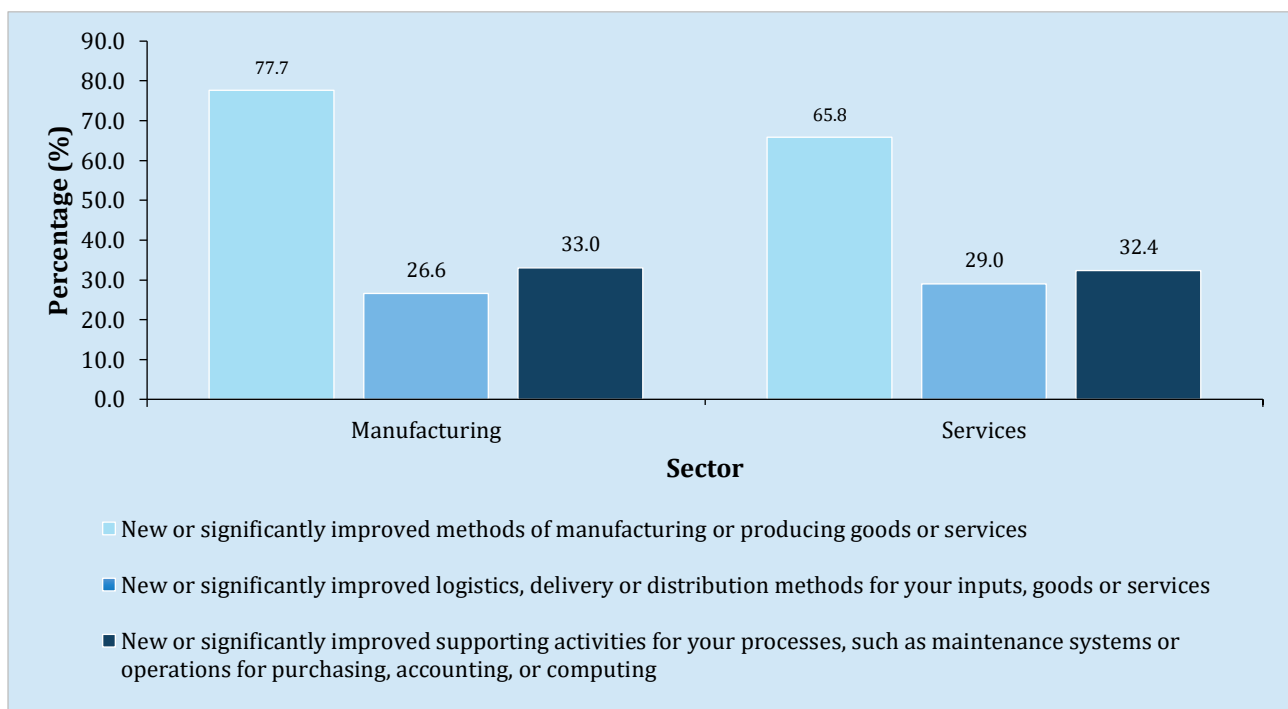


Source: National Survey of Innovation 2018

7.3.2 Process Innovation

Process innovation is defined as “the implementation of a new or significantly improved production or delivery method”. For both the manufacturing and services sectors, the majority of the process innovation is in the form of new or significantly improved methods of manufacturing or producing goods or services (77.7% and 65.8% respectively) followed by new or significantly improved supporting activities (33.0% and 32.4%) and new or significantly improved logistics, delivery or distribution methods (26.6% and 29.0%) as shown in Figure 7.8. The survey findings also indicate that the process innovations are mostly developed as closed innovations in all its sub-divisions for both sectors. This propensity towards closed innovations is also reflected in the case of product innovations suggesting that innovations are viewed as game-changers and are not to be disclosed to competitors.

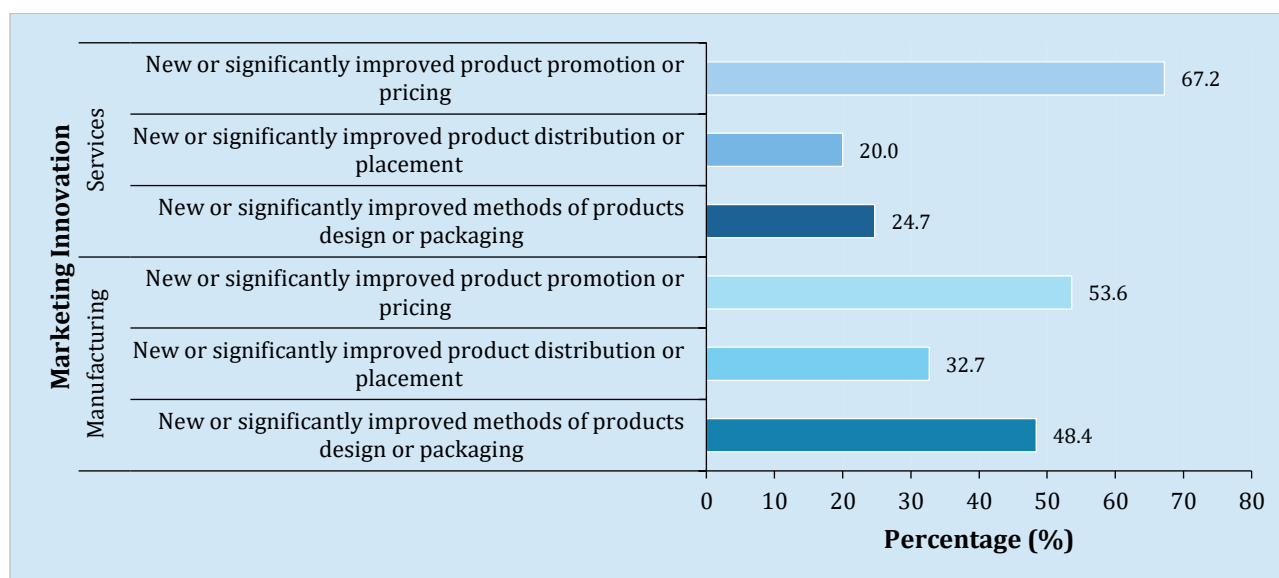
Figure 7.8 Process Innovation Based on Business Sectors



Source: National Survey of Innovation 2018

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 both the manufacturing and services sectors, the majority of the marketing innovations are in the form of new or significantly improved product promotion or pricing followed by new or significantly improved methods of product design or packaging and new or significantly improved product distribution/placement (Figure 7.9). The survey findings also reveal that, for both sectors, closed innovation - as in the case of product and process innovations - is the leading mechanism for all categories of marketing innovation.

Figure 7.9 Marketing Innovation Activities Based on Business Sectors

Source: National Survey of Innovation 2018

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 survey findings indicate that new or significantly improved methods in the firm’s business practices as well as new or significantly improved workplace organisation are the two leading modes of organisational innovation (more than 50%) across both business sector and firm size (Figure 7.10). The third type of organisational innovation – namely, new or significantly improved workplace external relation – though, not leading in any sector or firm size, is nevertheless significantly adopted by all the survey respondents.

Figure 7.10 Organisational Innovation Activities by Sectors

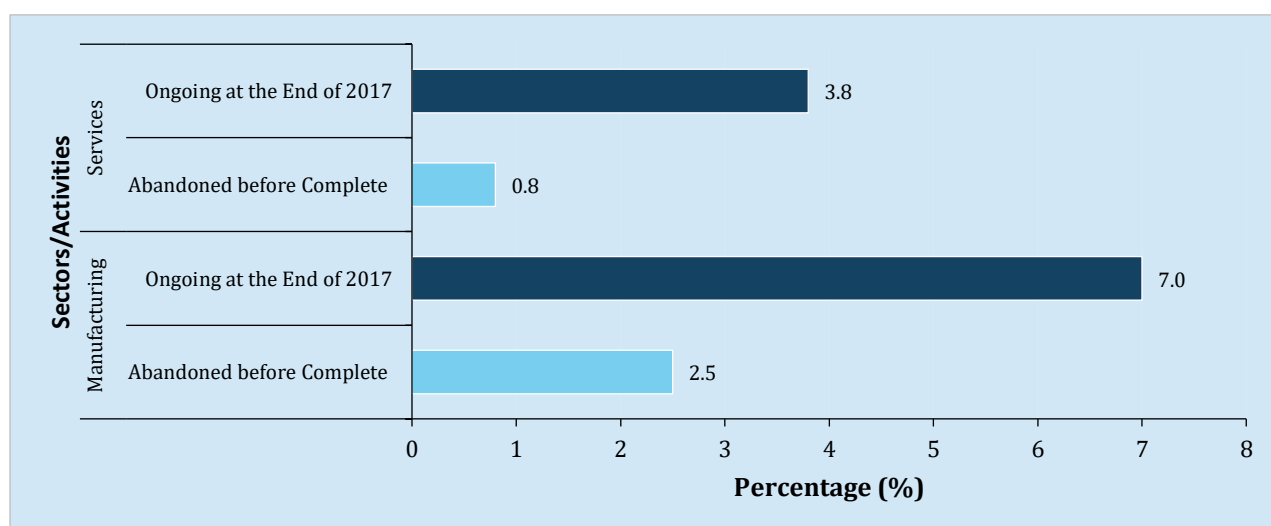


Source: National Survey of Innovation 2018

7.3.5 Abandoned and Ongoing Innovation Activities

There is a much lower percentage of firms in the manufacturing (2.5%) and services sectors (0.8%) reporting abandoned innovation activities compared to the previous NSI-15 survey (28.5% and 35.8% respectively). This marked reduction can be attributed to, among others, improved management (including identification and implementation) of innovation projects. (Figure 7.11). Similarly, the NSI-2018 survey reveals that the percentage of companies with ongoing innovation activities for both sectors (7.0% and 3.8%) are much less than those reported under NSI-2015. This lower proportion could be a reflection of increasing preoccupation by firms to focus on more short-term projects.

Figure 7.11 Abandoned and Ongoing Innovation Activities



Source: National Survey of Innovation 2018

7.4 Objectives, Effects and Activities of Innovation

The most important objective of innovation activities for both manufacturing and services sectors is on improving their products and services quality as presented in Table 7.3. Other important objectives for both sectors include extending product range; fulfilling the required regulations and standards; and reducing labour cost, material and energy consumption.

Both manufacturing and services companies indicated that the highest impact of their product and process innovations is on the quality of goods or services and the opportunity to enter new markets or increased market share (Table 7.4). Similarly, improved quality of goods or services is seen as the most important effect of marketing and organisational innovations in both the manufacturing and services sectors. It is also important in reducing the time to respond to customer or supplier needs (Table 7.5).

Table 7.3 Degree of Importance of Objectives in Innovation Activities

The Objective of Innovation	Mean	
	Manufacturing	Services
To replace products being phased out	0.95	0.96
To improve product quality	1.32	1.12
To extend product range	1.22	1.06
To fulfil regulation and standard	1.16	1.08
To reduce labour costs	1.08	1.01
To reduce materials consumption	0.99	0.96
To reduce energy consumption	1.01	0.96
To reduce environmental damage	1.03	0.91
To utilise incentives, grants, loan, etc	0.88	0.92
Others	0.36	0.30

Note: 0-Not relevant; 1-Low; 2-Medium; 3-High

Source: National Survey of Innovation 2018

Table 7.4 Effects of Product and Process Innovation

Effect of Product and Process Innovation	Mean	
	Manufacturing	Services
Increased range of products	1.08	0.93
Entered new markets or increased market share	1.09	0.99
Improved quality of goods or services	1.2	1.07
Improved flexibility of production or service provision	1.07	0.97
Increased capacity for production or service provision	1.07	0.94
Reduced labour costs per unit produced or provided	0.94	0.86
Reduced materials and energy per unit produced or provided	0.9	0.83
Reduced environmental impacts or improved health and safety	0.93	0.83
Met regulations and/or standards	0.92	0.88
Increased value added	0.92	0.89
Others	0.28	0.24

Note: 0-Not relevant; 1-Low; 2-Medium; 3-High
Source: National Survey of Innovation 2018

Table 7.5 Effects of Marketing and Organisational Innovation by Sectors

Effects of Marketing and Organisational Innovation	Mean	
	Manufacturing	Services
Reduced time to respond to customer or supplier needs	1.07	1.10
Improved quality of goods or services	1.17	1.14
Reduced costs per unit of output or service	1.03	1.00
Others	0.34	0.30

Note: 0-Not relevant; 1-Low; 2-Medium; 3-High
Source: National Survey of Innovation 2018

The survey findings reveal that making efficient use of R&D expenditure and getting new products to the market quickly are perceived as the two most important innovation activities by respondents from both sectors as given in Table 7.6. A similar rating of importance of these activities was also observed at the enterprise level. In terms of type of innovation activity, the NSI-2018 findings show that that training of staff and employees on innovation is the top priority for both sectors followed by acquisition of machinery, equipment and software and intramural R&D (Table 7.7).

Table 7.6 Rating on Importance of Innovation Activities Based on Business Sectors

Objectives	Mean	
	Manufacturing	Services
Getting new products to the market quickly	1.07	1.10
Making efficient use of R&D expenditure	1.17	1.14
Coming up with breakthrough/radical technologies	1.03	1.00
Bringing breakthrough technologies to the market	0.34	0.30

Note: 1-Very poor; 2-Poor; 3-Average; 4-Good; 5-Excellent

Source: National Survey of Innovation 2018

Table 7.7 Innovation Activities (%) Based on Business Sectors

Types of Innovation Activities	Manufacturing (%)		Services (%)	
	Yes	No	Yes	No
In-house R&D (intramural R&D)	16.20	83.80	5.50	94.50
Acquisition of R&D (extramural R&D)	5.60	94.40	1.50	98.50
Acquisition of machinery, equipment and software	20.50	79.50	8.10	91.90
Acquisition of external knowledge	6.60	93.40	3.20	96.80
Training	33.30	66.70	24.40	75.60
Market introduction of innovations	8.50	91.50	3.40	96.60
All forms of design	6.30	93.70	2.10	97.90
Preparation for marketing innovation	6.60	93.40	2.20	97.80
Preparation for organisational innovation	5.90	94.10	2.10	97.90

Source: National Survey of Innovation 2018

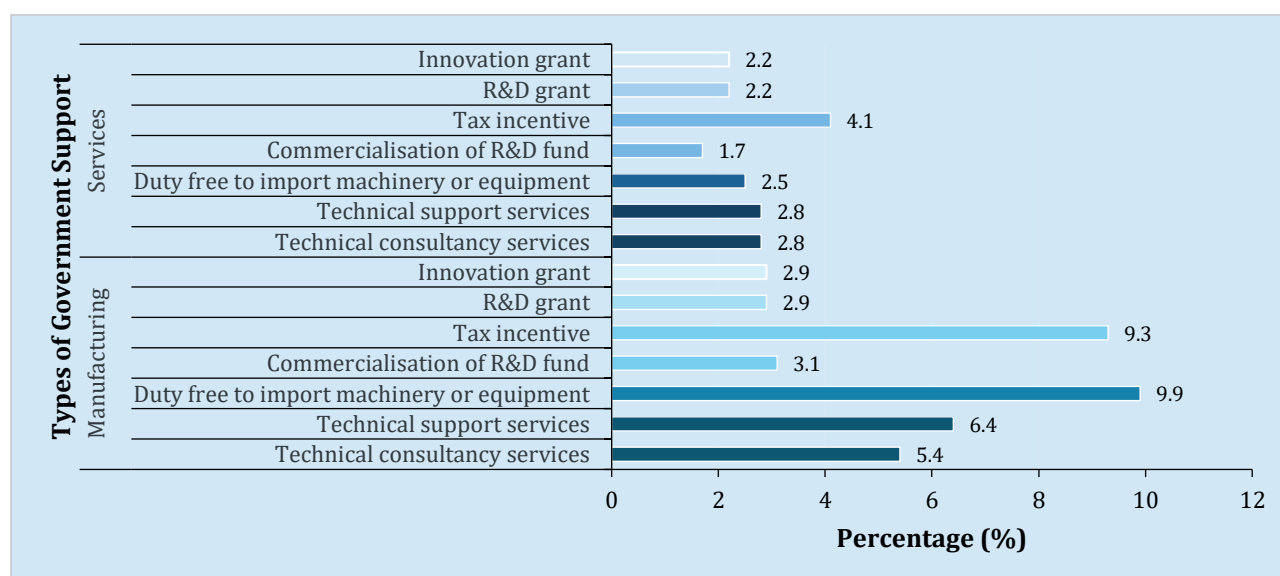
7.5 Resources for Innovation Activities

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

There is a distinct lack of uptake of government incentives and support for innovation activities among the respondents from both the manufacturing and services sectors. The percentage of positive responses is below 10% (far below the 30% achieved under NSI-2015) for both sectors with responses even much lower for the services sector (Figure 7.12). Entities from the manufacturing sector responded positively to duty free importation of machinery or equipment (9.9%) followed by tax incentive (9.3%), technical support services (6.4%) and technical consultancy services (5.4%). Firms from the services sector responded in the affirmative on tax incentive (4.1%) followed by technical consultancy services (2.8%), technical support services (2.8%) and duty-free importation of machinery or equipment (2.5%).

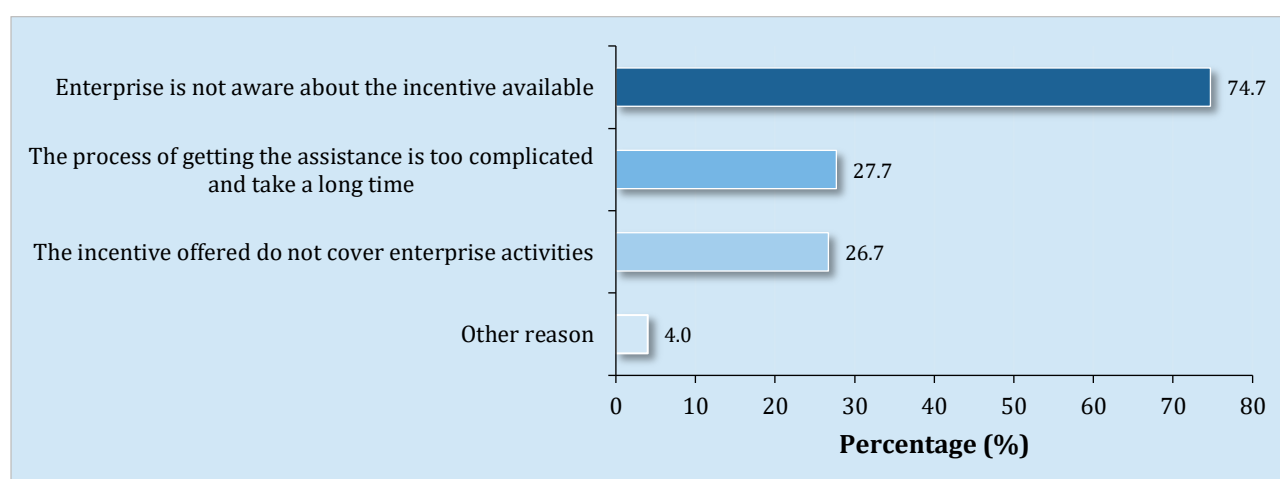
Figure 7.12 Government Support on Innovation Activities Based on Business Sectors



Source: National Survey of Innovation 2018

The poor uptake of government incentives and other support measures can be attributed to firms not being fully aware of the incentives (74.7%), complicated and lengthy process of getting assistance (27.7%) and that the incentives offered do not cover enterprise activities (26.7%) as highlighted in Figure 7.13.

Figure 7.13 Reasons for Not Getting Government Support



Note: Example of Others = Enterprises highlighted that the reliance on Government Tenders, Human Resource Development Fund (HRDF), and other types of incentives.

Source: National Survey of Innovation 2018

7.5.2 Funding for Innovation Activities

An overwhelming majority of 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 – is from their own sources (Table 7.8). The second

highest source of funding for both sectors is from private sources. This trend of funding was similarly reported in NSI-15.

Table 7.8 Funding of Innovation Activities

Source	Types of Innovation/Activity				
	Product	Process	Marketing	Organisation	R&D
Manufacturing Sector					
Own	274	268	242	190	106
Private	36	32	33	25	21
Public	18	18	10	12	14
Others	5	3	5	6	2
Services Sector					
Own	483	522	512	464	88
Private	26	21	22	21	13
Public	15	11	11	8	12
Others	4	4	3	1	4

Source: National Survey of Innovation 2018

7.5.3 Innovation Cooperation

Both the manufacturing and services sectors reported that the most important innovation partners are other enterprises within own enterprise group, consultants and competitors and other enterprises in own industry (Table 7.9). The least important partners are clients or customers and others. Universities and GRIs are considered one of the least important partners. This latter response from both sectors underscore the enormous effort needed by both universities and PRIs to enhance partnerships with industry.

Table 7.9 Innovation Cooperation and the Importance of Partners

Partners	Mean	
	Manufacturing	Services
Other enterprises within own enterprise group	1.82	1.52
Suppliers of equipment, materials, components, services or software	0.40	0.21
Clients or customers	0.17	0.12
Competitors and other enterprises in own industry	0.66	0.31
Consultants	1.66	1.47
Commercial laboratories and private R&D institutes	0.66	0.29
Universities or other higher education institutes	0.50	0.26
GRI or PRIs	0.41	0.20
Others	0.37	0.22

Source: National Survey of Innovation 2018

7.5.4 Sources of Information for Innovation

Based on the mean scores as given in Table 7.10 both the manufacturing and services sectors obtain information from institutional sources followed by market sources, internal sources and lastly from other sources. For both sectors, the two most important sources of information are from universities or other higher education institutes as well as from GRI or PRIs. In NSI-15, the two most important sources of information are market sources and internal sources. Given the earlier feedback by companies on cooperation with partners, it is evident that universities and PRIs are seen as important only in terms as sources of information and not as active research collaborators. Malaysia should explore various strategies such as open innovation concept as well as mission-oriented innovation system to further promote the network of innovation actors to work together. There are in place two initiatives to promote such networking, namely the Malaysian Collaborative Network Platform for Disruptive Innovation (I-CONNECT) and Malaysia Open Science Platform (MOSP) Initiatives for this purpose. Efforts must be undertaken to ensure the effectiveness of these networking initiatives.

Table 7.10 Source of Information for Innovation Activities

Sources of Information	Mean	
	Manufacturing	Services
Internal Sources		
Within the company	0.94	0.99
Other companies within the company group	0.64	0.78
Average Mean	0.79	0.88
Market Sources		
Suppliers of equipment, materials, services or software	0.97	0.99
Clients or customers	0.92	0.96
Competitors and other companies in the industry	0.72	0.84
Average Mean	0.87	0.93
Institutional Sources		
Consultants	0.67	0.75
Commercial laboratories and private R&D institutes	0.67	0.79
Universities or other higher education institutes	1.36	1.22
GRI or PRIs	1.05	1.00
Average Mean	0.94	0.94
Other Sources		
Conferences, trade fairs, exhibitions	0.72	0.81
Scientific journals and trade/technical publications	0.67	0.75
Professional and industry associations	0.70	0.76
Technical, industry or service standards	0.72	0.77
Average Mean	0.70	0.77

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

Source: National Survey of Innovation 2018

7.6 IP and Protection

The number of IPs such as patents, industrial designs, trademarks and copyrights applied for and granted can be appraised as the outcome of innovation. In the manufacturing sector, the most commonly applied and approved method to protect IP rights is trademark followed by patents, industrial design and copyright. However, in the case of the services sector the protection method that is most applied and approved – in descending order – is trademark, copyright, patent and industrial design. Overall, a higher percentage of companies from the manufacturing sector have sought and obtained IP protection than their services counterparts (Table 7.11).

Table 7.11 IP Applied and Granted Based on Business Sectors

Type of IP	Manufacturing (%)		Services (%)	
	Applied	Granted	Applied	Granted
Patents	3.2	2.5	1.3	0.6
Industrial Design	2.4	2.1	0.7	0.4
Trademark	4.3	4.0	2.7	1.8
Copyright	2.2	1.9	1.4	1.0

Source: National Survey of Innovation 2018

7.7 Factors Hampering Innovation Activities

The high cost factor, as in the NSI-2015 survey, is the most important factor hampering innovation activities in both the manufacturing and services sectors in 2018. Other cost-related factors constraining innovation include the lack of funds within the organisation, lack of finance from sources outside the organisation and excessive perceived risk. Based on mean scores, the knowledge factor is the next most important factor that hampers innovation activities in both sectors, followed by the market factor (Table 7.12). The survey findings also reveal that the importance of these factors constraining innovation are not distinctly linked to size of firm.

Table 7.12 Factors Hampering Innovation Activities

Factors	Mean	
	Manufacturing	Services
Cost Factor		
Cost too high	1.79	1.49
Lack of funds within the organisation	1.64	1.43
Lack of finance from sources outside the organisation	1.33	1.28
Excessive perceived risk	1.27	1.22
Average Mean	1.51	1.35
Knowledge Factor		
Lack of qualified personnel	1.23	1.01
Lack of information on technology	1.14	0.97
Lack of information on markets	1.07	0.94
Difficulties in finding cooperation partners for innovation	1.02	0.90
Weakness of IP knowledge and rights	1.01	0.89
Average Mean	1.09	0.94
Market Factor		
Market dominated by established enterprise	1.07	0.88
Uncertain demand for innovative goods and services	1.09	0.88
Innovation is easy to imitate	1.01	0.84
Average Mean	1.05	0.87
Organisational Factor		
Attitude of personnel towards change	1.03	0.78
Attitude of managers toward change	1.00	0.78
Managerial structure of enterprise	0.98	0.75
Inability to devote staff to innovation activities due to production requirements	0.95	0.70
Lack of infrastructure (e.g. building)	0.93	0.69
Lack of facilities (e.g. machine, equipment)	0.87	0.67
Lack of networking with research institutions (e.g. Universities, Standard and Industrial Research Institute Malaysia (SIRIM), PORIM, FRIM, etc.)	0.87	0.62
Average Mean	0.95	0.71
Regulatory Factor / Public Policy		
Insufficient flexibilities of regulations or standards	0.88	0.62
Limitation of S&T public policies	0.78	0.58
Average Mean	0.83	0.60
Other Factors		
No need to innovate due to earlier innovations	0.83	0.58
No need to innovate because of lack of demand for innovation	0.37	0.24
Average Mean	0.60	0.41

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

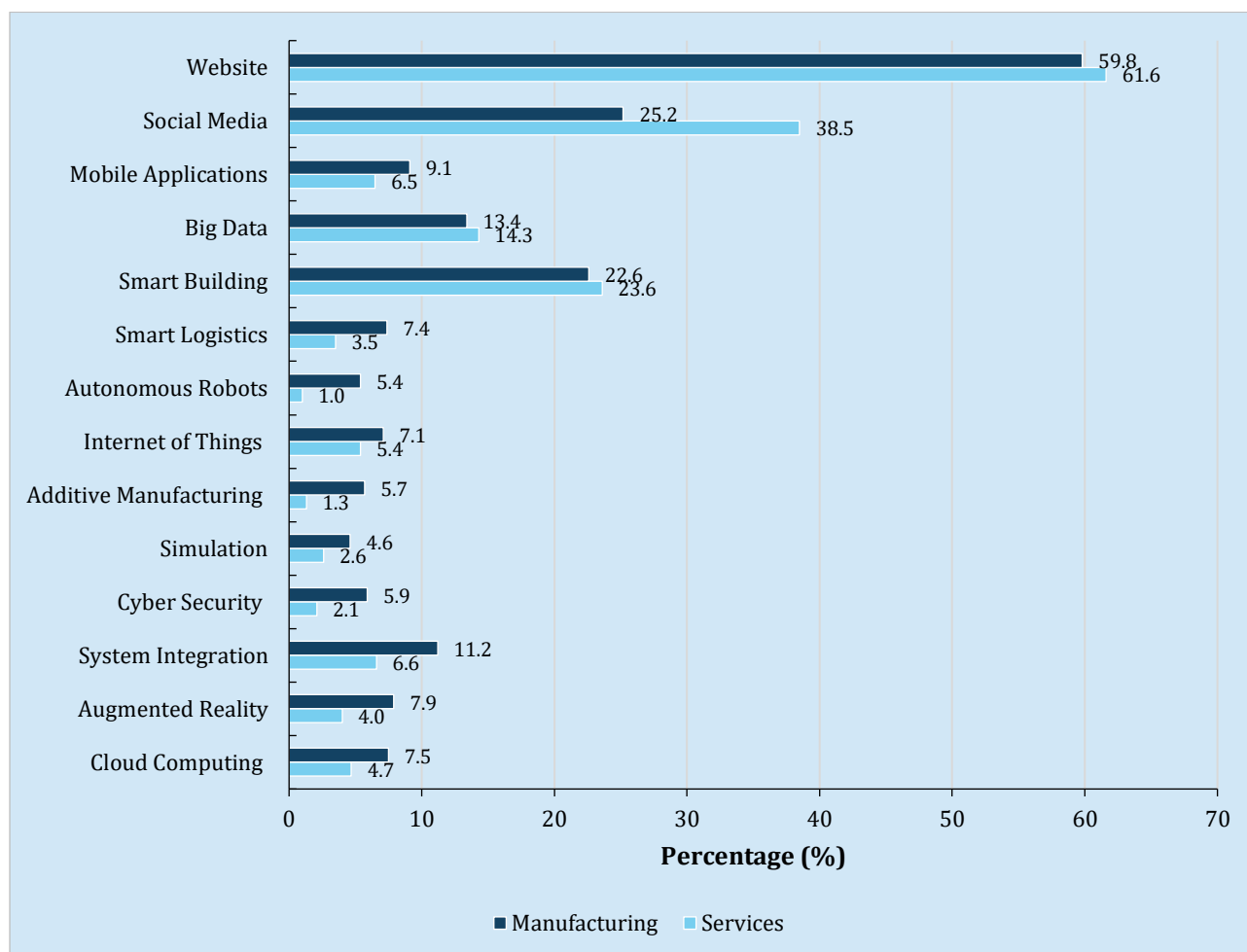
Source: National Survey of Innovation 2018

7.8 IR 4.0

The IR 4.0—characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilisation of new technologies such as, cloud computing, robotics, 3D printing, the IoT, and advanced wireless technologies—if properly mobilized and utilized, will help to unlock new markets, enhance productivity, improve businesses and, above all, improve livelihoods.

Figure 7.14 report that website and social media are among the leading IR 4.0 pillars adopted by companies in the manufacturing (59.8%) and services sectors (61.6%). However, the adoption of the newer technologies in both sectors - for example, Big Data, System Integration, Augmented Reality, Cloud Computing, Smart Logistics, Additive Manufacturing), - has been less than satisfactory (below 10% for most technologies).

Figure 7.14 IR 4.0 Pillars



Source: National Innovation Survey 2018

As a whole, IR 4.0 technologies have been applied in manufacturing sector mainly for product innovations while in the services sector these technologies are largely employed for marketing innovations. There is no distinct difference in the adoption of the IR 4.0 technologies across enterprise size for both sectors.

7.9 International Comparison

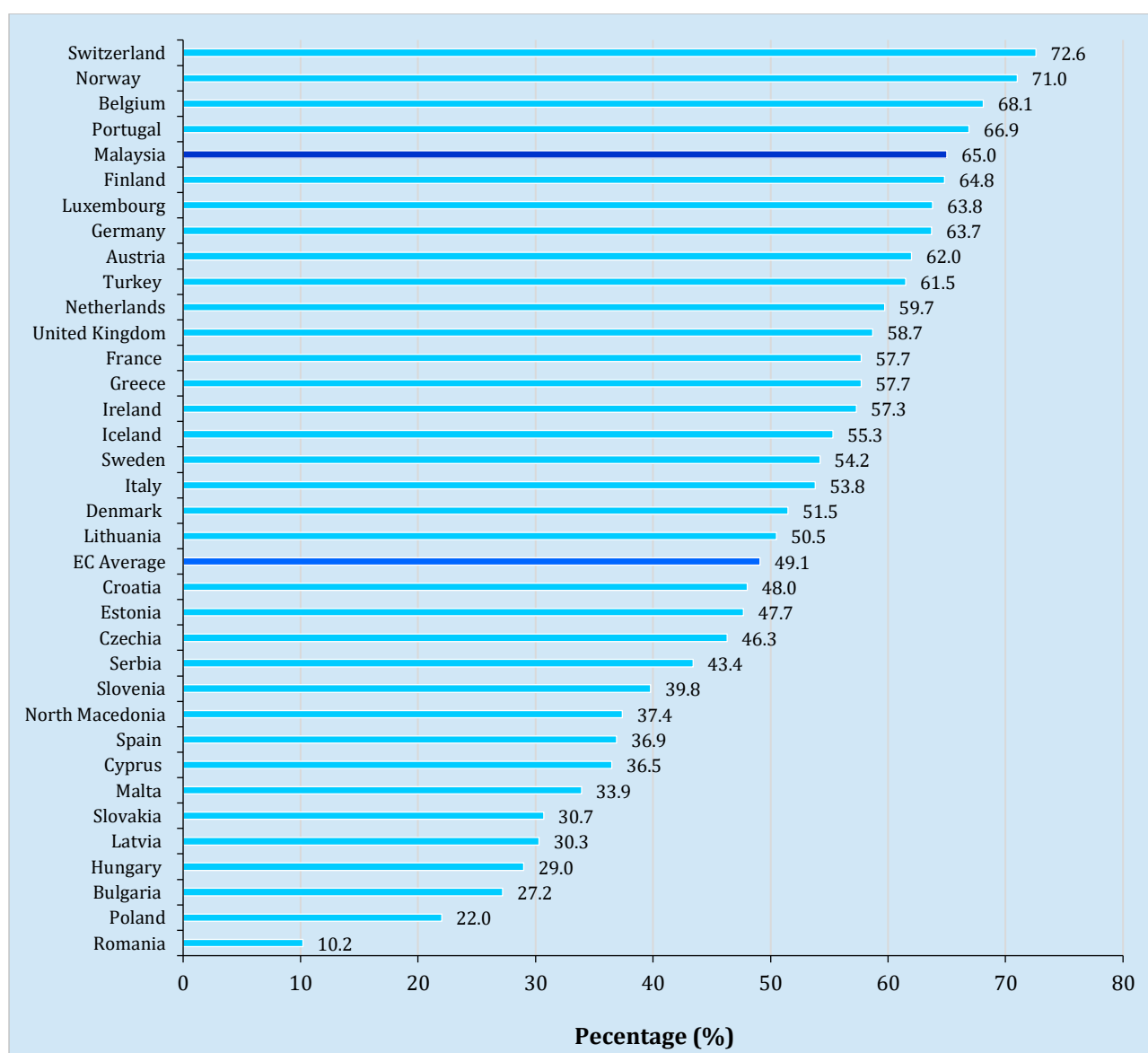
This section assesses and compares the innovation performance of Malaysia and other selected countries at the company and country levels. Comparable survey results as well as other national indicators of innovation are used.

7.9.1 Community Innovation Survey

The CIS-10 which covers data for the period 2014-2016 is used as the basis for comparison of innovations between Malaysia and the EU. Figure 7.15 shows that Malaysia is placed 5th in the innovation ranking of companies with a score of 65% which is well above the average rate for all European countries with a score of 49.1% as well as almost triple the score achieved in the previous NSI-2015 report (where Malaysia came in at 31st place). Malaysia's high ranking can be attributed to various government initiatives in promoting and mobilising businesses to embrace and enhance innovation practices.

Malaysia achieved moderate rankings for product and process innovation followed by marketing innovation and organisational innovation in the CIS-10 survey (Table 7.13).

Figure 7.15 Percentage of Innovative Enterprises



Notes: EC's Data from Community Innovation Survey 2016 (CIS-10), EC=European Countries
Source: National Survey Innovation 2018

Table 7.13 Percentage and Ranking of Malaysian Innovative Companies by Type of Innovation in CIS-10 Survey

	Product innovation	Process Innovation	Organisational Innovation	Marketing Innovation
Score (%)	30.1	27.4	10.2	25.4
Rank	15	16	34	20

Notes: EC's Data from Community Innovation Survey 2016 (CIS-10) EC=European Countries

Source: Adapted from National Survey Innovation-2018.

7.9.2 Global Competitiveness Index

Table 7.14 presents the GCI rankings for selected countries for the period 2016-2019 produced by the annual Global Competitiveness Report (GCR). Among Southeast Asian countries, Malaysia is ranked 27th in the 2019 edition of the GCR. The report indicates that the best performing pillar for Malaysia is financial system where the country is ranked 15th in the world while business dynamism and innovation capability are ranked at 18th and 30th respectively.

Table 7.14 Global Competitiveness Index Rankings of Selected Countries, 2016-2019

	GCI 2016 rank	GCI 2017 rank	GCI 2018 rank	GCI 2019 rank
Switzerland	1	1	4	5
United States	3	2	1	2
Singapore	2	3	2	1
Malaysia	25	23	25	27
Taiwan	14	15	13	12
Republic of Korea	26	26	15	13
Thailand	34	32	38	40
China	28	27	28	28

Source: Global Competitiveness Report (Various)

7.9.3 Global Innovation Index

Malaysia is placed 33rd in the 2020 edition of the Global Innovation Index (GII)- a slight improvement on the 35th position in the previous year (Table 7.15). Rankings in four of the seven GII pillars, namely, human capital and research (29th), market sophistication (20th), business sophistication (31st) and creative outputs (35th) improved while declining for infrastructure (48th) and knowledge and technology outputs (38th). Regionally, Malaysia is ranked below Singapore (8th) among ASEAN member countries in GII 2020.

Table 7.15 Global Innovation Index Ranking, 2016-2020

	GII 2016 rank	GII 2017 rank	GII 2018 rank	GII 2019 rank	GII 2020 rank
Switzerland	1	1	1	1	1
United States	4	4	6	3	3
Singapore	6	7	5	8	8
Malaysia	35	37	35	35	33
Republic of Korea	11	11	12	11	10
Thailand	52	51	44	43	44
China	25	22	17	14	14

Source: Global Innovation Index Report (Various)

7.9.4 Innovation Efficiency Ratio

The Innovation Efficiency Ratio (IER) shows how much innovation output a given country is getting for its inputs, that is, to what degree inputs are efficiently transformed into innovation outputs. Table 7.16 exhibits the innovation efficiency ratio and Global Innovation Index rankings for selected countries. Although positioned higher in the 2020 GII rankings, Malaysia (40th) is placed behind Vietnam (11th) in terms of innovation efficiency. However, Malaysia has steadily improved from its 59th position in terms of innovation efficiency from the 2016 edition of the GII Report.

Table 7.16 Innovation Efficiency Ratio and Global Innovation Index Ranking

	2016 rankings		2017 rankings		2018 rankings		2020 rankings	
	GII	IER	GII	IER	GII	IER	GII	IER
Switzerland	1	5	1	2	1	1	1	2
United States	4	25	4	21	6	22	3	13
Singapore	6	78	7	63	5	63	8	44
Malaysia	35	59	37	46	35	48	33	40
Republic of Korea	11	24	11	14	12	20	10	19
Thailand	52	53	51	24	44	33	44	43
China	25	7	22	3	17	3	14	1
Vietnam	59	11	47	10	45	16	42	11

Source: Global Innovation Index Report (Various)

Malaysia is the best performing country in this region after Singapore for both GCI (27th, 2019) and GII (33rd, 2020) rankings. In terms of IER, Malaysia has improved on its 59th position in 2016 to reach 40th place in 2020. However, Malaysia's position pales when compared to Vietnam (11th, 2020). There is much that Malaysia can do to improve on her innovation performance and Box 7.2 highlights what we can learn from Switzerland.

Box 7.2 Innovation Best Practices in Switzerland

According to the GII 2018 report, Switzerland remains the uncontested champion of innovation, topping the list every year since 2011. The report reveals that the key factors to Switzerland's consistent success are its first-rate patent and IP rules, high-tech manufacturing, excellent universities, and high investments in R&D. Switzerland has also been continuously improving its performance in several areas like business environment, and information and telecommunication infrastructure. Being the most innovative country in the world, Switzerland is a global centre for R&D, where scientists in top public and private institutions around the world are involved in ground-breaking research. It is one of the world's most internationalised countries in terms of research and innovation, with strong research collaboration between the industry and public research institutions. Switzerland recognises that excellent education, research and innovation are crucial for economic competitiveness, sustainable development and the welfare of its people. Thus, the Swiss Government is highly focused on sustaining outstanding and conducive environment to promote research and innovation to different stakeholders. The government also pursues a bottom-up policy in its research and innovation agenda. It prioritises basic research by supporting such research with long-term predictable funding. In terms of research commercialisation, Switzerland does not have specific innovation policy but the country strongly supports networking, collaboration and knowledge transfers between the public and private sectors. Every four years, the government presents its strategies for education, research and innovation. For the period of 2017-2020, the Swiss Government has defined the following four strategic goals:

Strengthening professional education: Improving the already well-functioning Swiss vocational and professional education system by allocating more financial support for students pursuing additional qualifications.

Supporting young scientists: Highly qualified and excellent young scientists are crucial to the competitiveness of Swiss research and innovation. In this context, universities play an active role in providing support to young scientists.

Enhancing innovation: Increased focus on supporting bottom-up networks between the public and private sectors to commercialise research. Several new funding programmes have been introduced to support the whole innovation value chain as well as increased promotion of the Swiss Innovation Park as a location for innovation.

Reinforcing innovative medicine initiative: Increased funding for supporting programmes in educating medical professionals. Several universities such as the Eidgenössische Technische Hochschule (ETH Zurich) will start to offer new medical degrees.

Source: Swiss Confederation (2018); Hotz-Hart, B. (2012)

7.10 Summary

The NSI-2018 survey findings have revealed that at least 60% of the companies surveyed are innovative. A significant proportion of firms in both the manufacturing (22%) and services (29.5%) sectors expended more than RM4 million on innovation-related activities. This contrasts with the small proportion (less than 2%) of such high spending firms in NSI-2015. The innovation-related expenditure patterns of firms in both sectors underscore the growing importance attached to innovation as a competitive tool. More companies reported introducing product innovations that are new to the market for both sectors under NSI-2018 than in NSI-2015. A significant proportion of the respondents in either sector (25% in manufacturing and 16% in services) have indicated that their product innovations are new to the world – far more than the 1% reported in NSI-2015 for the same item. These rising trends suggest, among others, that more companies are adept in innovating to enhance their competitiveness.

Despite the increasing participation of firms in innovation-related activities, a majority of firms (74.7%) continue to report on lack of awareness on government incentives and support available for innovation activities. They also claim that the process and procedures involved in getting the incentives are complicated and time consuming. Universities and GRIs are considered one of the least important partners in innovation cooperation. This latter response from both sectors underscore the enormous effort needed by both universities and PRIs to enhance partnerships with industry. Universities and PRIs are seen as important only in terms as sources of information and not as active research collaborators. Adoption rate of IPRs by enterprises from both sectors is minimal (< 10%). Website and social media are among the leading IR 4.0 pillars adopted by companies in the manufacturing (59.8%) and services sectors (61.6%). However, the adoption of the newer technologies in both sectors has been less than satisfactory (below 10% for most technologies). Policy coordination is key to accelerate the adoption rate that promotes these technologies to achieve circular economy (Chandran, 2020). Comparatively, Malaysia is the best performing country in this region after Singapore for both GCI (27th, 2019) and GII (33rd, 2020) rankings. In terms of Innovation Efficiency Ratio (IER), Malaysia has improved on its 59th ranking in 2016 to reach 40th position in 2020.

8

**KNOWLEDGE
AND
TECHNOLOGY
INTENSIVE INDUSTRIES**

CHAPTER 8: KNOWLEDGE AND TECHNOLOGY INTENSIVE INDUSTRIES

8.1 Introduction

Malaysia's efforts to transform into a knowledge-based economy started in the mid-1990s and various initiatives were put in place thereafter. Knowledge-based economy is a key driver as well as supporting industries that aids the achievement of the development goals. Undoubtedly, Knowledge and Technology Intensive (KTI) industries are a critical component of the knowledge-based economy especially during the digital-age in sustaining and intensifying Malaysia's competitiveness. The intensification of Malaysian KTI industries is vital to face the emergence of IR 4.0 revolution. This chapter examines the progress of the Malaysian KTI industries including commercial services using various indicators from 2011 until 2018. KTI industries comprise industries that establish substantial connection mainly between S&T.⁵ KTI industries definition cover high R&D intensive and medium-high R&D intensive industries whereby the industries equally deploy significant amount of their revenues on R&D related activities. High R&D intensive comprise several crucial industries namely aircraft; pharmaceuticals; computer, electronic, and optical products; scientific R&D services; and software publishing. Medium-high R&D intensive industries cover seven sub-industries such as chemicals and chemical products; motor vehicles; machinery and equipment; weapons and ammunition; electrical equipment; railroad and other transport; and IT and other information services.

8.2 Malaysia's KTI Value Added

Table 8.1 highlights the value-added of KTI industries that comprise value-added of both medium-high R&D and high R&D intensive industries respectively from 2011 until 2018. The value-added contribution had increased from USD29,846 million in 2011 to USD39,907 million in 2018. The overall KTI value added has grown steadily between 2011 and 2014. Although the overall KTI value-added significantly declined at the rate of 2.38% and 3.79% between 2015 and 2016 but the growth rate recovered positively at 7.83% and 12.18% respectively during 2017-2018 period. In the same vein, the high R&D intensive industries value-added also significantly declined at the rate of 11.82% in 2015 and 0.41% in 2016 unlike the decrease of medium-high R&D intensive industries value-added rate (7.10%) that occurred only in 2016. Although, the overall value-added share of KTI industries to GDP witnessed some decline between 2015 and 2016 but over the years the recorded average contribution is 34% with highest recorded in 2018. Specifically, in 2018, both the high and medium-high R&D intensive industries contributed equally (around 20%) to the value-added share of GDP.

⁵ This is based on the OECD (2001) classification.

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

	2011	2012	2013	2014	2015	2016	2017	2018
Value added of KTI industries (USD Million)	29,846	32,936	33,990	35,124	34,289	32,990	35,573	39,907
Value added of medium-high R&D intensive industries (USD Million)	14,350	15,616	15,755	15,880	17,319	16,089	17,519	20,124
Value added of high R&D intensive industries (USD Million)	15,495	17,320	18,235	19,244	16,970	16,901	18,054	19,783
Value Added of KTI industries (Share of GDP %)	29.60	32.66	33.71	34.83	34.00	32.71	35.27	39.57
Value Added of medium-high R&D Intensive (Share of GDP %)	14.23	15.49	15.62	15.75	17.17	15.95	17.37	19.96
Value Added of high R&D Intensive (Share of GDP %)	15.37	17.17	18.08	19.08	16.83	16.76	17.90	19.62

Source: US Science and Engineering Indicators 2019

Among the KTI industries in Malaysia, Computer, Electronic, and Optical Products, Chemicals and Chemical Products and Motor Vehicles are among the top three sectors contributed in terms of value-added between 2011 and 2018 (refer Table 8.2). Nevertheless, in terms of growth, three key sectors notably electrical equipment (88.32%), weapons and ammunition (81.98%) and pharmaceutical (65.22%) dominated the value-added growth of Malaysia's KTI industries during this period. In services, IT and other information services and scientific R&D services contribution is USD1,943 and USD2,342 million in 2018, respectively.

Table 8.2 Value Added of Malaysia's KTI Industries by Sectors, USD Millions

Industry	2011	2012	2013	2014	2015	2016	2017	2018	Growth rate (%)
Computer, Electronic, And Optical Products	11,799	13,481	14,177	14,874	13,390	13,283	14,322	15,492	31.30
Chemicals and Chemical Products	6,194	6,542	6,202	5,862	6,143	5,262	5,791	6,932	11.91
Motor Vehicles	2,288	2,551	2,703	2,855	3,058	2,786	2,987	3,410	49.04
Machinery and Equipment	1,651	1,772	1,818	1,864	2,068	2,078	2,321	2,637	59.72
Scientific R&D Services	1,712	1,899	2,072	2,184	1,982	2,043	2,089	2,342	36.80
Electrical Equipment	1,378	1,560	1,619	1,677	2,120	2,135	2,366	2,595	88.32
Weapons and Ammunition	1,404	1,548	1,669	1,779	2,259	2,121	2,287	2,555	81.98
IT and Other Information Services	1,354	1,510	1,654	1,741	1,616	1,659	1,717	1,943	43.50
Publishing Industry (Including Software)	1,149	989	843	907	758	751	756	840	-26.89
Aircraft and Spacecraft	536	629	766	851	465	445	471	616	14.93
Pharmaceutical	299	323	376	429	374	379	416	494	65.22
Railroad and Other Transport	81	133	90	101	55	49	50	53	-34.57

Source: US Science and Engineering Indicators 2019

It is vital that Malaysia improves its high knowledge and R&D intensive sectors performances. One key strategy to improve the value-added activities is by close collaboration. The current i-Connect initiatives should be explored further to build collaborative network approach to intensify Malaysian KTI development. This quadruple helix network model is able to integrate players from both R&D and the market in rendering high value products and services for the society. The case of Kontron Design Manufacturing illustrates how collaboration helped improve its engineering services (Box 8.1).

Box 8.1: Value Addition via Collaboration, Kontron Design Manufacturing Services

Kontron Design Manufacturing Services was initiated locally in 2005 with its main core business embedded in computing technology. Kontron has substantially positioned its organisation identity as a custom solution and application providers of operational decision manager (ODM) systems. Kontron has attained remarkable success in the domestic market by serving its clients' needs domestically and globally particularly in providing local engineering support and value-added related services.

In fact, Kontron expanded such services to several essential industries notably avionics, medical, transportation and defence. The shift, over the periods, enabled Kontron to expand its existing business scope to greater-margin business. This was made possible with close collaboration with CREST which allowed Kontron to provide value addition to its services particularly extending customised solution for its clients from various industries. Furthermore, Kontron's collaboration with CREST empowered its superiority as a competitive engineering services provider that mainly focused on larger market penetration in order to gain greater margin revenue and market access. In summary, the collaboration between Kontron and CREST catalysed knowledge and technology transfer besides ensuring innovation spill-over effect for business sustainability in the long run. Indeed, such shift enabled Kontron management to solely focus on critical technologies-based engineering mission due to its substantial core engineering capabilities.

Source: MIDA, 2020

8.3 Malaysia's KTI Industries Trade Performances

Overall, Malaysia's KTI exports increased by 26.94% between 2011 and 2018 to USD132,323 million (see Table 8.3). In 2018, the industry contributed 36.90% as a share of GDP. Nevertheless, during the period of 2015-2016, the overall export value of KTI industries fell slightly before rebounding in 2017. The exports of high R&D intensive industries dominated the Malaysian KTI industries in terms of absolute value and GDP share, over the years.

Table 8.3 Malaysia's KTI Industries Exports and Share of GDP

	2011	2012	2013	2014	2015	2016	2017	2018	Growth rate (%)
Exports of KTI industries (USD millions)	104,241	102,475	103,477	108,466	99,911	97,876	112,396	132,323	26.94
Exports of medium-high R&D Intensive Industries (USD millions)	36,455	38,651	39,001	41,144	38,906	38,179	40,585	44,580	22.29
Exports of high R&D Intensive Industries (USD millions)	67,787	63,824	64,476	67,322	61,005	59,697	71,811	87,743	29.44
Exports of KTI industries (Share of GDP %)	34.99	32.59	32.01	32.08	33.70	33.01	35.74	36.90	5.48
Exports of medium-high R&D Intensive (Share of GDP %)	12.24	12.29	12.06	12.17	13.12	12.87	12.90	12.43	1.61
Exports of high R&D Intensive (Share of GDP %)	22.75	20.30	19.94	19.91	20.58	20.13	22.83	24.47	7.55

Source: US Science and Engineering Indicators 2019

Table 8.4 shows that the imports of Malaysian KTI industries totalled USD119,344 million in 2018. Respectively, the imports of medium-high R&D intensive industries and high R&D intensive industries are USD60,306 million and USD59,038 million. The imports of medium-high R&D intensive industries surpassed the high R&D intensive industries imports over the same period. The KTI industries import share to GDP declined by 3.93% between 2011 and 2018. Comparatively, the import share of GDP for both medium-high R&D intensive industries and high R&D intensive industries registered de-growth by 2.89% and 4.97% respectively during the period.

Table 8.4 Malaysia's KTI Industries Imports and Share of GDP

	2011	2012	2013	2014	2015	2016	2017	2018	Growth Rate (%)
Imports of KTI industries (USD Million)	103,213	105,580	108,166	109,317	95,791	95,097	108,037	119,344	15.63
Imports of medium-high R&D Intensive Industries (USD Million)	51,614	55,610	55,905	55,762	50,162	50,279	55,352	60,306	16.84
Imports of high R&D Intensive Industries (USD Million)	51,599	49,971	52,261	53,555	45,629	44,818	52,685	59,038	14.42
Imports of KTI industries (% Share of GDP)	34.64	33.58	33.46	32.34	32.31	32.07	34.35	33.28	-3.92
Imports of medium-high R&D Intensive (% Share of GDP)	17.32	17.69	17.29	16.49	16.92	16.96	17.60	16.82	-2.92
Imports of high R&D Intensive (% Share of GDP)	17.32	15.89	16.17	15.84	15.39	15.11	16.75	16.46	-4.93

Source: US Science and Engineering Indicators 2019

Notably, Malaysian KTI industries achieved a trade surplus between 2015 and 2018 (see Table 8.5). The high R&D intensive industries have remained a key contributor to the overall surplus unlike the trade balance of medium-high R&D intensive industries that accounted for the trade deficit from 2011 until 2018. Overall, Malaysian KTI industries have developed export competitive advantage, particularly in the high R&D intensive.

Table 8.5 Malaysia's KTI Industries Trade Balance

	2011	2012	2013	2014	2015	2016	2017	2018
Trade Balance of KTI industries (USD Million)	1,029	-3,106	-4,689	-851	4,120	2,779	4,359	12,979
Trade Balance of medium-high R&D Intensive Industries (USD Million)	-15,159	-16,959	-16,904	-14,618	-11,256	-12,100	-14,767	-15,726
Trade Balance of high R&D Intensive Industries (USD Million)	16,188	13,853	12,215	13,767	15,376	14,879	19,126	28,705

Source: US Science and Engineering Indicators 2019

8.4 Commercial Services Trade Performance in Malaysia

Commercial services export is captured by excluding government services export. Although the commercial services export highlights the volatile trend between 2011 and 2018 (see Table 8.6), but the overall export of commercial services has grown by 3.42%. Specifically, the export share of computer, communications and other services continuously remained more than 30% of the overall commercial services between 2011 and 2018. The insurance and financial services export share are extremely small, contributing between 1%-2% to the overall commercial services. Hence, it is vital for Malaysia to revisit the existing financial law and regulations to enhance the insurance and financial services sector export share.

Table 8.6 Malaysia's Commercial Services Exports Trend, 2011-2018

	2011	2012	2013	2014	2015	2016	2017	2018
Commercial service exports (current USD Million)	38,751	40,497	42,004	41,971	34,841	35,512	37,022	40,077
Computer, communications and other services (% of commercial service exports)	34.18	36.86	35.88	32.85	35.21	35.07	35.99	36.14
Insurance and financial services (% of commercial service exports)	2.04	2.12	1.82	1.92	2.03	2.28	2.23	2.29

Source: World Development Indicators, 2020

Malaysia's commercial services sector imports increased gradually between 2011 and 2018 and grew by 16.35% during the period. In absolute terms imports surpassed exports during this period contributing to trade deficit in overall commercial services trade. In 2018, import value amounted to USD44,308 million mainly contributed by the computer, communications and other services (Table 8.7). It is important to realise that the import share of computer,

communications and other services accelerated by 9.56% between 2011 and 2018. In contrast, the overall import of insurance and financial services declined by 12.34% between 2011 and 2018. This shows that Malaysia has gradually reduced the dependency on insurance and financial services imports.

Table 8.7 Malaysia's Commercial Services Imports Trend, 2011-2018

	2011	2012	2013	2014	2015	2016	2017	2018
Commercial service imports (current USD million)	38,083	43,131	44,973	45,128	39,923	39,896	42,022	44,308
Computer, communications and other services (% of commercial service imports)	35.35	36.92	38.40	37.16	39.88	42.23	40.41	38.73
Insurance and financial services (% of commercial service imports)	7.94	7.89	7.16	7.04	7.00	6.92	6.75	6.96

Source: World Development Indicators, 2020

8.5 International Comparison of KTI Industries

8.5.1 Value Added

In 2018, three main countries, notably the United States (0.25%), China (0.24%) and EUs (0.21%) dominate the global KTI industries value added (Table 8.8). In terms of KTI contribution to GDP, Taiwan accounts for 49.90%, followed by China (15.72%), Japan (14.21%) and Vietnam (12.51%) in 2018. Malaysia's KTI industries value added share of GDP has surpassed the world share, standing at 11.13%. However, as a share of world value added, Malaysia's contribution is still low given its size of the industry.

Table 8.8 Value Added of KTI industries, Selected Countries

Country	Value Added of KTI industries (USD Million)					% of World Value Added	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Taiwan	103,040	255,700	249,018	279,982	294,374	0.03	49.90
China	1,134,976	1,644,512	1,697,668	1,905,819	2,184,420	0.24	15.72
Japan	821,220	634,329	710,755	672,049	703,853	0.08	14.21
EU	2,026,456	1,675,714	1,706,800	1,757,783	1,928,566	0.21	12.10
Vietnam	8,322	20,285	23,248	28,889	30,674	0.00	12.51
United States	1,607,940	1,913,546	2,003,810	2,112,621	2,296,415	0.25	11.16
Malaysia	29,846	34,289	32,990	35,573	39,907	0.00	11.13
India	133,384	161,211	169,194	190,867	209,216	0.02	7.71
Thailand	32,089	33,826	34,432	35,519	38,940	0.00	7.69
Indonesia	50,486	52,559	54,946	58,626	58,859	0.01	5.65
Philippines	11,494	13,581	14,063	15,560	14,695	0.00	4.24
Singapore	43,702	13,609	14,880	15,457	15,057	0.00	4.03
South Korea	222,166	44,446	45,567	52,713	57,592	0.01	3.35
World	7,008,185	7,545,253	7,779,187	8,277,119	9,020,711	-	10.44

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020.

In general, the value added of medium-high R&D intensive industries show an increasing trend for every nation between 2011 and 2018 (see Table 8.9). China (0.26%) has dominated the world share of value added compared to the United States (0.22%) and the combined European Union (0.23%) share. While, in terms of value-added contribution to GDP by medium-high R&D intensive industries, Japan (11.26%) has surpassed two main technology giants notably China (10.90%) and South Korea (10.22%) during this period. In the case of Malaysia, its medium-high R&D intensive industries contribution (5.61%) is lower than other ASEAN peers like Singapore (5.87%) and Thailand (5.69%) but ahead of Indonesia (4.75%).

Table 8.9 Value Added of Medium-High R&D Intensive Industries, Selected Countries

Country	Value Added of medium-high R&D Intensive Industries (USD Million)					% of World Value Added	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Japan	600,833	487,559	551,769	531,050	557,675	0.10	11.26
China	819,709	1,144,562	1,180,309	1,322,095	1,515,010	0.26	10.90
South Korea	130,897	152,093	149,475	167,752	175,925	0.03	10.22
EU	1,183,183	1,138,553	1,157,932	1,199,642	1,309,099	0.23	8.22
Taiwan	33,454	36,869	37,967	42,535	44,588	0.01	7.56
United States	832,417	1,022,762	1,077,975	1,140,267	1,251,693	0.22	6.08
Singapore	14,031	16,069	18,944	19,761	21,923	0.00	5.87
Thailand	21,179	24,202	25,036	25,969	28,823	0.00	5.69
Malaysia	14,350	17,319	16,089	17,519	20,124	0.00	5.61
India	99,067	116,324	118,978	134,817	148,221	0.03	5.46
Indonesia	39,923	44,090	45,749	48,791	49,465	0.01	4.75
Vietnam	5,540	8,253	9,312	10,572	11,497	0.00	4.69
Philippines	4,992	7,360	8,216	8,468	8,051	0.00	2.32
World	4,498,171	4,808,112	4,965,841	5,289,404	5,778,935	-	6.69

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020

Likewise, globally, the value added of high R&D intensive industries increased steadily between 2011 and 2018. United States and European Union have conquered the global value-added share of this industry, 0.32% and 0.23% respectively in 2018 (Table 8.10). On the other hand, China has contributed 0.21% of global value-added share. Additionally, Taiwan, Singapore and Vietnam have successfully registered greater value-added share contribution to GDP of 16.12%, 9.56% and 7.82% respectively in 2018 compared to other global giant economies particularly the United States (5.08%), China (4.82%), European Union (4.73%), South Korea (6.88%) and Japan (2.95%). The Malaysian value-added share of high R&D intensive industries to GDP (5.52%) has surpassed the share of total global value-added to world GDP (3.75%) as well as other emerging economies such as India (2.25%), Indonesia (0.90%), Philippines (2.02%) and Thailand (2.00%) during this period.

Table 8.10 Value Added of High R&D Intensive Industries, Selected Countries

Country	Value Added of high R&D Intensive Industries					% of World Value Added	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Taiwan	69,586	84,708	85,777	94,535	95,094	0.03	16.12
Singapore	29,671	28,378	26,622	32,951	35,669	0.01	9.56
Vietnam	2,782	12,032	13,936	18,316	19,177	0.01	7.82
South Korea	91,269	103,607	99,543	112,230	118,449	0.04	6.88
Malaysia	15,495	16,970	16,901	18,054	19,783	0.01	5.52
United States	775,523	890,784	925,835	972,354	1,044,722	0.32	5.08
China	315,267	499,950	517,359	583,723	669,410	0.21	4.82
EU	552,677	651,698	665,009	684,088	754,038	0.23	4.73
Japan	220,387	146,769	158,985	140,999	146,178	0.05	2.95
India	34,317	44,887	50,216	56,050	60,995	0.02	2.25
Philippines	6,503	6,249	6,664	6,988	7,006	0.00	2.02
Thailand	10,910	9,625	9,396	9,549	10,117	0.00	2.00
Indonesia	10,564	8,469	9,197	9,835	9,393	0.00	0.90
World	2,510,015	2,737,141	2,813,346	2,987,715	3,241,776	-	3.75

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020

8.5.2 KTI Industries Exporters

The KTI industries export value increased gradually for most of the nations between 2016 and 2018. In terms of KTI industries global export share, the EU remain as dominant (0.39%) compared to other global key players namely China (0.16%), United States (0.09%), Japan (0.06%), South Korea (0.05%) and Taiwan (0.03%). In terms of exports share as GDP Asian countries reliance on exports is obvious. Notably the share is higher for Singapore (69.32%), Vietnam (56.73%), Taiwan (39.09%) and Malaysia (36.90%) (Table 8.11).

Table 8.11 Global Key Exporters of KTI Industries, 2011-2018

Country	Exports of KTI industries (USD Million)					% of World (KTI Exports)	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Singapore	242,229	229,379	221,756	238,478	258,710	0.03	69.32
Vietnam	21,981	65,095	75,070	98,392	139,106	0.02	56.73
Malaysia	104,241	99,911	97,876	112,396	132,323	0.02	36.90
Taiwan	193,591	190,067	190,994	219,532	230,566	0.03	39.09
Thailand	109,403	117,062	118,613	130,870	140,001	0.02	27.64
South Korea	390,242	393,568	369,074	428,113	444,013	0.05	25.81
EU	3,116,947	2,877,746	2,920,483	3,186,279	3,359,220	0.39	21.08
Philippines	21,983	40,186	38,236	47,243	47,491	0.01	13.69
Japan	580,870	442,567	461,925	495,660	525,116	0.06	10.60
China	966,711	1,112,836	1,062,585	1,196,151	1,344,673	0.16	9.68
India	73,956	80,286	81,089	91,088	108,297	0.01	3.99
United States	748,009	775,924	747,032	778,173	809,276	0.09	3.93
Indonesia	33,499	28,459	29,609	31,468	34,055	0.00	3.27
World	7,491,711	7,377,737	7,318,792	8,058,857	8,587,777	-	9.94

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020

Similar trend is observed for both the medium-high R&D intensive and high R&D intensive industries. In the medium-high R&D intensive industries gradual increase is recorded between 2016 and 2018 (Table 8.12). In 2018, the EU KTI's industries total contribution to global exports is 0.43% followed by China (0.12%) and United States (0.10%). The export share of medium-high R&D intensive industries to GDP is dominated by top four nations from Asia continent notably Singapore (31.52%), Thailand (19.49%), Taiwan (16.63%) and Vietnam (14.12%). Malaysia's export contribution of medium R&D intensive industry to GDP is 12.43%.

Table 8.12 Global Exporters of Medium-High R&D Intensive Industries, 2011-2018

Country	Exports of Medium-High R&D Intensive Industries (USD million)					% of World (Medium- High R&D Exports)	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Singapore	105,726	95,776	94,978	103,071	117,624	0.02	31.52
Thailand	72,883	81,306	83,554	90,366	98,722	0.02	19.49
EU	2,328,501	2,128,315	2,162,055	2,365,211	2,497,137	0.43	15.67
South Korea	291,222	278,174	257,388	275,928	257,473	0.04	14.96
Vietnam	10,592	17,393	19,580	26,039	34,627	0.01	14.12
Taiwan	94,383	84,243	78,227	89,106	98,093	0.02	16.63
Malaysia	36,455	38,906	38,179	40,585	44,580	0.01	12.43
Japan	482,481	369,791	388,899	417,144	445,311	0.08	8.99
Philippines	8,786	13,879	12,001	21,074	19,885	0.00	5.73
China	508,315	587,416	559,134	619,447	696,878	0.12	5.02
India	55,427	60,016	60,935	71,706	86,349	0.01	3.18
United States	546,853	560,401	532,661	562,103	588,745	0.10	2.86
Indonesia	24,836	22,129	23,903	25,516	27,908	0.00	2.68
World	5,241,777	5,028,702	4,983,891	5,454,712	5,787,353	-	6.70

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020

Table 8.13 displays the top exporters namely EU, China and the United States in the high R&D intensive industries. As for export share of global KTI industries, China (0.23%) remained the single country dominating the world share while EU combined contribution is 0.31% with United States contribution being 0.08%. Malaysia recorded 0.03% global export share of high R&D intensive industries which is equivalent to other top industrial economies such as Japan. At the same time, the high R&D intensive industries of Vietnam, Singapore and Malaysia established remarkable export share contribution to GDP of 42.61%, 37.80% and 24.47% respectively in 2018.

Table 8.13 Global Exporters of High R&D Intensive Industries, 2011-2018

Country	Exports of high R&D Intensive Industries (USD Million)					% of World (High R&D Exports)	% of GDP
	2011	2015	2016	2017	2018	2018	2018
Vietnam	11,388	47,702	55,490	72,353	104,479	0.04	42.61
Malaysia	67,787	61,005	59,697	71,811	87,743	0.03	24.47
Singapore	136,503	133,603	126,778	135,407	141,086	0.05	37.80
Taiwan	99,208	105,824	112,767	130,426	132,473	0.05	22.46
South Korea	99,021	115,394	111,685	152,184	186,540	0.07	10.84
Thailand	36,520	35,757	35,059	40,504	41,278	0.01	8.15
Philippines	13,197	26,307	26,235	26,168	27,606	0.01	7.96
EU	788,446	749,431	758,428	821,068	862,083	0.31	5.41
China	458,396	525,420	503,451	576,704	647,796	0.23	4.66
Japan	98,389	72,776	73,026	78,516	79,804	0.03	1.61
United States	201,157	215,523	214,371	216,069	220,531	0.08	1.07
India	18,529	20,270	20,153	19,382	21,948	0.01	0.81
Indonesia	8,662	6,330	5,706	5,952	6,147	0.00	0.59
World	2,249,934	2,349,035	2,334,901	2,604,145	2,800,423	-	3.24

Source: US Science and Engineering Indicators 2019 & World Development Indicators 2020

8.5.3 KTI Industries Trade Balance

Globally, trade balance of the KTI industries are in deficit. This indicates that the industry remained import dependence. In particular, large economies such as United States, India and Indonesia are highly import dependent recording a deficit of USD600,836 million, USD101,493 million and USD53,150 million respectively (Table 8.14). On the other hand, South Korea and China recorded significant trade surplus. Not only China and South Korea, but in ASEAN, Singapore, Thailand, Malaysia and Vietnam have recorded trade surplus. Likewise, some countries also recorded declining trade balance such as Singapore and Japan. Evidently, emerging market economies mainly from Asia have gradually dominated international trade in KTI industries.

Table 8.14 Trade Balance of KTI Industries, Selected Countries

Country	Trade Balance (USD Million)				
	2011	2015	2016	2017	2018
World	-130,118	-203,032	-350,615	-357,175	-458,423
EU	420,082	412,362	396,503	423,919	435,316
China	42,159	161,936	17,414	134,915	137,163
India	-47,109	-49,602	-46,651	-57,732	-101,493
Indonesia	-45,288	-38,930	-35,717	-41,328	-53,150
Japan	316,567	193,275	208,564	225,739	230,276
Malaysia	1,028	4,120	2,779	4,359	12,979
Philippines	-3,049	-1,651	-12,978	-10,594	-16,886
Singapore	64,555	62,713	56,172	58,202	55,020
South Korea	202,881	198,358	177,535	208,396	214,460
Taiwan	53,730	63,433	58,265	73,419	72,257
Thailand	9,883	17,697	19,360	23,007	24,653
United States	-	-469,173	-482,702	-528,509	-600,836
Vietnam	-25,173	-25,978	-21,909	-22,465	6,136

Source: US Science and Engineering Indicators 2019

Table 8.15 and Table 8.16 show the trade balance position of the medium-high R&D intensive and high R&D intensive industries, respectively. Globally, the trade balance of medium-high R&D intensive industries was dwindling between 2011 and 2018 by USD183,147 million (Table 8.15). Within Asia, China, Japan, Singapore, Taiwan, South Korea and Thailand recorded trade surplus while Malaysia, Indonesia, India, Vietnam recorded trade deficits.

In Asia, Vietnam and South Korea had recorded an impressive growth in trade balance of high R&D intensive industry (Table 8.16). Similarly, Malaysia and Taiwan recorded a moderate growth in trade surplus. Overall, Malaysia has dominated other Asian counterparts (Indonesia, Philippines, Singapore and Thailand) by gaining significant trade surplus in high R&D intensive industries.

Table 8.15 Medium-High R&D Intensive Industries Trade Balance, Selected Countries

Country	Trade Balance (USD Million)				
	2011	2015	2016	2017	2018
World	133,084	84,829	38,862	28,600	-50,063
EU	462,586	423,821	403,835	417,371	420,554
China	-41,998	102,328	65,131	96,616	116,257
India	-34,771	-30,491	-27,954	-26,428	-59,984
Indonesia	-36,715	-32,403	-28,428	-32,309	-42,213
Japan	332,889	233,472	249,198	265,461	275,922
Malaysia	-15,159	-11,256	-12,100	-14,767	-15,726
Philippines	-6,434	-5,990	-15,282	-10,218	-13,196
Singapore	25,754	24,253	22,497	26,375	29,156
South Korea	164,610	154,806	138,669	136,083	114,749
Taiwan	7,923	11,192	3,270	11,625	15,669
Thailand	3,997	15,378	16,743	20,049	22,649
United States	-99,808	-229,790	-244,068	-253,492	-296,616
Vietnam	-23,207	-35,508	-35,639	-40,257	-42,250

Source: US Science and Engineering Indicators 2019

Table 8.16 High R&D Intensive Industries Trade Balance, Selected Countries

Country	Trade Balance (USD Million)				
	2011	2015	2016	2017	2018
World	-263,202	-287,861	-389,478	-385,776	-408,361
EU	-42,503	-11,460	-7,333	6,548	14,762
China	84,157	59,608	-47,716	38,299	20,907
India	-12,339	-19,111	-18,698	-31,303	-41,509
Indonesia	-8,574	-6,527	-7,289	-9,019	-10,937
Japan	-16,322	-40,197	-40,633	-39,721	-45,647
Malaysia	16,188	15,376	14,879	19,126	28,705
Philippines	3,386	4,340	2,304	-377	-3,690
Singapore	38,801	38,460	33,675	31,827	25,864
South Korea	38,271	43,552	38,865	72,312	99,710
Taiwan	45,807	52,241	54,996	61,794	56,588
Thailand	5,886	2,320	2,617	2,957	2,003
United States	-195,888	-239,383	-238,634	-275,017	-304,220
Vietnam	-1,967	9,530	13,731	17,791	48,386

Source: US Science and Engineering Indicators 2019

8.6 Summary

Malaysia's KTI industries contribution to exports and GDP are vital. Malaysian KTI industries, based on value added, is dominated specifically by three sub-industries, namely computer, electronic, and optical products, followed by chemicals and chemical products, and motor vehicles. In terms of trade, Malaysia recorded trade surplus in the high R&D intensive

industries. Malaysia's KTI industries have performed relatively better than other counter parts. In the context of international comparison of KTI industries performance, Malaysia has successfully maintained trade surplus and managed to increase its value-added contribution over the years. However, the main challenges remained on how Malaysia could accelerate its contribution of the services industries and the medium R&D intensive industries. Indeed, Malaysia had to achieve significant growth like South Korea and China by being more competitive in the KTI sectors.

9

ENERGY AND GREEN TECHNOLOGY

CHAPTER 9: ENERGY AND GREEN TECHNOLOGY

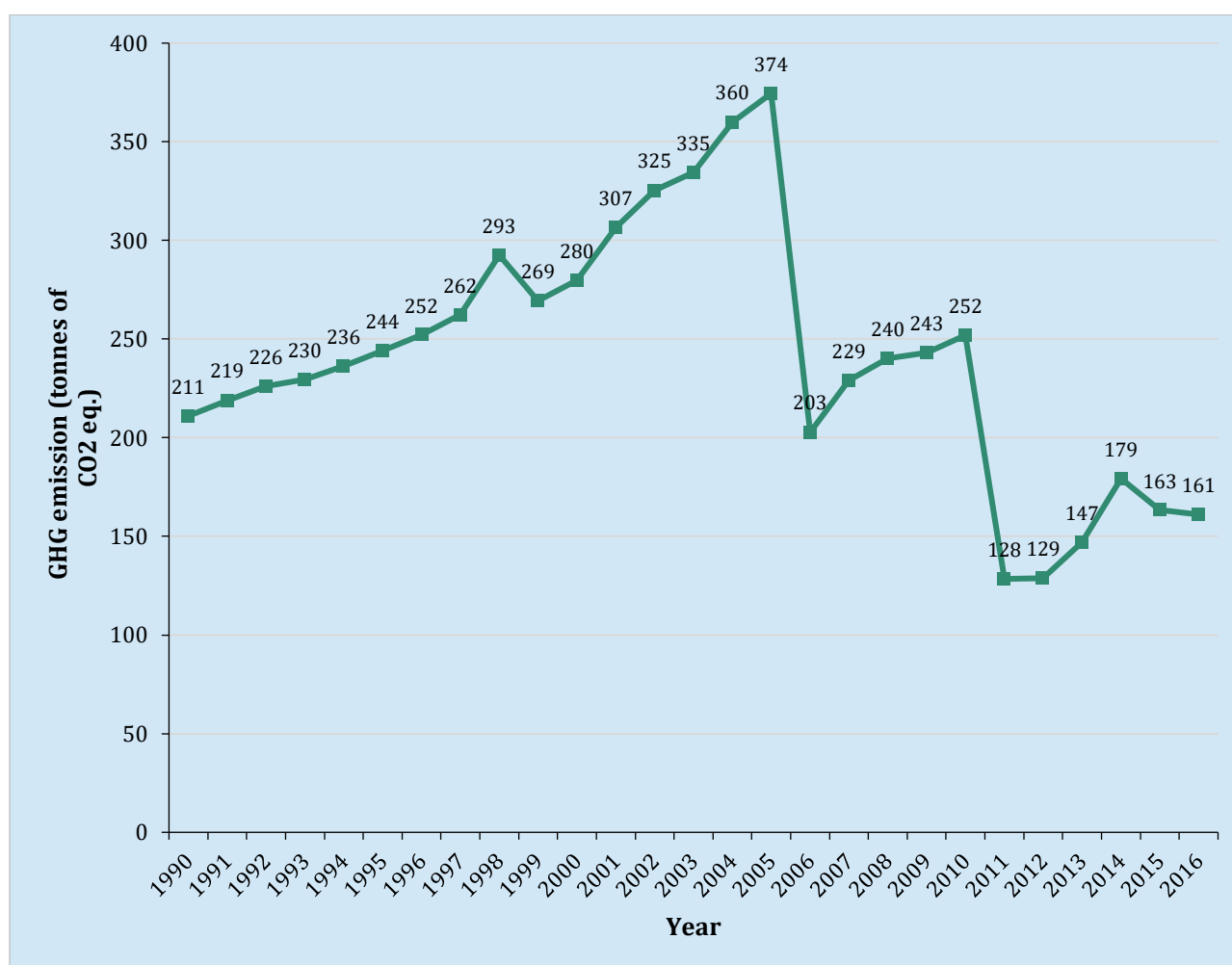
9.1 Introduction

The sustainable development goals emphasis on affordable and clean energy requiring nations to transform the energy consumption landscape by promoting new technology adoption and increasing investments in green growth industries. Indeed, achieving the goal complements in attaining other goals such as climate action, sustainable cities, responsible consumption and production. Malaysia's policy drive and commitment has been in tandem with the rest of the world. The government have had committed in driving Malaysia to a greener path via various broader and specific policies such as National Policy on the Environment, National Green Technology Policy, Green Technology Master Plan Malaysia (2017-2030), National Policy on Climate Change, National Renewable Energy Policy and Action Plan, 2009 and National Energy Efficiency Action Plan (2016-2025). These policies established specific initiatives and targets. This chapter assesses Malaysia's progress in selected green growth indicators as proposed by OECD⁶ (OECD, 2017). The chapter uses selected relevant indicators to understand the overall green growth path as well as STI indicators related to energy and green technology.

9.2 Energy and Low Carbon Path

Malaysia's commitment to reduce greenhouse gas (GHG) started in 2006. As reflected in its Nationally Determined Contribution based on the Paris Agreement, its target is to reduce GHG emission intensity by 45% by 2030 with international financial and technological support. By 2011, Malaysia managed to reduce carbon emission intensity by 33% and it shows that Malaysia is able to move into the low carbon development path. Figure 9.1 and Figure 9.2 shows the GHG emissions and CO₂ emission intensity of Malaysia respectively. Since 2006, Malaysia experienced a drastic decline in GHG emissions from the peak of 374 tonnes in 2005 to 161 tonnes of CO₂ equivalent of GHG emission in 2016. The reduction in GHG emissions is mainly due to sound management of land-use and forestry. Malaysia also experienced a slight decline in GHG emission in the manufacturing and construction sectors. However, in the main contributing sectors, electricity and heat as well as transportation, GHG emissions have increased over the years. Malaysia should focus in reducing the GHG emissions in the major contributing sectors.

⁶ 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.

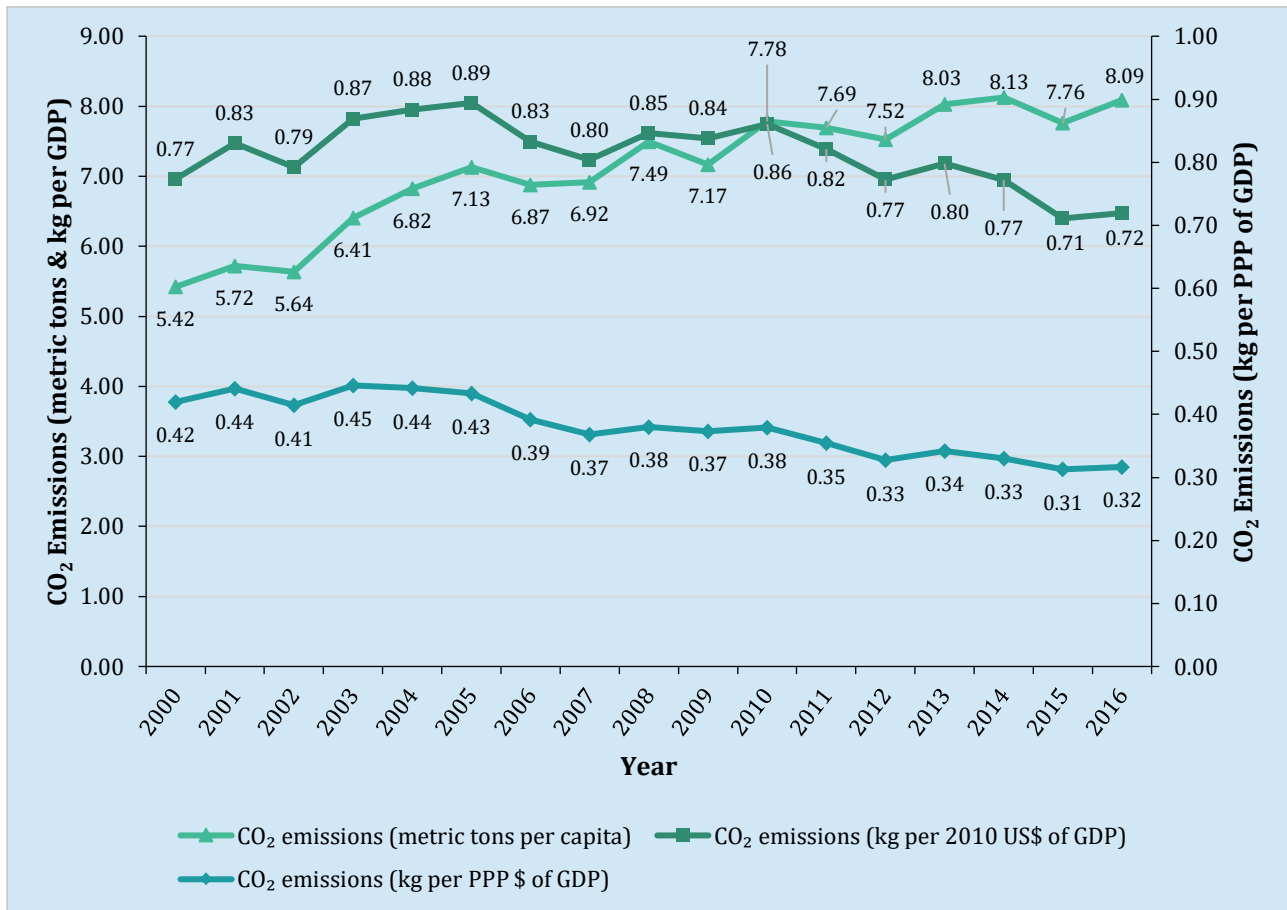
Figure 9.1 Greenhouse Gas Emissions, 1990-2011

Note: Greenhouse gas emissions are measured in tonnes of carbon dioxide-equivalents (CO₂e), and include emissions from land-use change and forestry.

Source: CAIT Climate Watch Data Explorer via Climate Watch

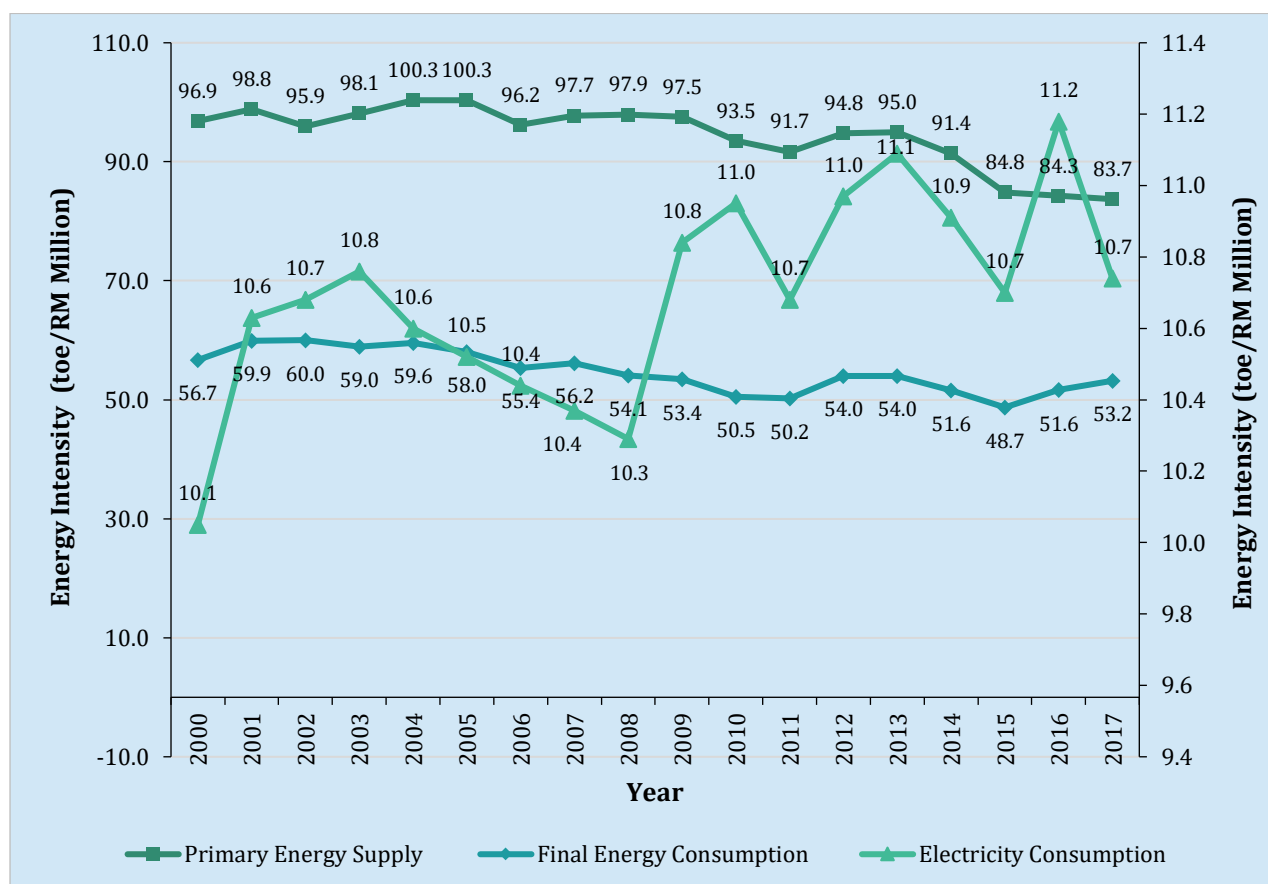
Figure 9.2 shows the CO₂ emissions over the periods of 2000 until 2016. Examining the CO₂ emission per capita (divided by population) over the years shows an increasing trend, increasing from 5.42 to 8.09 metric tons per capita. Nevertheless, understanding the decoupling of CO₂ emissions from economic activity measured by CO₂ emissions kg per GDP shows a declining trend mainly since 2010 from 0.86 to 0.72. It may indicate that Malaysia's effort to reduce carbon footprint showing effect over the years. Similar trend is observed for CO₂ emission at purchasing power parity of GDP that sets for global comparison. Malaysia has been successful in bringing its emission intensity down.

Figure 9.2 CO₂ Emissions, 2000-2016



Source: World Development Indicators

The National Energy Efficiency Action Plan has set various strategies to improve energy efficiency specifically targeted to reduce the electricity consumption. Figure 9.3 shows the energy intensity of the primary energy supply, final energy consumption and electricity consumption. In terms of primary energy supply intensity, the trend has been declining over the years from 96.9 (toe/RM million) in 2000 to 83.7 (toe/RM million) in 2017. The final energy consumption intensity shows a similar trend declining from 56.7 (toe/RM million) in 2000 to 53.2 (toe/RM million) in 2017. In terms of electricity consumption intensity, while a declining trend is observed after 2003 until 2008, the trend seems to increase since 2009 and recorded a peak of 11.2 (toe/RM million) in 2016. The demand side management of the electricity consumption intensity is crucial in improving energy efficiency especially demand from the industry.

Figure 9.3 Primary, Final and Electricity Energy Consumption Intensity, 2000-2017

Note: Primary energy consist 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

Malaysia targets to achieve 20% of renewable energy (RE) capacity mix in the energy sector by 2025. To date, programmes to promote renewable energy include net energy metering, Feed-in-Tariff and large scale solar. Figure 9.4 shows the share of RE in total energy supply over the years. Since 2010, the share of RE in total energy supply has been increasing and the current share in 2019 stands at 6.01%. Malaysia needs to intensify its efforts in achieving a higher RE mix in its total energy supply mix. Placing the necessary regulatory framework, infrastructure and financing are critical in achieving its RE targets.

Figure 9.4 Renewable Energy in Total Energy (%)

Note: Renewable energy sources includes hydropower, solar, wind, geothermal, bioenergy, wave and tidal. It does not include traditional biofuels, which can be a key energy source especially in lower-income settings.

Source: BP Statistics Review of World Energy, 2020.

Decomposing the total primary energy supply by fuel types (Table 9.1) indicates that natural gas (41.90%), oil (29.89%) and coal (21.13%) as the main fuel types contributing to the total primary energy supply. In 2017, hydropower, biodiesel, biomass, biogas and solar contributes 7.1% of the total primary energy supply. Among the fuel types hydropower contributes the largest share followed by biodiesel and biomass.

Table 9.1 Total Primary Energy Supply by Fuel Types, ktoe.

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	24	-	-	-	79,289
2012	29,502	38,648	15,882	2,150	115	183	4	11	86,495
2013	32,474	39,973	15,067	2,688	188	297	6	38	90,731
2014	33,422	40,113	15,357	3,038	300	181	12	63	92,486
2015	29,165	41,853	17,406	3,582	389	189	18	75	92,677
2016	31,327	41,257	18,744	4,501	389	198	21	90	96,525
2017	29,379	41,201	20,771	6,240	379	194	41	93	98,298

Source: Energy Commission

Table 9.2 shows the commissioned RE installation projects and the annual power generation from RE under the Feed-in-Tariff system. The total RE power generation has increased from 143,057.00 MWh in 2012 to 791,910.80 MWh in 2018. Solar accounts for the largest (45.52% in 2018) among the sources of RE followed by biomass and biogas, respectively.

Table 9.2 Power Generation (MWh) of Commissioned RE Installations, 2012-2018

Year	Biogas	Biogas (Landfill / Agri Waste)	Biomass	Biomass (Solid Waste)	Small Hydro	Solar	Total RE
2012	98.10	7,465.40	101,309.90	3,234.50	25,629.80	5,319.30	143,057.00
2013	12,962.70	9,804.10	209,407.60	11,144.30	79,081.80	50,756.60	373,157.10
2014	19,772.30	31,844.40	226,198.40	4,347.80	67,567.90	184,284.00	534,014.80
2015	16,988.66	41,122.40	192,372.20	18,090.10	55,406.40	263,875.50	587,855.26
2016	17,143.10	70,486.00	151,385.20	36,751.70	47,798.30	316,964.90	640,529.20
2017	16,319.90	198,985.20	247,542.90	19,303.90	74,831.30	426,834.70	983,817.90
2018	11,680.10	170,802.30	194,688.30	4,101.30	50,124.90	360,513.90	791,910.80
TOTAL	94964.86	530509.80	1322904.50	96973.60	400440.40	1608548.90	4054342.06

Source: SEDA

As for sustainable development, the promotion of diversification moving towards non-carbon sources of energy generation is a high priority. Indeed, increasing the share of non-carbon fuels reduces emissions per unit of energy and the greenhouse gases as well as other pollutants. Table 9.3 illustrates the sources of fuel mix in the power stations. Malaysia's power generation have gradually moved into using natural gas before 2010 and since 2010 coal have dominated the fuel mix. Overall, coal and natural gas are the dominate sources of fuel mix and they account for 82.21% of the fuel mix in 2017. Contribution of hydropower has increased to 16.64% of the total fuel mix in 2017. In terms of renewable energy, it only represents 0.49% of the total fuel mix in 2017. Among the renewable energy, solar energy contributes 50.27% of the total

renewable energy followed by biomass (28.11%) and biogas (21.62%). Although there is a slight increase in renewable energy generation over the years, challenges remain in moving towards renewable energy as an important source of fuel mix for power generation.

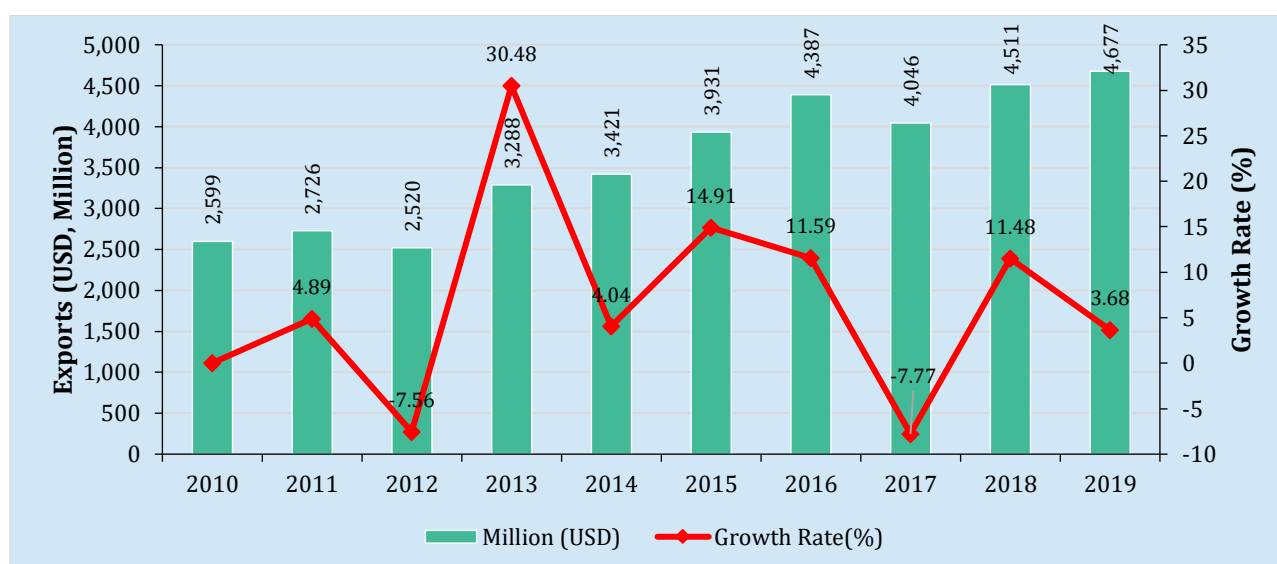
Table 9.3 Source of Fuel Mix in Power Station, ktoe, 2000-2017

Years	Fuel Oil	Diesel	Natural Gas	Hydropower	Coal	Renewables	TOTAL
2000	592	191	11,580	1,612	1,495	-	15,470
2001	730	278	11,922	1,687	1,994	-	16,611
2002	1,363	476	12,424	1,329	2,556	-	18,148
2003	289	340	10,893	1,056	4,104	-	16,682
2004	274	272	10,545	1,329	5,327	-	17,747
2005	275	298	12,271	1,313	5,541	-	19,698
2006	171	617	12,524	1,567	5,964	-	20,843
2007	199	314	12,549	1,522	7,486	-	22,070
2008	181	299	13,651	1,964	8,069	-	24,164
2009	205	384	13,390	1,627	9,010	-	24,616
2010	125	415	12,628	1,577	12,951	-	27,696
2011	1,103	981	10,977	1,850	13,013	-	27,924
2012	550	811	11,533	2,150	14,138	80	29,262
2013	392	623	13,520	2,688	13,527	208	30,958
2014	269	622	13,860	3,038	13,648	171	31,608
2015	101	279	13,378	3,582	15,627	166	33,133
2016	155	165	13,260	4,499	17,101	168	35,348
2017	99	147	11,872	6,240	18,967	185	37,510

Note: Excluding co-generation and private power plants.

Source: Energy Commission 2019

The exports of photosensitive semiconductor devices products have significantly increased from USD2,599 million in 2010 to USD4,677 million in 2019 (Figure 9.5). On average exports of PV products has increased around 7.30% annually over the 2011 and 2019 period. Malaysia has been one of the key production hubs for solar products and with the adequate foreign direct investments and generous support the sector shows significant progress.

Figure 9.5 Exports PV Products, 2010-2019

Note: Photovoltaic (PV) products refer to HS 854140 - Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels, Light emitting diodes. Annual average growth is the average sum of between 2011-2019. Source: Comtrade database accessed on 6 November 2020.

9.4 Green Scientific Knowledge and Low Carbon Technology Inventions

R&D are crucial in supporting low carbon growth path. This section captures the scientific knowledge and technological inventions in low carbon and green fields based on publications and patents. It allows policy makers to assess Malaysia's knowledge and technological capability. Malaysia recorded increasing share of publications in areas related to energy fuel and green and sustainable S&T. For the period of 2011-2019, the total number of publications related to energy and green technology is 6,442. It shows an increasing trend where in 2011 only 312 publications were recorded, and it has since increased nearly more than twofold in 2019 from the original number (Table 9.4). The total share of publication in 2019 is 16.45%.

Table 9.4 Energy and Sustainable Science and Technology Knowledge, Malaysia

Year	No. of Publications	Percentage of Total (%)
2011	312	4.84
2012	396	6.15
2013	548	8.51
2014	683	10.60
2015	706	10.96
2016	877	13.61
2017	965	14.98
2018	895	13.89
2019	1,060	16.45
TOTAL	6,442	100

Note: Search is based on keywords – Energy Fuel, Green and Sustainable Science and Technology

Source: Science Citation Index Expanded (SCIE) & Social Science Citation Index (SSCI).

Date of extraction: 29th July, 2020

Table 9.5 shows the technological capability measured by patents. A total of 70 patents were recorded since 2011 in the PCT. The largest share of patent registered is in the years of 2012, 2013 and 2015 recording 20% of the total share between 2011-2019. Malaysia needs to intensify its effort by encouraging more patent applications in areas of green technology to support the industrial progress in renewable energy. Given that renewable energy promises as a new growth prospective, these patent applications could potentially allow Malaysia to further commercialise its inventions and create new types of industries related to RE technologies.

Table 9.5 Low Carbon Energy Related Patents, Malaysia, 2011-2019

Year	No. of Patents	Percentage of Total (%)
2011	10	14.29
2012	14	20.00
2013	14	20.00
2014	3	4.29
2015	14	20.00
2016	4	5.71
2017	4	5.71
2018	1	1.43
2019	6	8.57
TOTAL	70	100

Note: Search is based on keywords - renewable energy; alternative energy source; biogas; biomass; biomass energy; hydroelectric power; solar energy; steam power; thermal energy; wind power.

Source: PATSEER.

Date of extraction: 29th July, 2020.

In building the industrial path towards production of green products and services, Malaysia initiated the MyHijau programme as part of the green recognition scheme. Table 9.6 shows the targets and achievements of the initiative. Since 2015 a total of 5,577 products and services were registered and given the recognition. The achievements are above the target set at 5,000 products and services. In terms of number of companies, a total of 407 companies were registered as part of the green recognition scheme. Recognition is important given that it acts

as one of the important driving factors for companies to engage in the production of green products and services thus improving productive capacity in Malaysia.

Table 9.6 Number of Products & Services and Companies

Targets/Achievements	2015	2016	2017	2018	2019	2020
	No. of Products/Services					
Targets	150	250	800	1,000	1,250	1,550
Achievements	181	215	934	1,812	2,041	394
Cumulative Target	150	400	1,200	2,200	3,450	5,000
Cumulative Actual	181	396	1,330	3,142	5,183	5,577
	Number of Companies					
Achievements	51	69	106	64	97	20
Cumulative	51	120	226	290	387	407

Note: The figure for 2020 is until October 2020

Source: Malaysian Green Technology Corporation

Table 9.7 shows the percentage of international collaboration established with others in environmental related patents applied. On average, for the total patents, the international collaboration stands at 37% between 2008 and 2016. It shows that Malaysian inventors' engagements with other inventors. As for water related adaptation technologies patents, the international collaboration is significant. Among others, patents related the environmental technologies have had a greater collaboration than general environmental management and climate change mitigation technologies. Intensifying international collaborations would help Malaysia position itself as technology inventor in the future especially in critical green technologies where Malaysia has yet to build its capabilities.

Table 9.7 International Collaboration in Technology Development (%), 2008-2016

Technology domain	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total Patents	37	46	51	37	40	34	31	31	28
Environment-related technologies	41	35	30	45	23	48	17	50	14
General environmental management	37	35	27	36	20	50	50	33	0
Water-related adaptation technologies	0	100	100	0	0	0	0	0	0
Climate change mitigation	47	35	21	50	25	50	15	50	16

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

Source: OECD

9.5 Green Financing and Green Jobs

Malaysia has embarked in financing green technology in an effort to encourage domestic firms and entrepreneurs to involve in green technology projects. The Green Technology Financing Scheme has been introduced since 2010, and the scheme was targeted at sectors such as energy, waste, water, building, transport and manufacturing. Around 28 financial institutions have participated in financing green technologies. Table 9.8 shows the financing of the green

technology projects from 2016-2019. In terms of green project certification, a total of 94 projects were certified. The projects largely came from the solar and biogas power plant representing 29.79% and 24.47% of the total projects certified. Nearly, 58.83% of the total number of projects with secured financing are for the solar (38.66%) and solar rooftop (20.17%). Solar farm and biogas power plant represent 11.76% and 15.97% of the total number of projects with secured financing. A total of RM1,936.16 million was financed for various projects. The largest amount of financing is for solar farm (3.23%) and solar technologies (28.89%).

Table 9.8 Project Financing by Type of Project, 2016-2019

Type of Projects	Green Project Certificate		Projects with Secured Financing		Financing Amount (RM Million)	%
	Number of Projects	Percentage (%)	Number of Projects	Percentage (%)		
Solar Farm	11	11.70	14	11.76	643.43	33.23
Solar	28	29.79	46	38.66	559.40	28.89
Biogas Power Plant	23	24.47	19	15.97	228.41	11.80
Hydro Power Plant	2	2.13	4	3.36	182.97	9.45
Waste	8	8.51	6	5.04	139.41	7.20
Solar Rooftop	14	14.89	24	20.17	98.84	5.11
Biomass	4	4.26	3	2.52	55.72	2.88
Energy Efficiency (Building)	1	1.06	1	0.84	10.00	0.52
Energy Saving Initiatives	1	1.06	1	0.84	10.00	0.52
Electric Vehicle	-	-	1	0.84	7.98	0.41
Pellet Plant	2	2.13	-	-	0.00	0.00
TOTAL	94	100	119	100	1,936.16	100

Note: Data for 2018 is not available. Green project certification data for 2016 is not available.

Source: Malaysian Green Technology Corporation

In terms of sectors that received financing between 2016-2017, the energy sector received the most financing (92.55%) amounting to RM944.68 million (Table 9.9). This is followed by the waste and water sector with 5 projects. Projects in energy sector also received the largest number of green certifications with 85.33% of the projects securing green certification. A total of 150 projects received green certification between 2016 and 2017.

Table 9.9 Project Financing by Type of Project, 2016-2017

Sectors	Green Project Certificate		Projects with Secured Financing		Financing Amount (RM Million)	%
	Number of Projects	Percentage (%)	Number of Projects	Percentage (%)		
Energy	128	85.33	87	92.55	944.68	90.96
Waste and Water	17	11.33	5	5.32	75.92	7.31
Building	3	2.00	1	1.06	10.00	0.96
Transport	2	1.33	1	1.06	7.98	0.77
TOTAL	150	100	94	100.00	1,038.57	100

Note: Data for 2018 and 2019 is not available by sectors.

Source: Malaysian Green Technology Corporation

In moving towards sustainable development, the generation of green jobs and skills are central. Promoting green enterprises requires active engagement of workers and employers who can actively act as the agents of change and transforming the existing labor force to acquire green skills is essential. The project financing by the government has also generated a total of 7,076 green jobs (Table 9.10). The largest number of jobs created was in the years 2019, 2017 and 2015 with above 1,000 jobs annually.

Table 9.10 Green Jobs Generated from Projects, 2011-2019

Years	Number of Employed
2011	150
2012	406
2013	713
2014	787
2015	1,200
2016	964
2017	1,118
2018	438
2019	1,300
TOTAL	7,076

Note: Total employment generated from Green Technology Financing Scheme (GTFS) 1 & 2, GITA and GITE

Source: Malaysian Green Technology Corporation

Additionally, green financing has also kick started with initiatives in the capital market with the issuance of green bonds and loans. Malaysia aspires to become the global and regional hub for green sukuk financing, and it continues to grow the green sukuk markets. The number of issuers has grown from 3 in 2017 to 6 in 2019 focusing mostly on energy and building related projects. Box 9.1 illustrates the green financing progress in Malaysia.

Box 9.1 Green Financing in Malaysia

The Malaysian government has formulated strategies to develop the capital market and private financing with the launch of Sustainable and Responsible Investment Roadmap by the Malaysia Securities Commission. In addition, Green Sukuk Grant Scheme was established in 2018 and the government is in the process of formulating sustainable reporting taxonomy to better recognize, support and capture green financing initiatives among the financial institutions. Since 2017, there are 12 green financing (bond and sukuk deals) issuances amounting to RM5,245 million. In 2019, 6 issuers predominately in the energy sectors issued a total of RM2,424 million with first mini-hydro sukuk (Telekosang Hydro One Sdn Bhd) in Malaysia. Telekosang Hydro issued RM120 million of 20-year green junior bond and another RM470 million 18-year green sukuk, both allocating a 24MW “run-of-river minihydro” plant. PNB Merdeka Ventures was the largest issuer in the buildings sector (RM690 million) while Quantum Solar was the largest related to energy sector (RM1,000 million). The progress illustrates that Malaysia can develop the market further to support its green growth path and further place Malaysia as the potential green Islamic hub, globally and regionally.

Issuer	Amount Issued (RM Million)	Year Issued	Use of proceeds
PNB Merdeka Ventures Sdn Bhd	435	2019	Energy
Cypark Ref Sdn Bhd	550	2019	Energy
Edra Solar Sdn Bhd	245	2019	Energy, Land use
Telekosang	590	2019	Energy
PNB Merdeka Ventures Sdn Bhd	445	2019	Energy
Pasukhas Group	158	2019	Energy, Buildings, Water, Waste, Land use,
Universiti Teknologi Mara	222	2018	Energy
Mudajaya Group Berhad	245	2018	Energy
SEGI Astana SDN Bhd	415	2018	Buildings
PNB Merdeka Ventures Sdn Bhd	690	2017	Buildings
Quantam Solar	1,000	2017	Energy
Tadau Energy	250	2017	Energy
TOTAL	5,245		

Source: Climate Bonds Initiative, ASEAN State of the Market 2019

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, Thailand and Vietnam. Overall, final energy intensity has been decreasing over the years in ASEAN. Over the years, in the case of Malaysia, energy intensity has been slightly decreasing from 0.183 Mtoe/billion USD in 2000 to 0.163 Mtoe/billion USD in 2016 (Table 9.11).

Table 9.11 Final Energy Intensity in ASEAN, Mtoe/Billion USD

Country	1973	1980	1990	2000	2005	2010	2015	2016
Vietnam	0.905	0.773	0.544	0.411	0.412	0.416	0.378	0.396
Thailand	0.263	0.228	0.204	0.232	0.246	0.249	0.251	0.240
Myanmar	1.523	1.177	1.175	0.717	0.440	0.252	0.224	0.220
Malaysia	0.165	0.156	0.17	0.183	0.185	0.167	0.156	0.163
Indonesia	0.311	0.274	0.258	0.265	0.232	0.189	0.168	0.159
Philippines	0.263	0.204	0.208	0.191	0.145	0.119	0.109	0.111
Brunei	0.015	0.018	0.036	0.048	0.047	0.096	0.072	0.100
Singapore	0.073	0.066	0.074	0.062	0.079	0.065	0.063	0.062

Source: Energy Balances of Non-OECD Countries, 2018 Edition, International Energy Agency (IEA)

Table 9.12 shows the final energy consumption per capita indicates energy consumption per population in the selected ASEAN member countries. Malaysia is way below in terms of per capita energy consumption compared to Singapore and Brunei. Despite Malaysia recording lower 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 2010, final energy consumption per capita in Malaysia is 1.512 toe per capita and it increased to 1.793 toe per capita in 2016 (Table 9.12).

Table 9.12 Final Energy Consumption (toe) Per Capita in ASEAN

Country	1973	1980	1990	2000	2005	2010	2015	2016
Brunei	1.000	1.050	1.167	1.900	1.575	3.275	2.450	3.325
Singapore	0.636	0.888	1.670	2.078	3.130	3.029	3.300	3.289
Malaysia	0.395	0.519	0.773	1.283	1.479	1.512	1.680	1.793
Thailand	0.271	0.320	0.510	0.803	1.069	1.263	1.440	1.415
Vietnam	0.286	0.243	0.243	0.323	0.427	0.555	0.636	0.700
Indonesia	0.275	0.337	0.441	0.568	0.585	0.589	0.644	0.631
Myanmar	0.253	0.250	0.232	0.249	0.266	0.249	0.302	0.312
Philippines	0.368	0.344	0.317	0.307	0.264	0.253	0.285	0.306

Source: Energy Balances of Non-OECD Countries, 2018 Edition, International Energy Agency (IEA)

9.7 Summary

The trends and analysis show that Malaysia is progressing towards green growth path with some progress in diffusing green technology. However, the progress towards low carbon path requires Malaysia to intensify its efforts further, namely, in increasing its share of renewable energy in total energy supply. Similarly, the knowledge and technology diffusion in areas of green technology should be further encouraged. The high cost of renewable energy and technologies would be one of the major barriers in the diffusion of green technologies. While the current initiatives provide strong encouragement to increase the supply of renewable energy and technologies, the demand management and adoption of these green technologies

are crucial in creating the markets for such technologies. Significantly, more efforts are needed to decouple the economy from the conventional sources of energy, namely, fossil fuels and coal. Malaysia's inspiration to move into green growth path requires significant investments and the technological know-how.

10

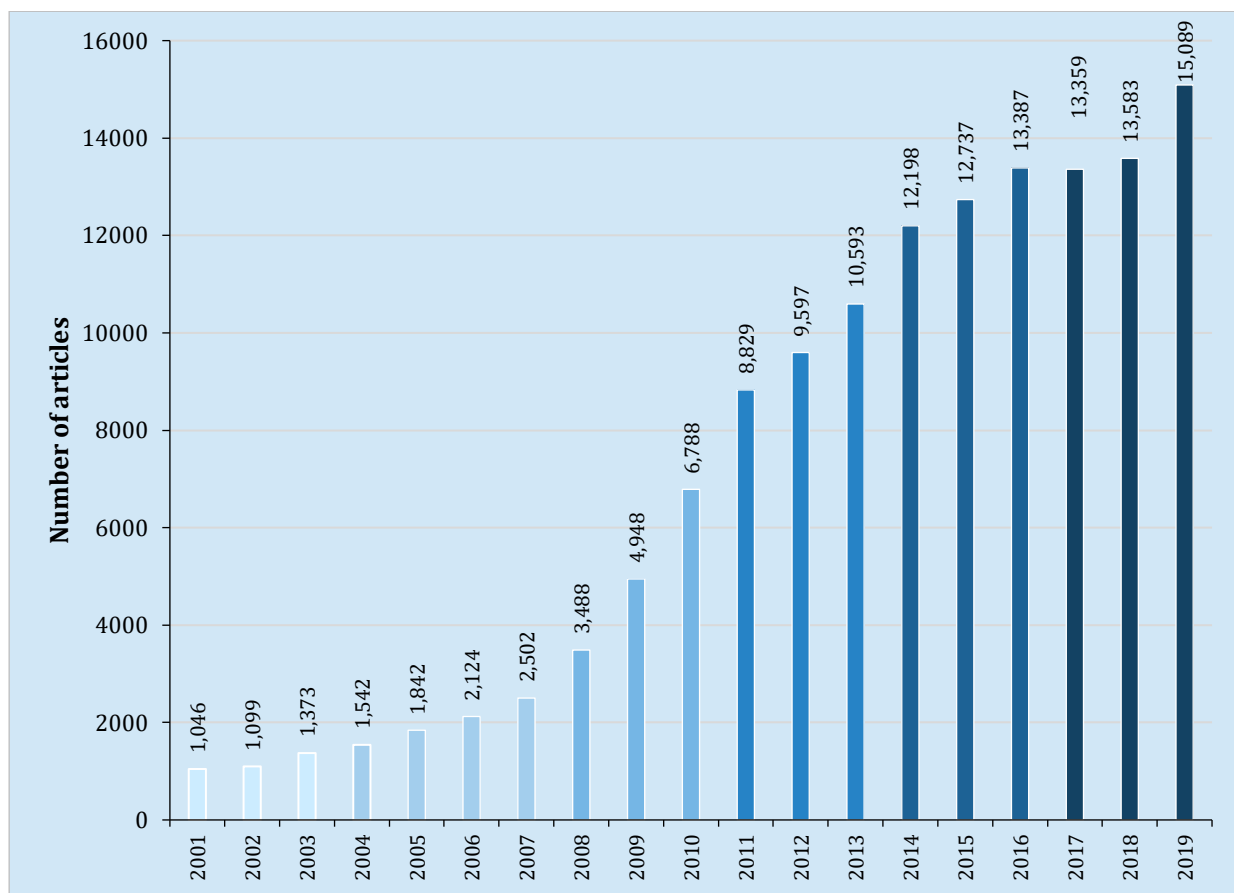
BIBLIOMETRICS

CHAPTER 10: BIBLIOMETRICS: PUBLICATION AND CITATIONS**10.1 Introduction**

This chapter provides an analysis of the progress of scientific capabilities in Malaysia by assessing the production of scientific publications that are listed in the Web of Science database. Publications in journals indexed under Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) are considered. The assessment includes (1) a review on publication counts, (2) performing institutions in publications, (3) fields of research, (4) joint publications, (5) citations and (6) h-index. The performance is benchmarked with that of other countries. This chapter reveals the productivity and competency of the science system of Malaysia. It also explores top fields in scientific research and their competitive positions comparing to that of top countries in the world.

10.2 Performance in Scientific Publications**10.2.1 Total Publication Counts**

A total of 136,124 articles were published between the period of 2001 and 2019. The publication counts for the case of Malaysia has increased from 19,850 in 9th MP to 53,954 in 10th MP and 55,418 in 11th MP (2016-2019). As shown in Figure 10.1, a surge in publications is observed starting 2008 followed with a low growth between 2016 and 2018. Malaysia produced 15,089 articles in 2019 with a modest growth of 11% from 2018. The trend implies progress towards accomplishing the optimal state for scientific production constrained by the resources in terms of funding and workforce.

Figure 10.1 Total Number of Articles, 2001-2019

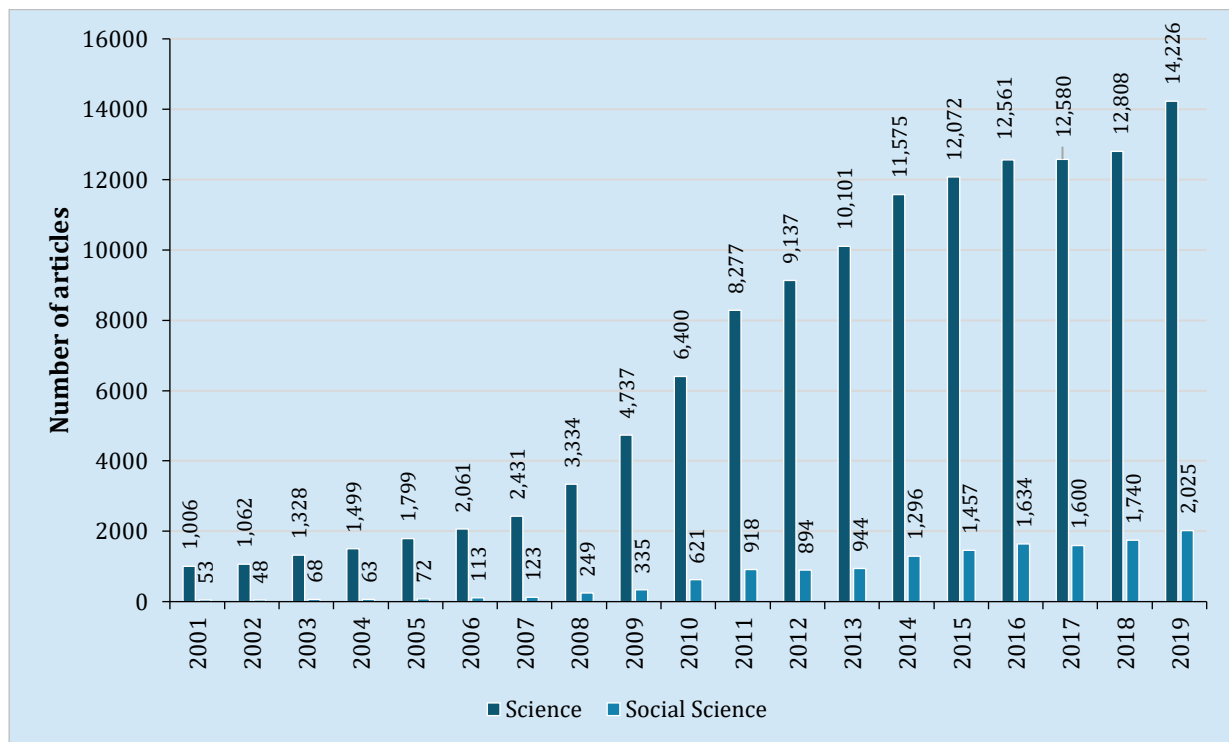
Source: Web of Science (SCIE and SSCI)

Date of Extraction: 29th July, 2020

10.2.2 Number of Articles between Science and Social Science

Figure 10.2 shows the articles count for two categories: Sciences and Social Sciences. For Sciences, it is noted that a surge of publications occurred in 2008 and reached an optimal level around 2015. Compared to 2018, an increase of about 11% is recorded in 2019. For Social Sciences, a surge is observed in 2006 and it has an average growth rate of 33% between 2006-2011. The growth then flattens and increases at an average rate of 8% between 2012-2018. However, there is an increase of 16% in 2019. It is yet to be observed if the increases for 2020 in Sciences and Social Sciences publication counts are sustainable.

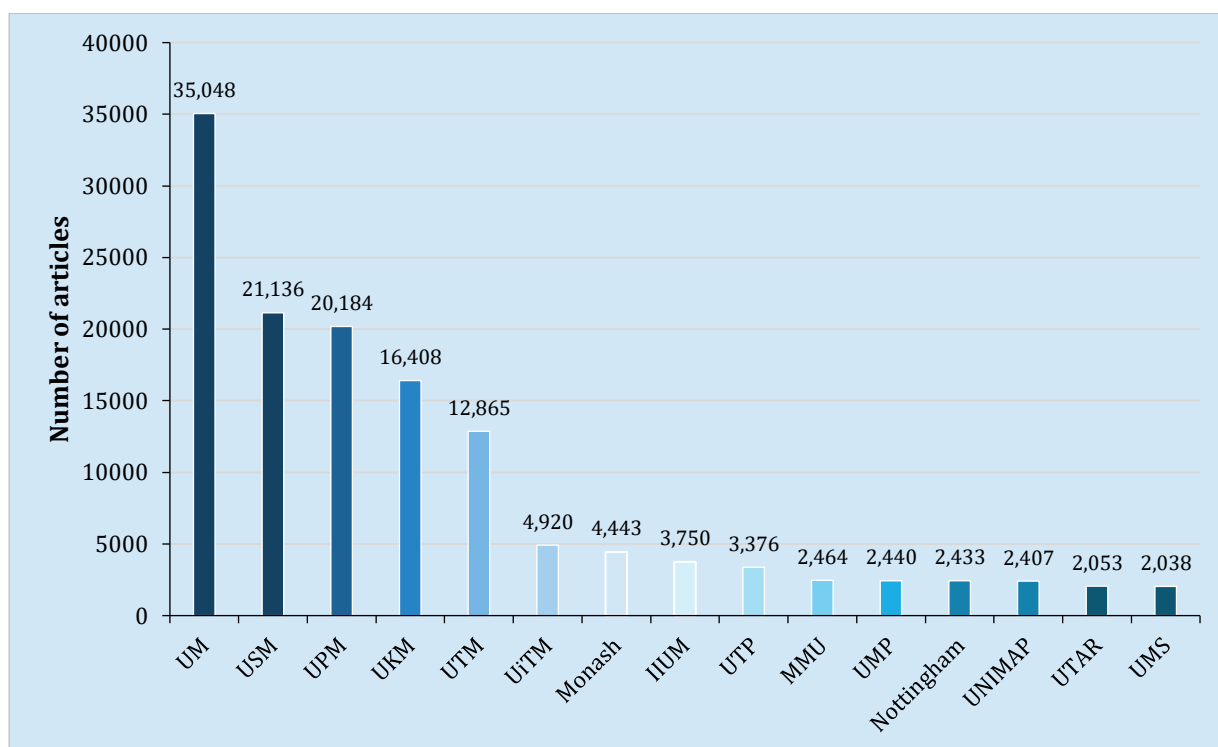
Figure 10.2 Total Number of Articles, Sciences and Social Sciences



Note: The total is not equivalent to Figure 10.1 since some journal articles are classified under both Science and Social Science.
 Source: Web of Science (SCIE and SSCI)
 Date of Extraction: 29th July, 2020

10.2.3 Scientific Publications in HLIs

Figure 10.3 shows the top 15 higher learning institutions by publication counts. UM stands out as the top institution producing 13,912 (about 66%) more articles than the second in the rank- USM. The top 5 research universities- UM, USM, UPM, UKM and UTM produced a total of 105,641 articles from 2001 to 2019. This total accounted for 78% of the total articles in Malaysia. Private universities such as Monash, Nottingham, Multimedia University (MMU) and UTAR are among the top listed institutions. Their publication footprints are considerably evident in the scientific publishing landscape of Malaysia.

Figure 10.3 Articles by Top Institutions, 2001-2019

Source: Web of Science (SCIE and SSCI)
 Date of Extraction: 29th July, 2020

10.2.4 Scientific Publications in Public Research Institutions

Public Research Institutions (PRIs) in Malaysia are playing an important role in scientific publications. Importantly, scientist and researchers working for medical and health-related institutions have contributed to scientific publications. Such institutions include the Ministry of Health, Hospital Kuala Lumpur, Sarawak General Hospital, Penang General Hospital, Hospital Selayang, Queen Elizabeth Hospital, Hospital Sultanah Bahiyah and Hospital Sultanah Aminah. They, collectively, have produced a total of 4,035 articles between 2001-2019, accounting for 2.96% of total articles in Malaysia. Contribution from agricultural and forestry-related institutions (Malaysian Palm Oil Board, Forest Research Centre, Malaysian Agricultural Research and Development Institute and Malaysia Rubber Board) and energy and industrial related institutions (Malaysian Nuclear Agency, SIRIM and MIMOS) are noticeable. Ministry of Health, Malaysian Palm Oil Board and Malaysian Nuclear Agency recorded more than 1,000 publication counts.

Table 10.1 Articles by Public Research Institutions, 2001-2019

Institution	Number of Articles	%
Ministry of Health, Malaysia	1,959	24.16
Malaysian Palm Oil Board	1,163	14.35
Malaysian Nuclear Agency	1,151	14.20
Forest Research Centre	850	10.48
Kuala Lumpur General Hospital (Hospital Kuala Lumpur)	659	8.13
Sarawak General Hospital	484	5.97
Malaysian Agricultural Research and Development Institute	365	4.50
Penang General Hospital (Hospital Pulau Pinang)	299	3.69
Selayang Hospital (Hospital Selayang)	228	2.81
SIRIM	220	2.71
Malaysia Rubber Board	167	2.06
Queen Elizabeth Hospital	164	2.02
MIMOS	156	1.92
Hospital Sultanah Bahiyah	122	1.50
Hospital Sultanah Aminah	120	1.48
TOTAL	8,107	100

Source: Web of Science

Date of Extraction: 29th July, 2020

10.2.5 Scientific Publications by Fields of Research

Table 10.2 reports the top 15 fields of research by counts of article. “Materials Science-Multidisciplinary” is found as the top field with a total of 9,407 articles between 2001 and 2019. It accounted for 6.91% of the total articles in Malaysia. Other top multidisciplinary fields are “Multidisciplinary Sciences” and “Chemistry Multidisciplinary”. They accounted for 4.93% and 3.89% respectively. Eight fields are performing at a capacity of above 5,000 articles. Pharmaceutical and biotechnology-related fields- such as “Pharmacology Pharmacy”, “Biotechnology Applied Microbiology” and “Biochemistry Molecular Biology” are some of the other emerging fields in the scientific publication landscape of Malaysia.

Table 10.2 Malaysia's Top 15 Fields of Research, 2001-2019

Field	Number of Articles	%
Materials Science Multidisciplinary	9,407	11.51
Engineering Electrical Electronic	7,649	9.36
Multidisciplinary Sciences	6,712	8.21
Engineering Chemical	6,297	7.70
Environmental Sciences	6,165	7.54
Energy Fuels	5,752	7.04
Chemistry Multidisciplinary	5,297	6.48
Physics Applied	5,185	6.34
Food Science Technology	4,791	5.86
Pharmacology Pharmacy	4,580	5.60
Crystallography	4,486	5.49
Chemistry Physical	4,306	5.27
Biotechnology Applied Microbiology	4,039	4.94
Biochemistry Molecular Biology	3,639	4.45
Polymer Science	3,426	4.19
Total	81,731	100

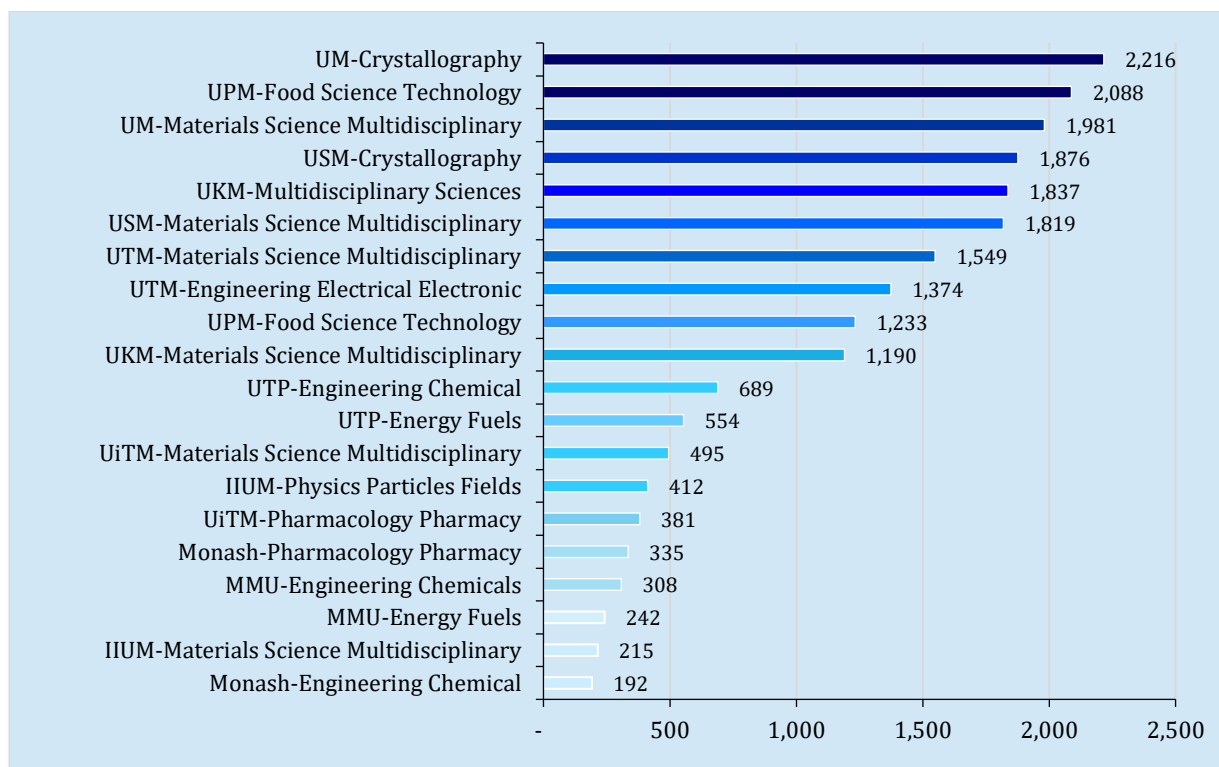
Source: Web of Science

Date of Extraction: 29th July, 2020

10.2.6 Institutions and Fields of Research

Figure 10.4 shows the two top fields of research by top HLIs. Material Science related research emerged as a favourable field for almost all selected institutions except for the private universities- Monash, Universiti Teknologi Petronas (UTP) and MMU. Besides Material Science related research, UM and USM performed in “Crystallography”, UPM in “Food Science Technology”, UTM in “Engineering - Electrical and Electronic”, Universiti Teknologi Mara (UiTM) in “Pharmacology Pharmacy” and International Islamic University Malaysia (IIUM) in “Physics Particles Fields”. Monash University performed in “Pharmacology Pharmacy” and “Engineering-Chemical”, UTP in “Engineering-Chemical” and “Energy Fuels” and MMU in “Energy Fuels” and “Engineering-Chemical”. Box 10.1 further illustrates COVID-19 related publications.

Figure 10.4 Institutions by Top Two Fields of Research



Source: Web of Science

Date of Extraction: 29th July, 2020

Box 10.1 Case Study: COVID-19 Related Publications

The COVID-19 pandemic - a coronavirus outbreak that was first identified end of 2019 has been causing many countries to face unprecedented public health issues. The virus is contagious and able to spread between people in-close proximity. Its origin has yet to be completely understood. Nevertheless, scientists are committed to studying the disease and learn how to control it from spreading. Those from the pharmaceutical companies and biotech research institutions are motivated to develop vaccines. To date, there are a number of potential vaccines that has been rolled out for vaccination.

Malaysia (see Table below) is acknowledged as one that had 'flattened' the epidemic curve of infection cases. It has managed to slow down the spread of the virus to the public by enforcing lockdowns and adopting preventive measures. Scientists and researchers in Malaysia waste no time to study different preventive measures and possible treatments. To date (10th August 2020), Malaysia has a total of 87 related publications. The top 5 fields are Public Environment-Occupational Health, Environmental Sciences, Infectious Diseases, Medicine- General Internal and Pathology. While Malaysia's commitment towards appropriating science to learn and control the disease is commendable, comparably it lagged in terms of publication counts compared with other countries that are acknowledged to successful flatten the pandemic curve. Taiwan and South Korea produced 224 and 292 related articles, respectively. Their research articles focused not only on preventive measures and public health but also sciences (such as immunology,

microbiology and medicine- experimental research) that allow them to participate in the vaccine production process. A common vaccine requires 10 to 15 years to develop. The involvement in medical experimental research implies participation and strong attempts of their scientists (particularly for the case of Korea) in using mix of different techniques and new technologies to speed up the development process. Large countries such as China and the USA are at the forefront in terms of producing research related to the COVID-19. They produced 3,290 and 4,986 articles, respectively.

COVID-19 Related SCI Publications of Selected Countries, 01 January -10 August 2020

	USA	China	Taiwan	South Korea	Malaysia
Total Articles	4,986	3,290	224	292	87
Top Fields	1.Medicine-General Internal (564) 2.Surgery (405) 3.Public Environmental Occupational Health (395) 4.Cardiac Cardiovascular Systems (288) 5.Immunology (261)	1.Infectious Diseases (498) 2.Medical -General Internal (275) 3.Virology (252) 4.Public Environmental Occupational Health (218) 5.Immunology (198)	1.Medical -General Internal (37) 2.Infectious Diseases (35) 3.Immunology (28) 4.Microbiology (26) 5.Environmental Sciences (19)	1.Medical -General Internal (75) 2.Medicine Research Experimental (21) 3.Public Environmental Occupational Health (21) 4.Environmental Sciences (19) 5.Oncology (18)	1.Public Environmental Occupational Health (12) 2.Environmental Sciences (9) 3.Infectious Diseases (7) 4.Medicine-General Internal (7) 5.Pathology (6)

Note: Figure in parenthesis denotes publication counts. The COVID-19 publication data is extracted based on keywords 'covid' or 'coronavirus' for the periods of 1 January 2020 until 10 August 2020.

Source: Web of Science database (SCIE and SSCI)

Date of Extraction: 29th July, 2020

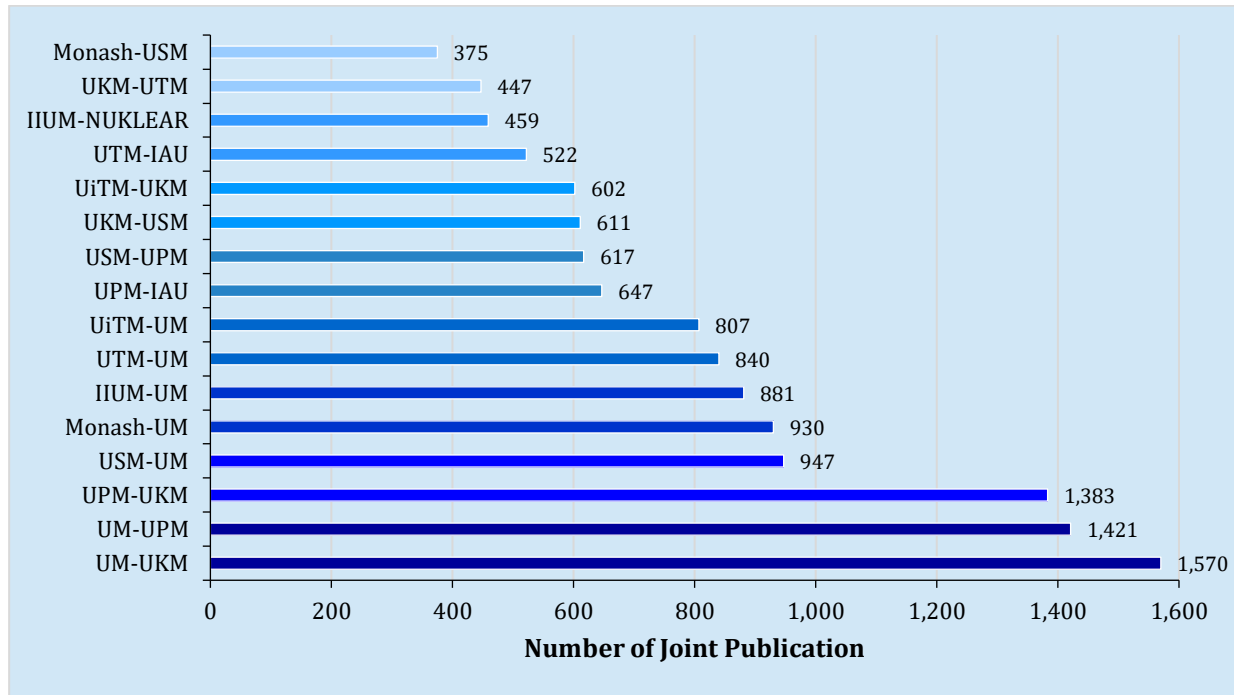
10.3 Collaboration Patterns in Publication

10.3.1 International Collaboration

It is noticeable that scientists and researchers in Malaysia have collaborated abroad and locally for joint publications. For local joint publications (Figure 10.5), UM-UKM, UM-UPM and UPM-UKM stand out as the top collaborating institutions in Malaysia. Likewise, many have also joint authored with developed countries making progress in international collaborations (Figure 10.6). As for international collaborations, the top three countries are England, USA and Australia. Joint publications are also visible with two emerging countries, China and India. Those from Japan, Iran and Saudi Arabia are among the top collaborators – producing 5,000 and more joint publications. Pakistan is at the border of 5,000 joint publications. European countries (Germany and France), neighbouring countries (Singapore and Thailand) and countries producing advanced semiconductor technologies (South Korea and Taiwan) are relatively underperforming with below 5,000 joint publication counts. Malaysia's vast diverse networks for publication implies its interest in pursuing advanced scientific knowledge with those from both advanced and developing countries. Its networks with countries producing advanced technologies (e.g. China, Japan,

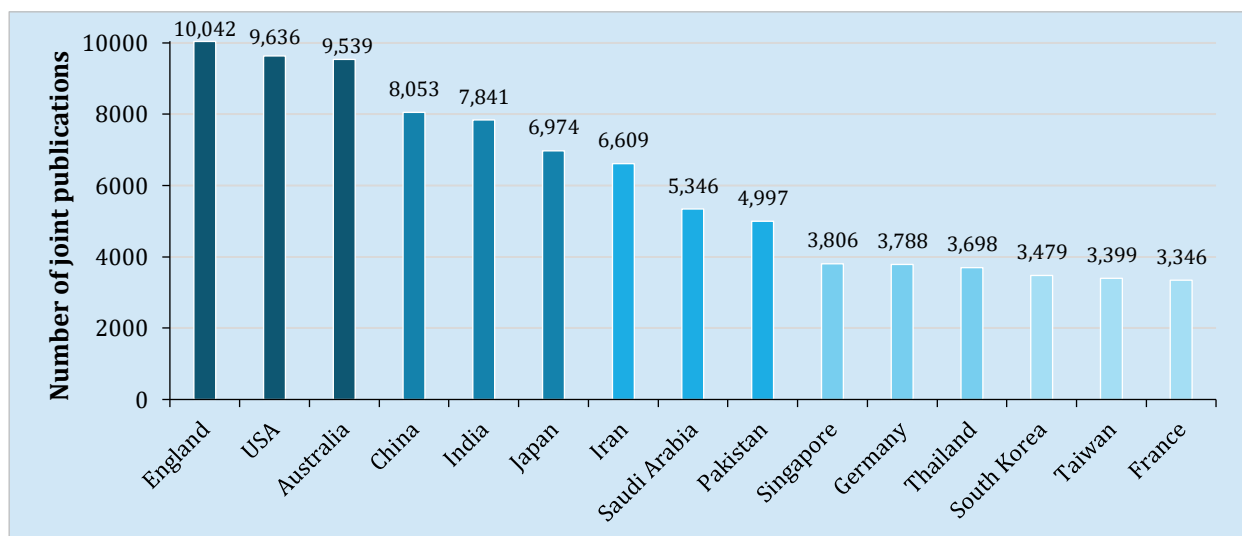
Germany, South Korea and Taiwan) suggests the interest of pursuing applied sciences for use in industrial applications.

Figure 10.5 Top 16 Collaborating National Institutions



Source: Web of Science (SCIE and SSCI)
Date of Extraction: 10th Aug, 2020

Figure 10.6 Joint Publications with Collaborating Countries, 2001-2019

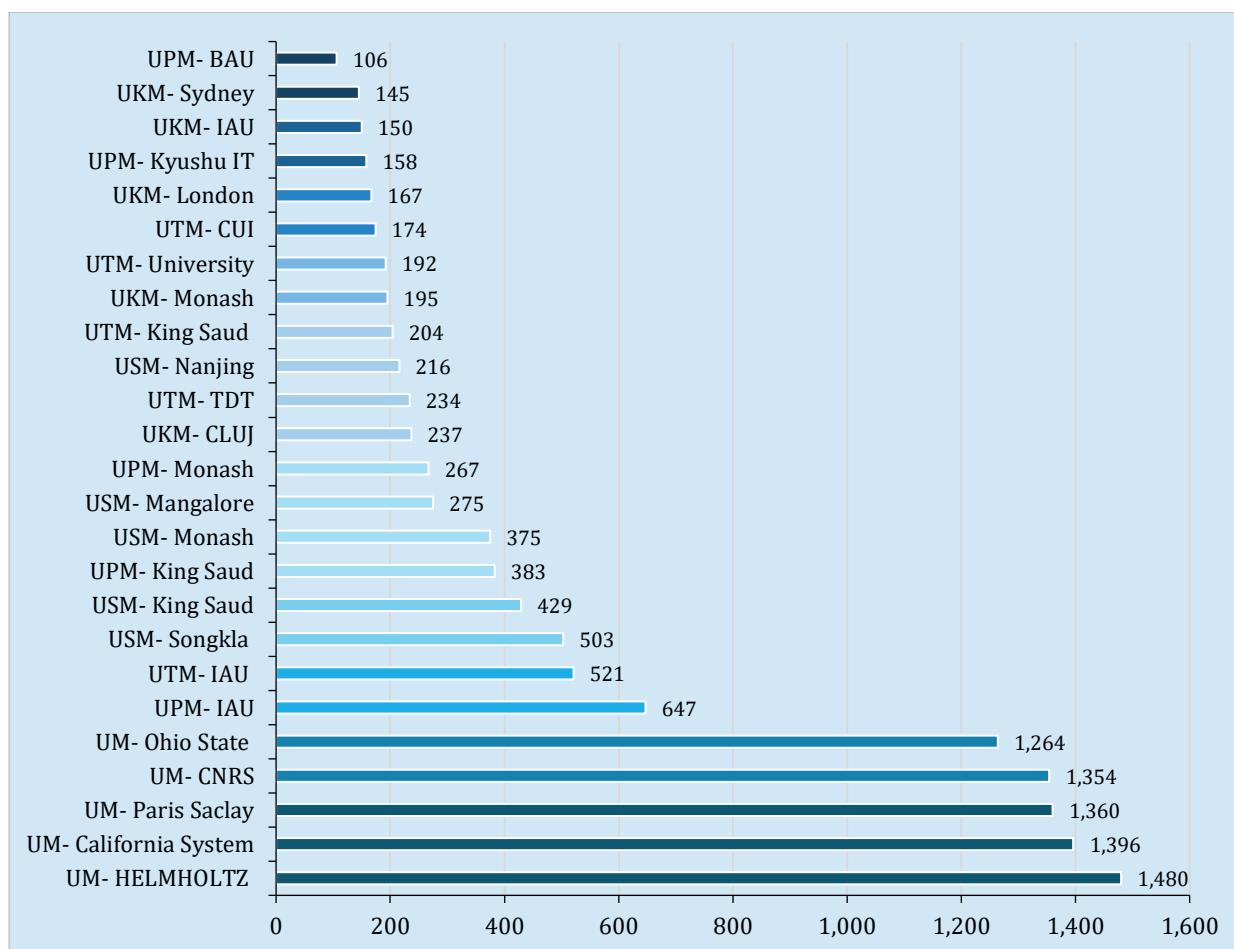


Source: Web of Science (SCIE and SSCI)
Date of Extraction: 30th August, 2020

Figure 10.7 shows top collaborating institutions abroad in terms of joint publications. It is observed that UM has tapped into the resources of a few research clusters with some of the advanced countries. They are HELMHOLTZ Institute of Germany, The University of

California System of the US and Paris Saclay and National Centre for Scientific Research (CNRS) of France. It is common to learn that research activities in advanced countries are clustered programmes (a joint effort of few universities/research institutions). UM seemed to have driven part of its research activities with the big research clusters abroad while other public universities in Malaysia are found to be committed to do joint publications on individual basis.

Figure 10.7 Top Collaborating Institutions Abroad, 2001-2019

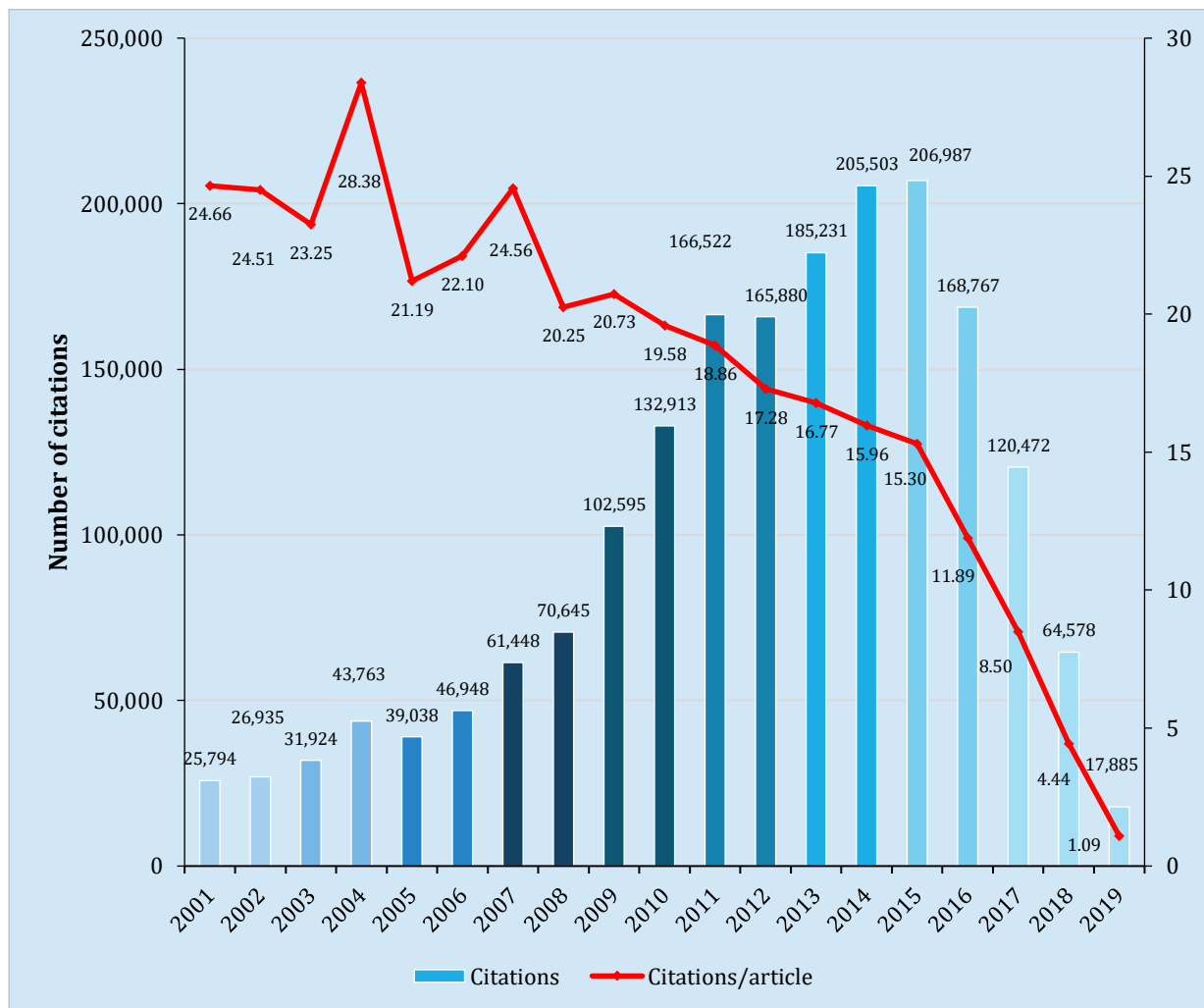


Source: Web of Science (SCIE and SSCI),
Date of Extraction: 10th Aug, 2020

10.4 Impacts of Malaysia's Article Publications

Figure 10.8 shows Malaysia's citations count and citations per article. As citation indicates research impact, the increasing citations trend highlights the cumulative impact of Malaysia's publications effort. For citations count, Malaysia witnessed a generally increasing trend since 2001. The increasing citations matured in 2015 and contracted since. This is attributable to the incomplete citations cycle that usually takes a 5-year window period. The increasing trend does coincide with the publications trend of Malaysia. Nevertheless, citations per article recorded a declining trend over the years.

Figure 10.8 Citations and Citations per Article



Source: Web of Science (SCIE and SSCI),
Date of Extraction: 10th Aug, 2020

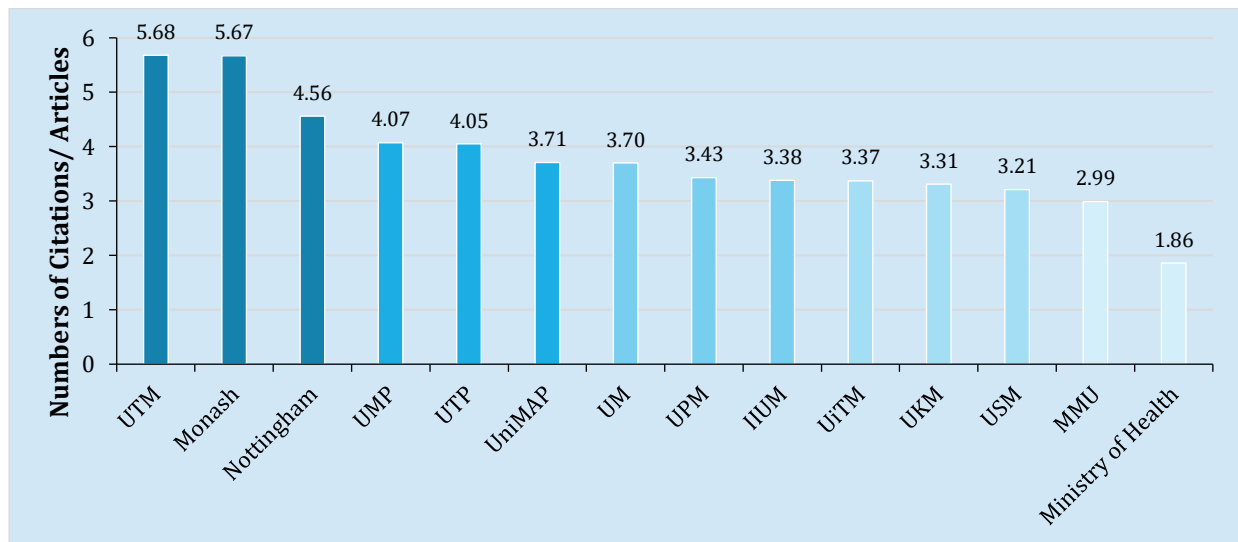
Table 10.3 reports the citation counts and citations per article for top fields of research in Malaysia. “Engineering” emerged as the field receiving the highest citation counts and citations per article. “Chemistry” is following closely with “Engineering” in terms of citation counts. It shared similar impact in terms of citations per article with that of “Clinical Medicine” and “Biology/ Biochemistry”. The citation performance and impacts in these fields are commendable.

Table 10.3 Article Citations by Fields of Research

Research Fields	Articles	Cites	Cites per Paper
Engineering	19,635	275,014	14.01
Chemistry	15,994	215,498	13.47
Clinical Medicine	11,824	161,843	13.69
Materials Science	10,672	122,983	11.52
Physics	6,656	81,970	12.32
Environment/Ecology	5,693	73,267	12.87
Biology/Biochemistry	4,238	57,068	13.47
Agriculture Science	5,596	56,781	10.15
Pharmacology and Toxicology	4,144	43,817	10.57
Plant & Animal Science	5,401	41,908	7.76

Source: Essential Science Index a rolling 10 years period 2009-2019
Date of Extraction: 4th October, 2020

Figure 10.9 shows the citations per article by institutions. It is noted that citations per article of UTM and Monash are much higher than other universities. Performing research universities in terms of publication counts such as UM, UPM, UKM and USM are lagging in citations per article.

Figure 10.9 Citations per Article by Institutions

Source: Web of Science database (SCIE and SSCI)
Date of Extraction: 4th October, 2020

Table 10.4 reports top institutions by h-index for several time periods with each having windows of three years. The index highlights the relative importance, significance, and broad impact of an institution in terms of cumulative research contributions. UM leads in the three time periods while other research universities closely following the lead of UM. Some private universities such as MMU and UTP are performing significantly behind to that of UM in h-index performance.

Table 10.4 Top Institutions by h-Index

Institution	2011-2013	2014-2016	2017-2019
UM	92	100	57
USM	76	55	37
UPM	70	61	36
UKM	62	57	38
UTM	63	67	44
UiTM	36	37	24
MMU	24	21	13
UniMAP	32	29	17
IIUM	28	33	25
UTP	32	35	26
Nottingham	34	35	24
UTAR	27	29	19
UMS	28	24	16

Source: Web of Science database (SCIE and SSCI)
Date of Extraction: 4th October, 2020

10.5 International Comparison

Table 10.5 shows article counts in selected countries and the USA, China and Germany are the top three countries contributing 25.32%, 18.18% and 6.81% respectively. India, a relatively high performer among the emerging economies contributes 3.95%, a level comparable to that of Spain and Australia. Other emerging economies such as Brazil and Russia contributed at less than 3%. The performance of all Southeast Asia countries are under the 1% benchmark.

Table 10.5 Top Countries in Terms of Article Counts and Share of Total

Countries	Articles	% of Total
USA	4,205,934	25.32
China	3,019,068	18.18
Germany	1,131,812	6.81
England	1,068,746	6.44
Japan	847,352	5.10
France	773,555	4.66
Canada	712,343	4.29
Italy	704,225	4.24
Spain	610,413	3.68
India	656,758	3.95
Australia	637,463	3.84
South Korea	587,993	3.54
Brazil	466,067	2.81
Netherlands	420,842	2.53
Russia	357,437	2.15
Singapore	136,336	0.82
Malaysia	112,663	0.68
Thailand	81,930	0.49
Vietnam	38,994	0.23
Indonesia	24,575	0.15
Philippines	13,765	0.08

Source: Essential Science Index a rolling 10 years period 2009-2019

Date of Extraction: 4th October, 2020

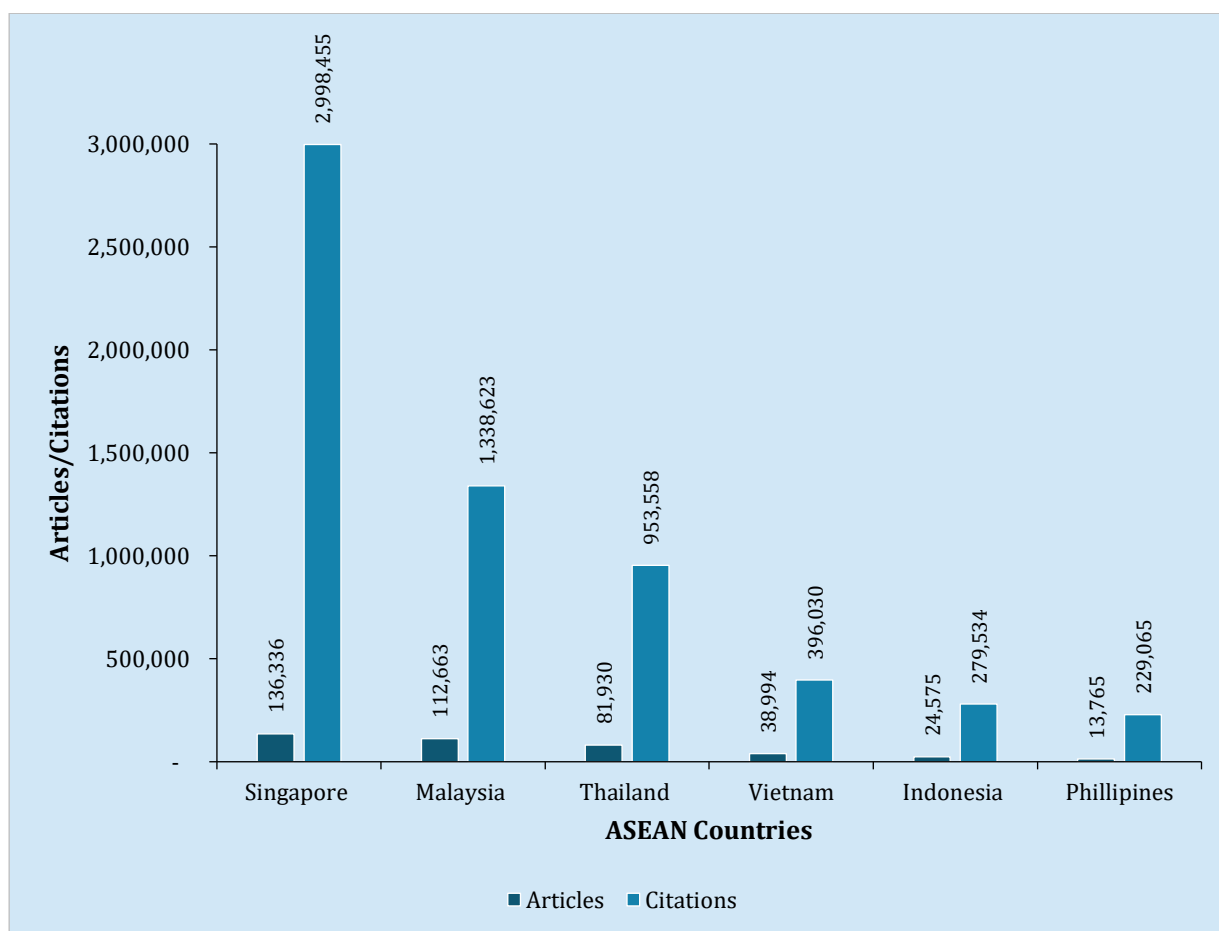
Table 10.6 reports the number of articles, number of highly cited articles, citations to highly cited articles and citations per highly cited articles of selected countries. Interestingly, few developing countries are performing way above the level of developed countries in term of citations per highly cited article. The Philippines and Indonesia are the top 2 countries achieving 280.06 and 277.87 while developed countries such as England, Italy and Australia are below the 230 benchmark. Malaysia's performance in citations per highly cited article is still low. It lagged in both highly cited article counts and citations to highly cited articles compared to Singapore and South Korea.

Table 10.6 Number and Citations of Highly Cited Articles by Countries

Countries	Highly Cited Articles	Cites to Highly Cited Articles	Cites per Highly Cited Article
Philippines	342	95,781	280.06
Indonesia	285	79,193	277.87
Russia	2,242	591,842	263.98
Japan	7,799	1,999,436	256.37
France	12,858	3,161,208	245.86
South Korea	5,376	1,312,261	244.10
USA	75,146	18,029,698	239.93
Canada	13,582	3,250,291	239.31
Netherlands	10,610	2,525,811	238.06
Germany	19,397	4,616,922	238.02
Singapore	3,740	883,344	236.19
Spain	9,311	2,152,020	231.13
England	23,737	5,423,792	228.50
Italy	11,025	2,431,635	220.56
Australia	13,144	2,798,516	212.91
Brazil	3,395	721,186	212.43
Thailand	863	178,429	206.75
India	4,657	891,308	191.39
Malaysia	1,591	249,832	157.03
Vietnam	696	107,230	154.07
China	37,170	5,564,664	149.71

Source: Essential Science Index a rolling 10 years period 2009-201
Date of Extraction: 4th October, 2020

Figure 10.10 presents the publication counts and their citations for selected ASEAN countries. Singapore stands out as the most productive nation for both articles and citations. It has 23,673 more articles than that of Malaysia and achieved 1,659,832 more citations. Indonesia and the Philippines are lagging behind in both.

Figure 10.10 Number of Articles and Citations for Selected ASEAN Countries

Source: Essential Science Index a rolling 10 years period 2009-2019
 Date of Extraction: 4th October, 2020

Table 10.7 provides an overview of the fields that are found to have high impact in terms of citations per article. The performance of Malaysia is compared to that of the USA and China. Citations per paper for “Engineering” of Malaysia stands out as the most impactful. It has higher citations per paper than the USA and China. There are number of other fields in which Malaysia performs at the level of China. These include “Agricultural Sciences”, “Pharmacology & Toxicology”, “Geosciences”, “Psychiatry/ Psychology” and “Mathematics”. Malaysia is leading China in the fields of “Clinical Medicine”, “Physics”, “Environment/Ecology”, “Biology & Biochemistry”, “Computer Science”, “Molecular Biology & Genetics”, “Microbiology”, “Immunology” and “Space Science”. Comparing to the case of the USA, almost all fields (except “Engineering”) of Malaysia are trailing behind.

Table 10.7 Citations of 22 Fields of Research, Malaysia, USA and China

Research Field	Malaysia			USA			China		
	Articles	Cites	Cites / Paper	Articles	Cites	Cites / paper	Articles	Cites	Cites / paper
Engineering	19,635	275,014	14.01	250,788	2,932,928	11.69	415,934	3,824,857	9.20
Chemistry	15,994	215,498	13.47	282,741	6,883,776	24.35	516,127	8,215,221	15.92
Clinical Medicine	11,824	161,843	13.69	926,526	17,699,989	19.10	326,651	3,273,179	10.02
Material Science	10,672	122,983	11.52	147,997	4,194,380	28.34	348,953	5,748,403	16.47
Physics	6,656	81,970	12.32	227,610	4,435,656	19.49	268,479	2,776,267	10.34
Environment / Ecology	5,693	73,267	12.87	146,770	2,858,630	19.48	115,497	1,313,965	11.38
Biology & Biochemistry	4,238	57,068	13.47	223,351	5,730,244	25.66	138,151	1,684,592	12.19
Agricultural Sciences	5,596	56,781	10.15	73,245	952,425	13.00	75,508	795,839	10.54
Pharmacology & Toxicology	4,144	43,817	10.57	99,985	1,767,570	17.68	83,319	862,383	10.35
Plant & Animal Science	5,401	41,908	7.76	182,478	2,382,005	13.05	98,757	993,526	10.06
Computer Science	4,275	40,311	9.43	84,335	985,512	11.69	108,137	940,420	8.70
Social Science, General	5,117	32,905	6.43	382,235	3,642,166	9.53	34,374	289,482	8.42
Molecular Biology & Genetics	1,802	27,146	15.06	184,228	6,722,408	36.49	106,242	1,540,655	14.50
Geosciences	2,178	26,300	12.08	140,216	2,785,632	19.87	111,055	1,337,564	12.04
Microbiology	1,498	16,485	11.00	64,474	1,530,079	23.73	33,262	348,087	10.47
Immunology	1,120	16,368	14.61	101,864	2,637,170	25.89	28,346	359,405	12.68
Neuroscience & Behaviour	1,144	13,180	11.52	207,667	5,047,911	24.31	52,823	657,275	12.44
Economics & Business	2,155	12,772	5.93	104,581	1,457,332	13.93	22,098	165,611	7.49
Psychiatry/ Psychology	1,247	10,788	8.65	197,386	3,109,165	15.75	16,717	140,573	8.41
Mathematics	1,782	8,605	4.83	98,141	614,903	6.27	98,963	499,826	5.05
Multidisciplinary	379	1,885	4.97	7,220	224,457	31.09	3419	62,360	18.24
Space Science	113	1,729	15.30	72,096	1,859,467	25.79	16,256	227,659	14.00

Source: Essential Science Index a rolling 10 years period 2009-2019

Date of Extraction: 4th October, 2020

10.6 Summary

Malaysia's interest in science and performance in publications are commendable. It has a total of 136,124 articles between period of 2001 to 2019 and witnessed an increased from 53,954 in 10th MP to 55,418 in 11th MP. The top research universities are UM, USM, UPM, UKM and UTM. These 5 universities produced a significance publication counts amounting 105,641 articles within a short period of 9 years (2001 to 2019). The impact assessment suggests Malaysia's move towards increasing citation counts trend since 2001. Various efforts and strategies are put forth by the universities in Malaysia to promote and advance multidisciplinary collaboration activities within the country and internationally. With the high and diverse collaborations, it does not only serve as an exposure for academic and laboratory skills within the universities, but there is a huge exchange of culture, good practices and fresh ideas from the other countries. However, there are number of key gaps in Malaysia's publication performance. For instance, Malaysia experienced a relative lower publication growth rate between 2016 and 2018. In the case of COVID-19 related research, Malaysia's performance is behind that of South Korea and Taiwan particularly in areas of related sciences such as immunology, microbiology, and medicine-experimental research. In addition, Malaysia's performance in citations per highly cited article is still low. As Malaysia aspires to move forward in advancing its publishing performance, policy measures should focus on improving funding capacity for research and publishing activities targeting at high impact research activities and research on critical areas such as coronavirus preventive measures and medical experimental research.

11

INTELLECTUAL CAPITAL

CHAPTER 11: INTELLECTUAL CAPITAL

11.1 Introduction

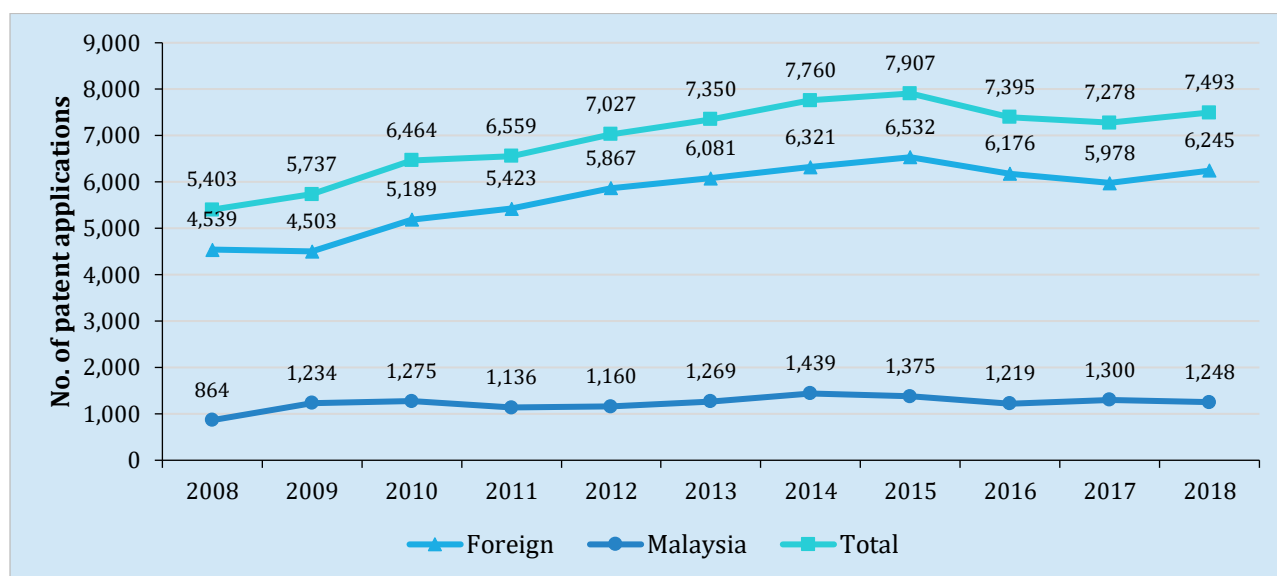
Patent has been a useful indicator for inventive activities. It is a proxy for technological innovation that has a market value. This chapter highlights Malaysia's achievements in patenting inventions. The statistics are acquired from published reports of World Intellectual Property Organizations (WIPO) and the Intellectual Property Corporation of Malaysia. Data are also extracted from a subscribed patent database (PATSEER). The data is sorted by inventors' and assignees' country of origin. The database was useful in extracting applied patent information under the Patent Cooperation Treaty (PCT) of WIPO. This chapter also provides valuable insights on where Malaysia stands in the global patenting landscape.

11.2 Domestic Patent and Utility Innovation – Local and Foreign Applicants

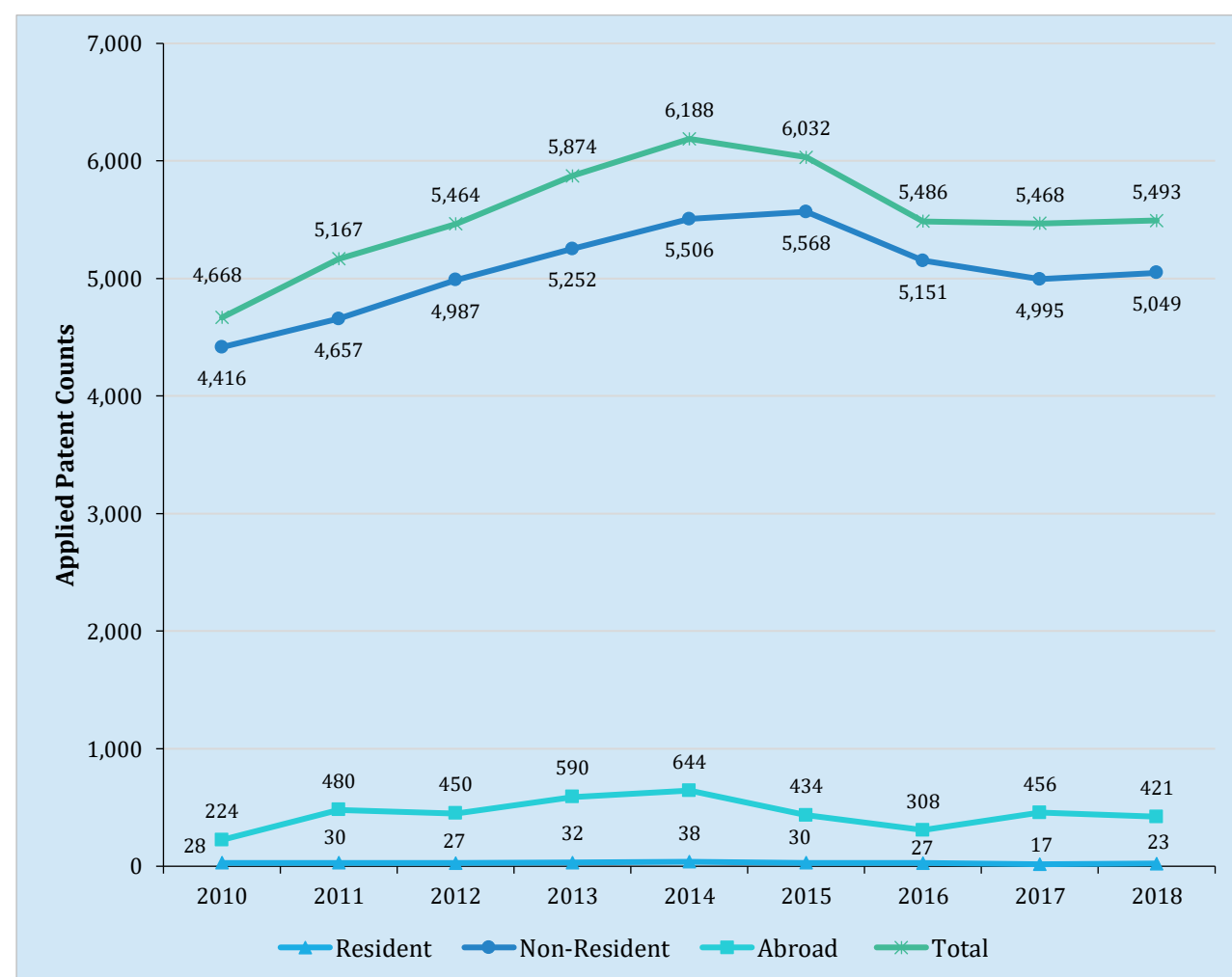
Figure 11.1 shows the counts of domestic patent and utility innovation for both foreign and local applications. Notably, foreign applications dominated the patenting landscape in Malaysia. There are 4,539 foreign applications in 2008- about 6 times compared to the local application. In 2018, the count for foreign applications increased to 6,245 but the ratio between foreign and local decreased to 5 times. The efforts⁷ of Malaysia in trying to boost the counts for local applications between 2008 and 2018 have yet to see significant progress. The foreign applications remain the key driver for patenting growth. The momentum of total application counts decreased between 2016 and 2017 before seeing a slight increase in 2018. The momentum appears to be driven by foreign applications. The average growth between 2008-2015 was 5% and subsequently it recorded a declining average growth of -2% between 2016-2018.

The trend of patenting by foreign applicants, shown in Figure 11.1, is consistent with that of non-resident applicants for PCT patents (Figure 11.2). These non-resident applicants seek IP protection from MYIPO before embarking on commercialising their inventions. The annual applications decreased from 5,568 in 2015 to 5,049 in 2018.

⁷ Wong, C-Y. and Salmin, M.M. (2016), Attaining a Productive Structure for Technology: The Bayh–Dole Effect on University–Industry–Government Relations in Developing Economy, *Science and Public Policy*, 43, 1, 29-45.

Figure 11.1 Domestic Patent and Utility Innovation Applications, 2008-2018

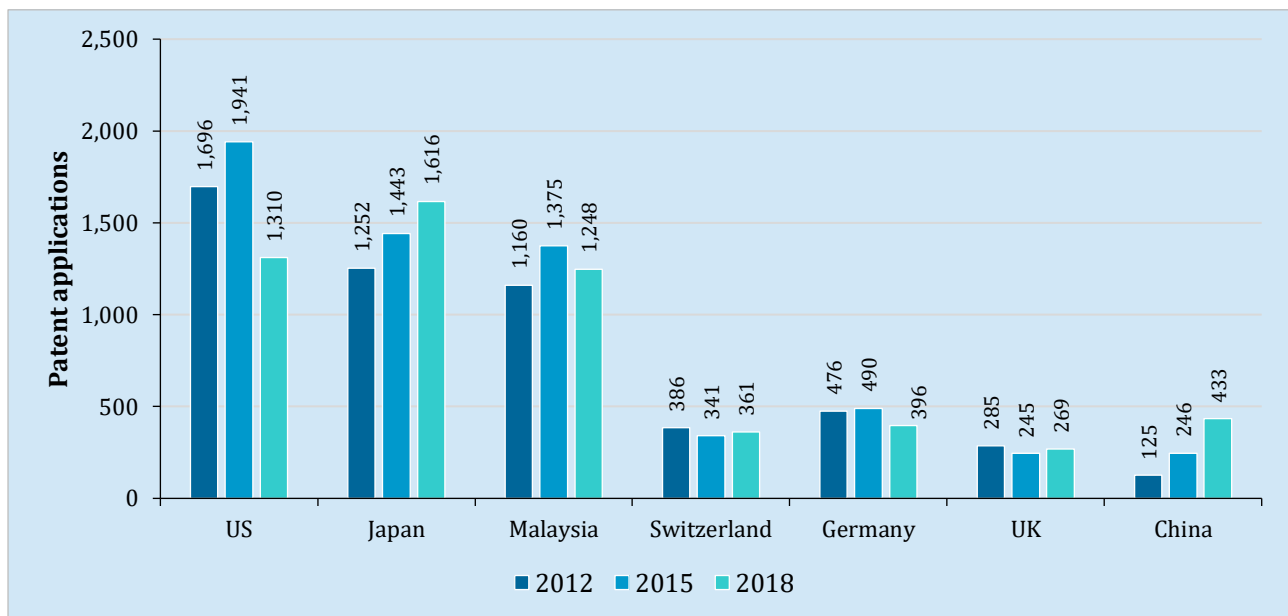
Source: MYIPO, 2019

Figure 11.2 Applied Patent Counts by Resident, Non-resident and Abroad

Source: WIPO, 2020

Figure 11.3 shows the top countries by applications filed for domestic patents and utility innovations. The US was once the dominant player in Malaysia's patenting landscape. However, its presence in applications has decreased from 1,941 in 2015 to 1,310 in 2018. In 2018, Japan has become the dominant player with an increase from 1,443 in 2015 to 1,616 in 2018. Malaysian applications have witnessed a slight contraction from 1,375 in 2015 to 1,248 in 2018. Switzerland, Germany and the UK have been performing relatively lower than the USA and Japan while China aggressively moving forward from 125 applications in 2012 to 246 in 2015 and 433 in 2018.

Figure 11.3 Domestic Patents and Utility Innovations Application Filed, Top Countries



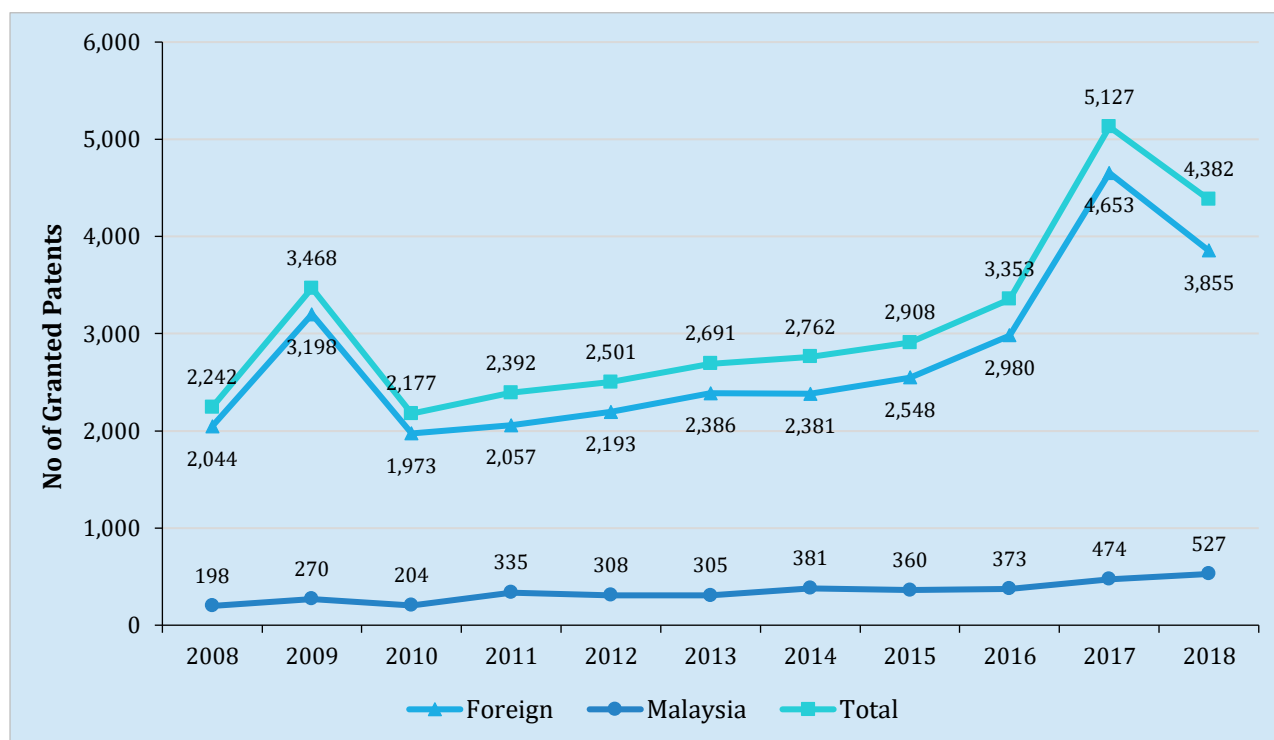
Source: MYIPO, 2019

Figure 11.4 shows the counts for domestic granted patents and utility innovations. There are two spikes throughout the period between 2008 and 2018. These may be attributed to changes in the administration of the patent granting process. Foreign inventors emerged as the dominant player. On average the granted patents to foreigners account for 88% of total granted patents between 2008-2018. Local inventors are performing significantly behind compared to the foreign applications. Figure 11.5 shows the top local assignees by domestic granted patent counts between 2010 and 2019. Public research institutions (MIMOS) and universities (UTM, UPM and UM) emerged as top organisations in the domestic patenting landscape. Private entities such as MPOB and Telekom are performing slightly higher than the benchmark of 100 patents. Other public universities are performing comparatively lower than the benchmark.

Figure 11.6 reports the domestic granted patent counts in term of International Patent Classification (IPC) classes in 2018. Class C (Chemistry, Metallurgy) emerged as the top class with 895 patents. This is followed by class A (Human Necessities) and class B (Performing Operations, Transporting). In class C, subclasses such as C12 (biochemistry; beer; spirits; wine; vinegar; microbiology; enzymology; mutation or genetic engineering), C08 (organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon) and C07 (organic chemistry) are among the common patented technologies. For class

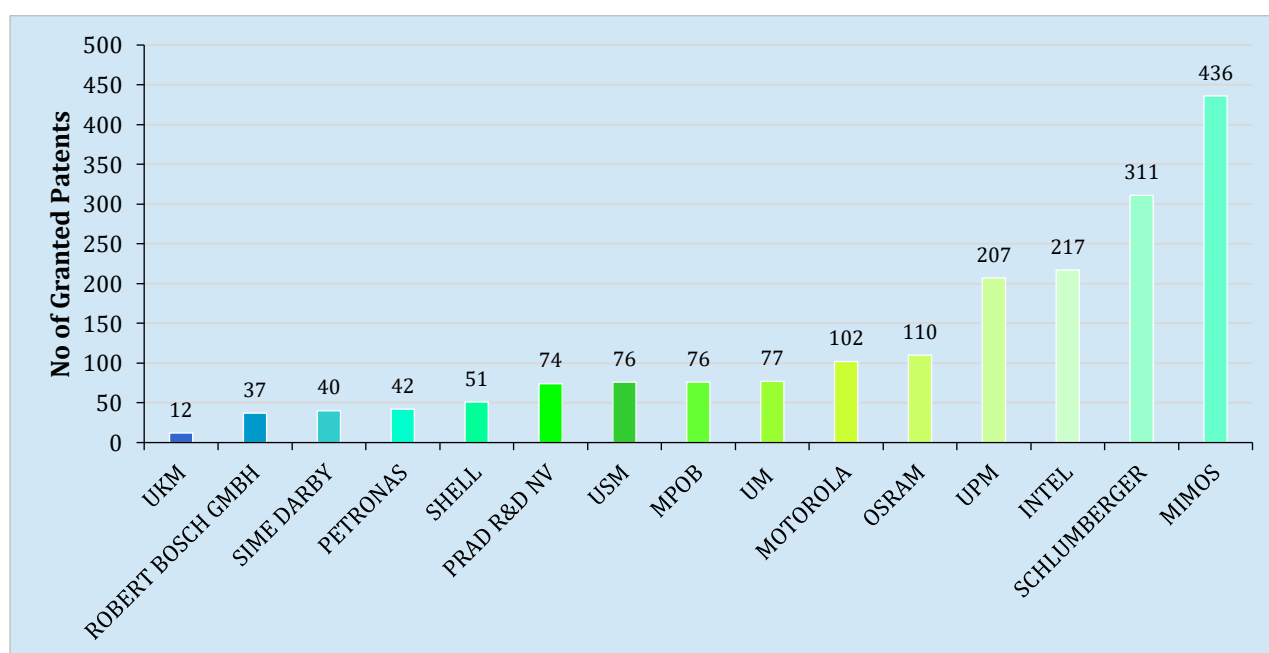
A, subfield A61 (medical or veterinary science; hygiene) and A01 (agriculture; forestry; animal husbandry; hunting; trapping; fishing) are the common ones. For class B, it is B01 (physical or chemical processes or apparatus in general).

Figure 11.4 Counts of Domestic Granted Patents and Utility Innovations, 2008-2018



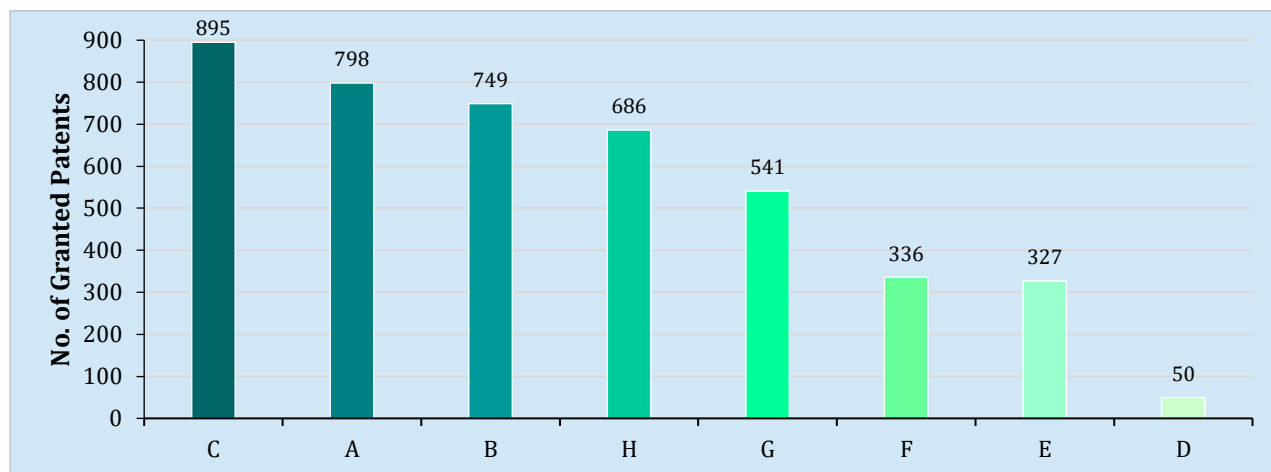
Source: MYIPO, 2019

Figure 11.5 Top Local Assignees by Domestic Granted Patent Counts, 2010-2019



Note: As we search via the subscribed database, the estimates may be slightly different compared to other available reports.

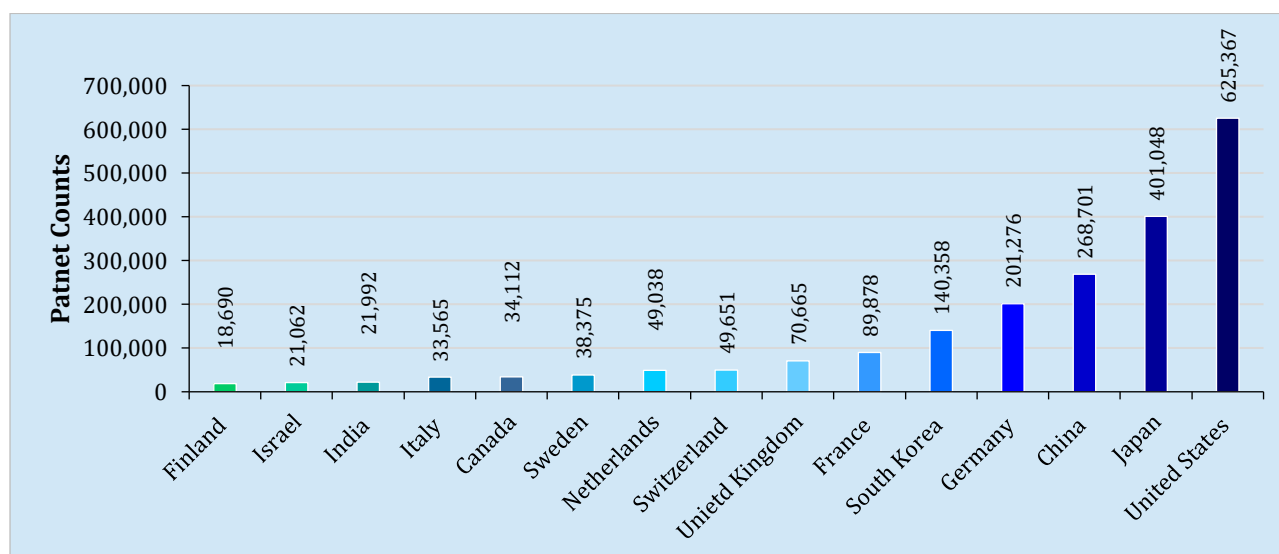
Source: PATSEER, (searched on 15 August 2020)

Figure 11.6 Top Classes of Domestic Granted Patents under IPC, 2018

Source: MYIPO, 2019

11.3 Patent Filings in the PCT

PCT of WIPO has been instrumental in promoting the use of patent protecting the rights of inventors and enabling the inventors to file their domestic patents in different patent offices of different countries. To date (31 Aug 2020) PCT accumulated 4,667,530 applications with the US, Japan, China, Germany and South Korea being the top countries in terms of patent application counts (Figure 11.7). The US has 625,367 applied patents from 2010 and 2019, and 224,319 more patents than that of Japan.

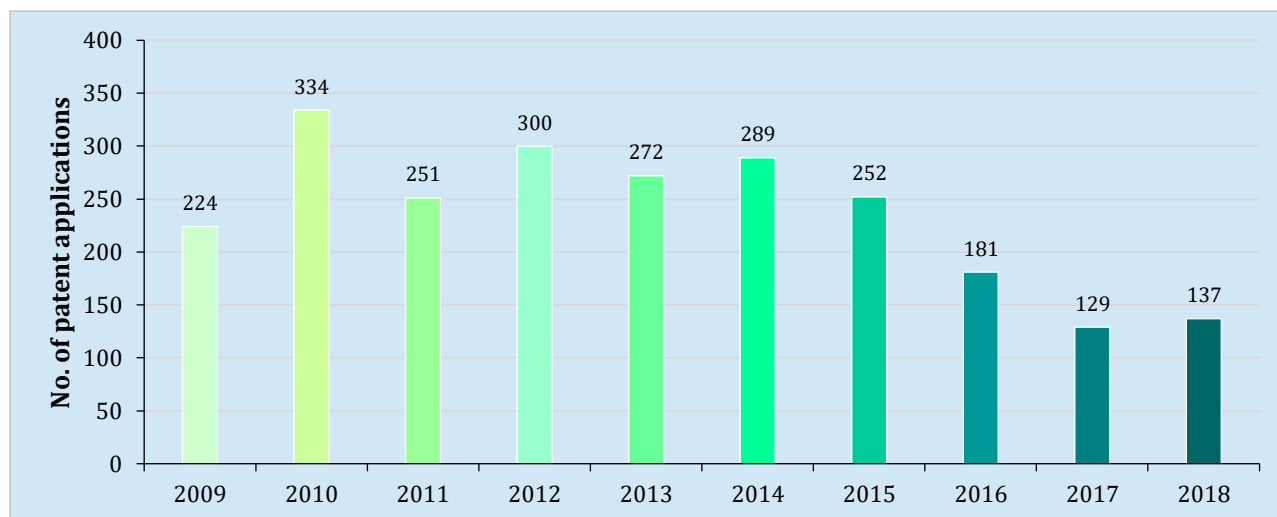
Figure 11.7 World Top Countries by Patent Counts Filed for PCT, 2010-2019

Note: As we search via the subscribed database, the estimates may be slightly different compared to other available reports.
Source: PATSEER (searched on 15 August 2020)

Malaysia in comparison is performing at a moderate pace. It has filed an average of 275 patents between 2009 and 2015 before contracting to a level below 200 patents. MIMOS emerged as the top assignees for PCT patent application counts between 2010-2019 (Figure 11.9). This is

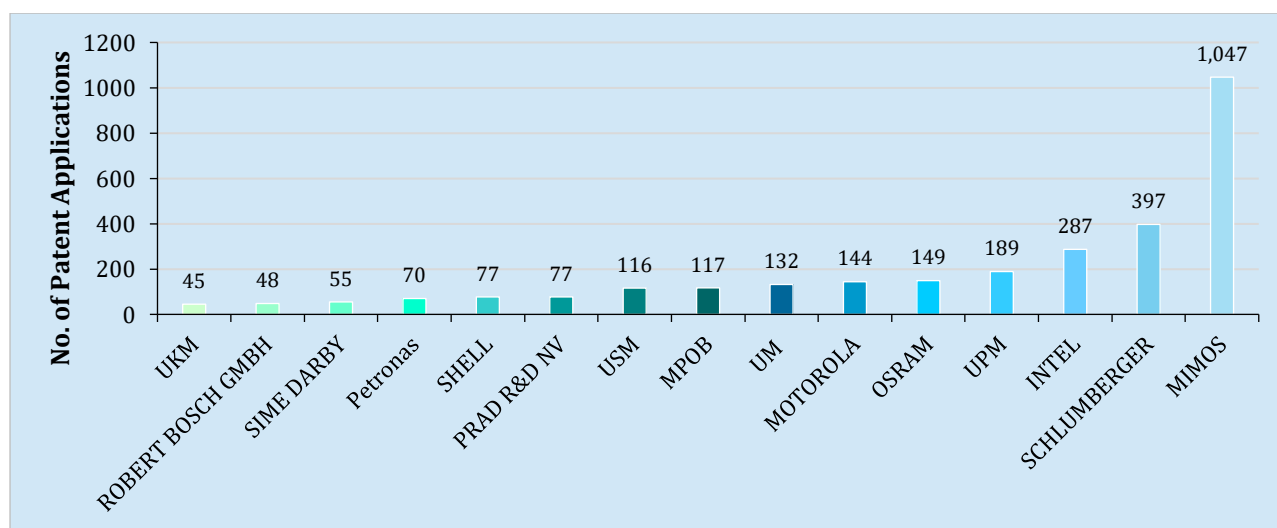
followed by Schlumberger and Intel, being the two top multinational assignees in Malaysia. UPM, UM, USM and UKM are the performing public universities in filing PCT patents. Figure 11.9 shows the dominance of multinational firms in PCT patent applications. Petronas is the only private locally owned company in the list.

Figure 11.8 Malaysia's Assignees Patent Applications in PCT, 2009-2018



Source: MYIPO, 2019

Figure 11.9 Top Assignees for Patent Applications in PCT, (2010-2019)



Note: As we search via the subscribed database, the estimates may be slightly different compared to other available reports.

Source: PATSEER (searched on 31 August 2020)

Table 11.1 lists the top fields of technology in PCT patent applications in Malaysia. The top three fields are Information and Communication Technology related (G06, H04 and H01). Other fields include health and biochemistry (A61, C12, C08, C07, etc.), foods and agriculture (A23, A01, etc.) and construction engineering (e.g. E21) related technologies. Box 11.1 illustrates Malaysia's progress in AI related patenting.

Table 11.1 Malaysia's Top Fields of Technology in PCT Patent Applications

Fields of Technology (IPC)	TOTAL
G06: COMPUTING; CALCULATING; COUNTING;	806
H04: ELECTRIC COMMUNICATION TECHNIQUE;	722
H01: BASIC ELECTRIC ELEMENTS;	602
A61: MEDICAL OR VETERINARY SCIENCE; HYGIENE;	556
G01: MEASURING; TESTING;	398
C12: BIOCHEMISTRY; BEER; SPIRITS; WINE; VINEGAR; MICROBIOLOGY; ENZYMOLOGY; MUTATION OR GENETIC ENGINEERING;	235
C08: ORGANIC MACROMOLECULAR COMPOUNDS; THEIR PREPARATION OR CHEMICAL WORKING-UP; COMPOSITIONS BASED THEREON;	192
C07: ORGANIC CHEMISTRY;	178
A23: FOODS OR FOODSTUFFS; THEIR TREATMENT, NOT COVERED BY OTHER CLASSES;	177
A01: AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING;	148
B01: PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL;	148
E21: EARTH OR ROCK DRILLING; MINING;	136
C11: ANIMAL OR VEGETABLE OILS, FATS, FATTY SUBSTANCES OR WAXES; FATTY ACIDS THEREFROM; DETERGENTS; CANDLES;	128
B65: CONVEYING; PACKING; STORING; HANDLING THIN OR FILAMENTARY MATERIAL;	113
C09: DYES; PAINTS; POLISHES; NATURAL RESINS; ADHESIVES; COMPOSITIONS NOT OTHERWISE PROVIDED FOR; APPLICATIONS OF MATERIALS NOT OTHERWISE PROVIDED FOR;	109

Note: As we search via the subscribed database, the estimates may be slightly different compared to other available reports.

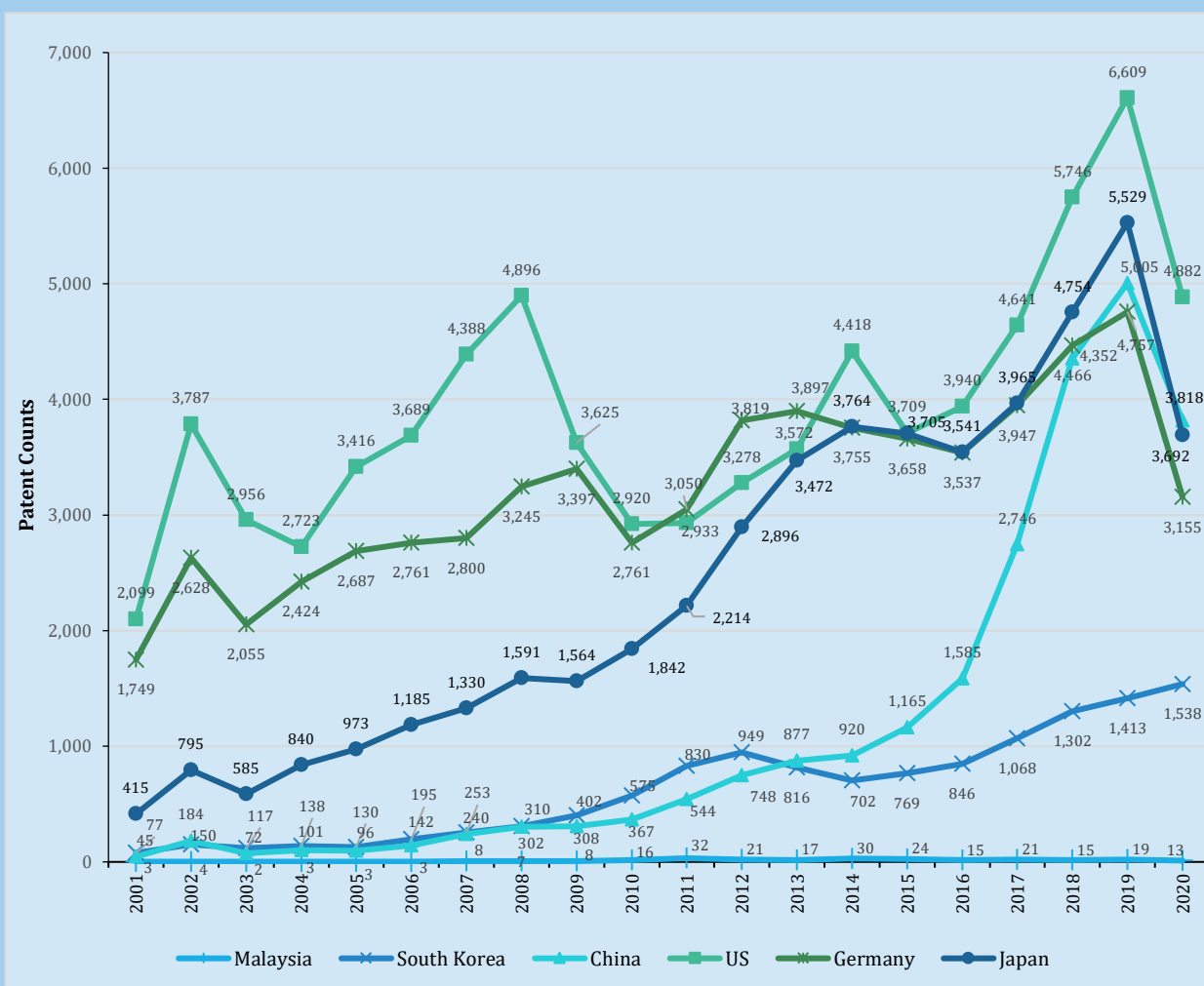
Source: PATSEER (searched on 31 August 2020)

Box 11.1 Case of AI-Related Patents

AI is acknowledged as an important technology supporting the overall progress of IR 4.0. It is used to automate machine (robots), learn routine to advance computing system (e.g. Internet-of-Things) and provide simulation to enable human to engage in learning-by-doing.

There are 329,696 AI-Related patents filed in PCT between 2001-Aug, 20th, 2020. The US and Germany are the top countries in filing AI-Related PCT patents. This is followed by Japan, a country that has been narrowing the gap since 2000s and China since mid of 2010s. Top assignees in the world include Toyota (with total of 12,664 patents), Robert Bosch GMBH (11,567 patents) and Porsche SE (6,964 patents). Malaysia has a total of 265 AI-Related patents for the same period. MIMOS (52 patents), Continental AG (11 patents) and INTEL (8 patents) are among the top assignees in Malaysia. Malaysia is relatively way behind to that of the selected countries (see Figure below). Importantly, inventions in these technologies are crucial as it is the core technologies in driving the progress of IR 4.0.

AI-Related Patents Filed in PCT, 2001-2019



Note: As we search via subscribed database, the estimates may be slightly different compared to other available reports.

Source: PATSEER (searched on 20 August 2020)

11.4 Summary

Malaysia witnessed a rising trend of patenting activities over the past 10 years. It has 5,403 domestic patent and utility innovation applications in 2008. The applications increased to 7,493 in 2018. The total applications for 2008 consists of 4,539 foreign applications. In 2018, the count for foreign applications increased to 6,245. Multinational corporations from the USA and Japan are among the frequent patent applicants for domestic patent and utility innovations. Therefore, foreign application accounts for, on average, 88% of the total applications between 2008-2018. Among the top local assignees, public research institutions (MIMOS) and universities (UTM, UPM and UM) emerged as the top organisations in domestic patenting. It is obvious that there are not many local private firms capable of performing at similar level of patenting as that of the foreign firms and public research institutions. In addition, efforts of the government and policy makers in boosting the counts for local applications between 2008 and 2018 have fallen short of significant progress. In PCT patenting, Malaysia is performing at a moderate pace compared to advanced countries. Nevertheless, in AI-related PCT patenting, for example, Malaysia's performance is lagging behind other countries such as the US and Singapore. In moving forward, awareness is important and radical strategies are required. Creating a conducive environment for industries, institutions, and enterprises to invest and take part in patenting activities are crucial. Among others, patenting fee, duration of patenting activities and expertise in areas of patent drafting can be key hurdles for promoting patenting. Key policies should focus on the need to have an effective incentive system to boost local patenting activities. It should be largely used to empower local private firms particularly the SMEs. Likewise, an effective joint research mechanism to co-create technologies between public research institutions, universities) and private local firms is essential. In addition, given that large number of patents in Malaysia are ICT related, an effective mechanism should be put forward to capitalise the knowledge base and propagate IR 4.0 related research and patenting among the local firms. And, research that could enable local firms to gain from the emerging technologies (such as AI) should be promoted with greater funding and supports as they are the core technologies in driving the progress of IR 4.0.

12

COMMERCIALISATION

CHAPTER 12: COMMERCIALISATION

12.1 Introduction

The R&D landscape have significantly emphasised on the need to commercialise the research outputs. Malaysia has targeted commercialisation as one of the important outcomes of research activities and has allocated resources and specific institutional settings to realise the commercialisation efforts. The 11th MP has earmarked on translating innovation to wealth as one of the game changers. The focus is on strengthening and enhancing the national innovation ecosystem by establishing collaborative efforts between government, academia, industry and other agents in research, development, commercialisation and innovation. Enhancing demand-driven research, strengthening the governance mechanism and promoting private financing has been among the strategies unleashed to promote research, development, commercialisation and innovation. This chapter describes the commercialisation efforts of the public and private sectors in Malaysia. Critical to assessing the commercialisation efforts is the definition of the term commercialisation. This chapter reports selected number of indicators that relate to number of products and services commercialised as well as revenue generation from various activities of the public and private sectors. It captures the research, licensing, product development at national, organisation and programme levels. Besides reporting the quantitative indicators, this chapter will also describe some of the successful commercialisation cases.

12.2 Commercialisation in Malaysia

Malaysia has a long history in promoting commercialisation outcomes. Specific funding and financing initiatives have been designed to avoid the valley of death trap by making available the bridging funds. Commercialisation financing, as well as institutional and programme arrangements were critical in helping Malaysia to kick-start the commercialisation efforts. Specific institutions such as MTDC, MAVCAP, PlaTCOM Ventures, and MDV was established to propel the commercialisation agenda. Indeed, programmes such as Biotechnology, Bioeconomy Corp Fund, and TechnoFund sets commercialisation as the target outcomes. As for better governance mechanism, the 1Dana portal, established in 2014, is expanded to serve as the centralised registry for sharing and recording research, development, commercialisation and innovation related information. More recently, in 2020, National Technology and Innovation Sandbox has been set up as a national solution coordinating and facilitating centre to accelerate innovative products/processes/solutions from R&D stage to commercially ready. Funding under this initiative is aimed at fast-tracking development and commercialisation of advanced technology projects, especially those with the highest potentials to boost key sectors such as healthcare, manufacturing, agriculture, education, travel and tourism. Table 12.1 shows the rate of commercialisation of the publicly funded research during various Malaysia plans. The rate is calculated based on the number of projects that was successfully commercialised. The commercialisation rate of the outputs of the Intensification of Research in Priority Areas (IRPA)

programme under the 6th MP and 7th MP stood at 5.1%. This rate declined to 3.4% during the 8th MP. It improved to 8% during the 9th MP and increased slightly to 9% during the 10th MP.

Table 12.1 Commercialisation Rate of Publicly Funded Projects

Malaysia Plan	Commercialisation Rate (%)
6 th MP (1990-1995) & 7 th MP (1996-2000)	5.1
8 th MP (2001-2005)	3.4
9 th MP (2006-2010)	8.0
10 th MP (2011-2015)	9.0

Note: Commercialisation rate refers to number of projects that has been commercialised (generated sales) out of the total projects during the periods. The rate is limited to publicly funded grants and programmes.

Source: MP, MOSTI, 2014 and 2018.

Table 12.2 shows the details of commercialisation outcomes of the publicly funded R&D projects in Malaysia during the various phase of Malaysia Plans namely in the 9th, 10th and the 11th MPs. In total, during the 9th MP, the highest funding was recorded, totalling RM2,896.74 million. The funding has declined significantly during the 10th and 11th MPs impacting the number of projects funded and completed. During the period of the 9th MP (2006-2010), revenue generated through commercialisation amounted RM3,431.98 million followed by RM840.00 million and RM38.12 million in the subsequent Plans. Over the period of 15 years the total revenue generated from publicly funded research totalled RM4,310.10 million. Significantly, the number of commercialised projects stood at 342 and 111 during the earlier periods of the two Malaysia Plans. In terms of outcome of the projects, new products and prototypes are the main outcomes during 2006-2010. Whereas for the periods of 2011-2015, new process and prototypes was the main types of project outcomes. Nevertheless, the success in terms of number of products commercialised was higher during the 9th MP. It is recorded that 232 products have commercialisation potentials.

Table 12.2 Commercialisation Outcomes of Publicly Funded Projects

Funding/Outcomes	2006-2010	2011-2015	2016-2020	TOTAL
Approved Funding (RM Million)	2,896.74	1,217.99	308.90	4,423.63
Number of Projects	4,566	1,901	330	6,797
Number of Completed Projects	3,937	1,623	124	5,684
Number of Potential Commercialised Projects	1,192	303	-	1,495
Number of Commercialised Projects	342	111	-	453
Sales Revenue (RM million)	3,431.98	840.00	38.12	4,310.10
Outcome of the Projects	2006-2010	2011-2015	2016-2020	TOTAL
Number of New Process	2	337	75	339
Number of Potential Commercialised Product	18	214	-	232
Number of Commercialised Product	66	5	-	71
Number of Prototypes	540	417	61	957
Number of New Technology	-	132	-	132

Note: Data for 2020 is up to June 2020. Some of the indicators are only available at the end of 2020.

Source: MOSTI, 2020

A total of 111 projects were commercialised for the period of 2011-2015. The highest rate of project commercialisation is from CRDF and BCG funding system (Table 12.3). In terms of revenue, six funds have contributed to the revenue generating activities totalling RM840 million. CRDF with the main mandate to commercialise has contributed RM396.47 million (47.20% of the total) in revenue generation. Likewise, BCG contributed 40.49% (RM340.1 million) to the total revenue recorded during 2011-2015. While Sciencefund and Technofund projects have the potential to commercialise it requires further upscaling to translate the projects to wealth creation phase. The potentials of these projects to commercialise should not be missed.

Table 12.3 Commercialisation by Types of Funds, 2011-2015

Funds	Sciencefund	Technofund	Innofund	CRDF	TAF	BCG	BTP	MGS	MCI	TOTAL
Potential Commercialised Projects	223	27	11	35	-	-	4	3	-	303
Commercialised Projects	-	-	12	68	6	18	2	4	1	111
New Process	340	-	-	-	-	-	-	-	-	340
Potential Commercialised Product	214	-	-	-	-	-	-	-	-	214
Commercialised Product	-	5	-	-	-	-	-	-	-	5
Prototype	404	-	13	-	-	-	-	-	1	418
New Technology	132	-	-	-	-	-	-	-	-	132
Revenue (RM Million)	-	-	0.51	396.47	59.01	340.1	42.08	1.83	-	840.00

Source: MOSTI, 2020

12.3 Commercialisation of IPRs: Royalties and Licensing Fees

A deeper understanding of the Malaysia's receipts and payments on IPR would indicate Malaysia's position in moving towards becoming an innovative economy. Malaysia relies on foreign IPRs as reflected by the increasing payments for IPR from 2010 to 2018. In 2010, payments amounted to USD1,318.01 million and they have increased to USD2,005.98 million in 2018. In terms of receipts, Malaysia has recorded an increasing trend with the amount received in 2018 (USD267.36 million) more than double the sum collected in 2010 (USD100.65 million). However, as a whole, Malaysia registered a deficit in IPR trade flows largely depending on foreign technology and know-how. Nevertheless, both payment and receipts can contribute positively to strengthening the national innovation ecosystem. Receipts show the strength of the local IPR in generating royalties and licensing from others while payments show the use of IPR to further improve productivity and efficiency of the production and economic activities.

Figure 12.1 Royalties and Licensing Fees, Malaysia

Note: Payments and receipts are charges for the use of IP rights (such as patents, trademarks, copyrights, industrial processes and designs and licensing agreements between residents and non-residents).

Source: World Bank, 2020

Globally, the USA are the largest recipient of IPR revenue recording a positive balance of payments. In 2018, USA recorded USD128,748 million in receipts for the licensing and as part of royalties from IPR (Table 12.4). Among others, Japan and Germany are the other top countries recording larger receipts compared to payments. Within ASEAN, Singapore and Indonesia have more receipts than payments. This may indicate either these countries are using less foreign IPR and know-how as well as utilising more local IPRs. Malaysia and the Philippines appear to be active users of foreign IPRs. This may be due to the presence of foreign multinational companies especially in the manufacturing sectors.

Table 12.4 IP as Payments and Receipts, Selected Countries, Million

Country	2016		2017		2018	
	Payments (USD)	Receipts (USD)	Payments (USD)	Receipts (USD)	Payments (USD)	Receipts (USD)
China	23,980	1,161	28,746	4,803	35,783	5,561
Germany	11,295	28,727	14,366	31,138	16,061	36,317
Japan	20,246	39,136	21,381	41,721	21,994	45,571
South Korea	9,429	6,936	9,702	7,287	9,812	7,749
USA	46,987	124,387	53,440	126,523	56,117	128,748
Cambodia	10	2	13	1	28	2
Indonesia	2	1,732	1	1,901	2	1,470
Malaysia	1,348	115	1,827	286	2,006	267
Philippines	1,732	47	1,901	50	1,470	61
Singapore	47	546	50	751	61	917
Thailand	546	9	751	17	917	44

Note: Payments and receipts are charges for the use of IP rights (such as patents, trademarks, copyrights, industrial processes and designs and licensing agreements between residents and non residents.

Source: World Bank, 2020

12.4 Commercialisation at Institutional and Organisational Level

In understanding commercialisation efforts, this section further details the government's efforts at the higher learning institutions, public research institutions and BEs. The section describes revenue generation and the products commercialised by the respective institutions.

12.4.1 Higher Learning Institutions

Increasing emphasis is placed on the public universities to engage in commercialisation activities as a source of income to sustain the public universities. Universities have actively pursued income generation from their consultancy, commercialisation, course offerings and training activities. The recent R&D Survey reported the extend in which commercialisation occurs in the higher learning institutions in 2018. A total of RM40.72 million was generated by the HLIs from the licensing activities with 136 commercialised technologies. In terms of products a total of 106 products were commercialised generating a revenue of RM14.72 million in total.

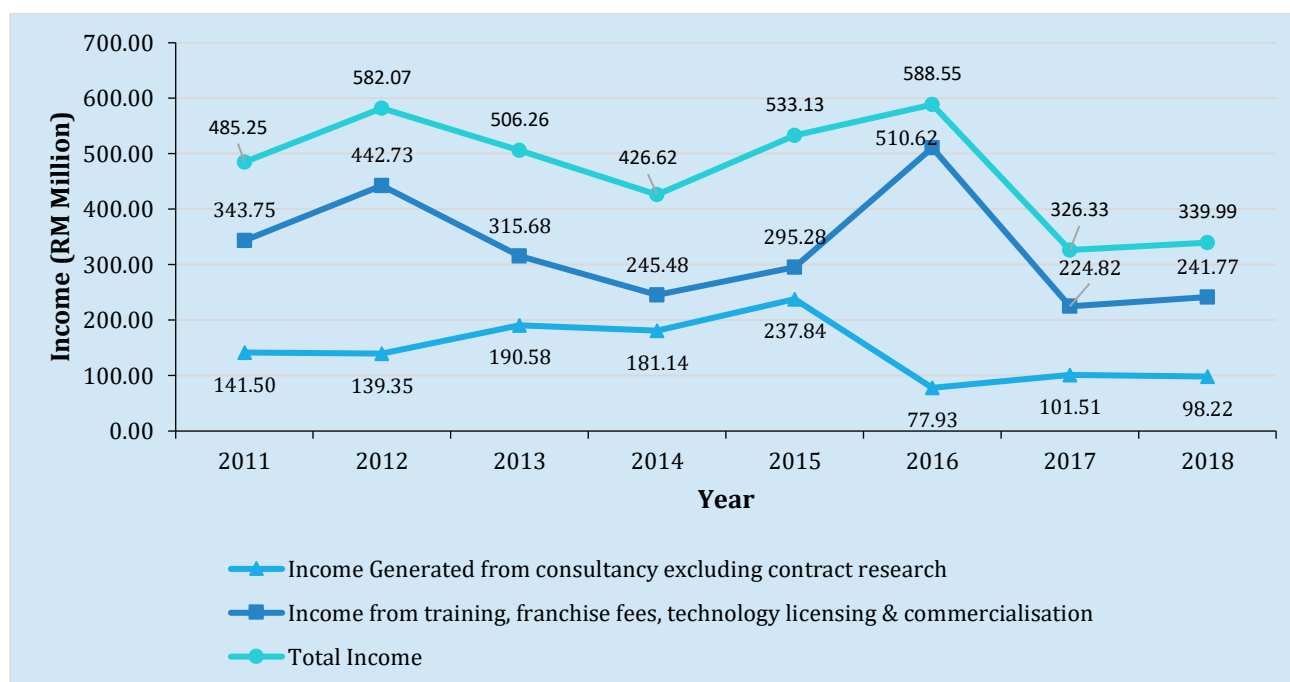
Table 12.5 Commercialisation of Higher Learning Institutions, 2018

Commercialisation	Technologies/Products (Number)	Amount (RM)
Patents licensing and technology know-how licensing	136	40,718,961
Commercialised products	106	14,722,912
TOTAL	242	55,441,873

Source: MOSTI, R&D Survey 2019

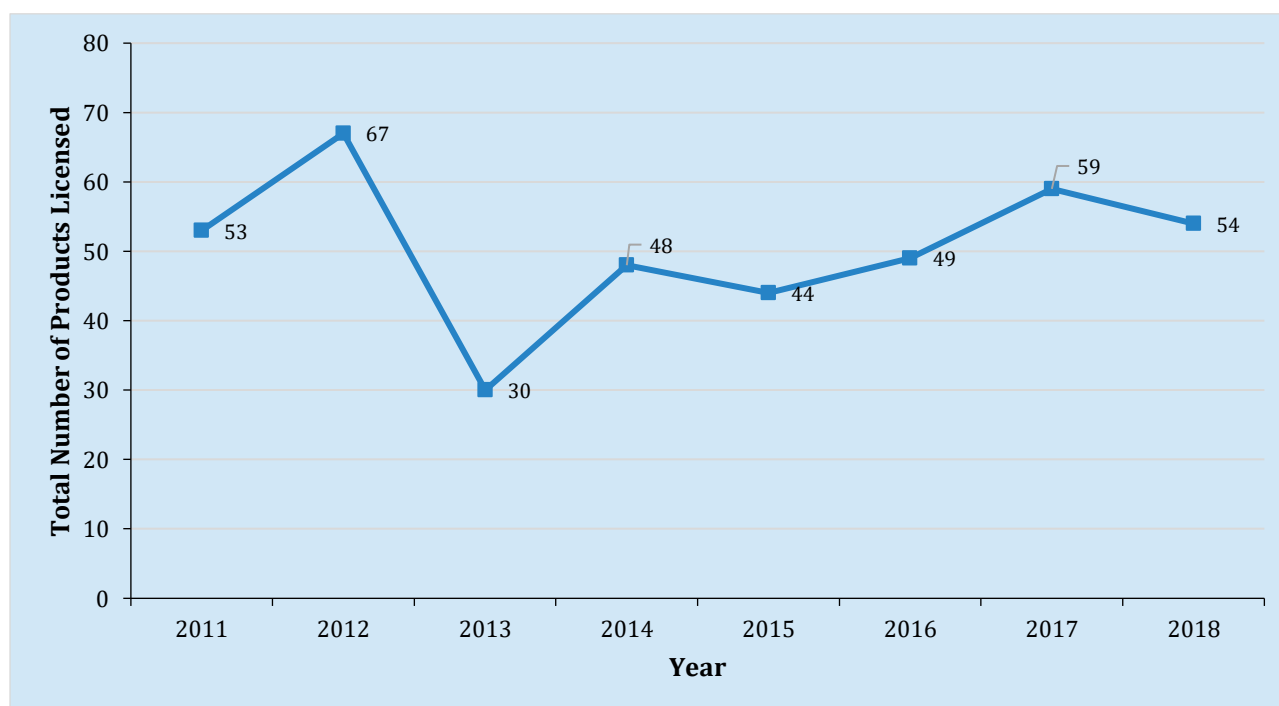
A study by MOE (2018) on the income generation (including student fees, licensing, spin-off and consultancy) of the research universities indicated that between 2007-2011 and 2012-2016 a total of RM3.6 billion and RM7.7 billion respectively was generated in revenue by the research universities. Figure 12.2 shows the trend of income generation among the 20 public universities from consultancy, training and other activities. Total income has been increasing from 2011 to 2016 (except in 2014). The average income generation between 2011 and 2016 was RM520.32 million. Nevertheless, in recent years (from 2017 and 2018), the income generation has declined. The highest income earned was recorded in the year 2016. The main income generation is from training, franchising fee, licensing and other commercialisation activities. On average it contributes nearly 69.17% to the total income generation during 2011-2018. Other source of income generation comes from consultancy services that represent the 30.83% of the income during the same periods.

In terms of number of licensed products, in total, 53 products were licensed in 2011 and it has increased to 59 and 54 in 2017 and 2018 respectively (Figure 12.3). Number of products licensed remains low despite public universities engaging in relatively high R&D activities. This may be due to the case that Malaysia's expenditure is increasingly allocated for basic research and less on applied research with industries. Indeed, commercialisation activities are still a risky and time-consuming process and proper institutional settings are required. Despite having the technology transfer units in universities, a more concentrated effort is needed to accelerate the product commercialisation efforts.

Figure 12.2 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 program fees/hospital recoupable fees / technology licensing / commercialised products

Source: MOHE, 2020

Figure 12.3 Total Number of Product Licensed, Public Universities

Note: Based on 20 public universities. Figures for 2011 and 2013 is the updated figures.

Source: MOHE, 2020

12.4.2 Business Enterprises

The National Survey of R&D activities in 2018 reported on the BEs ability to generate income through commercialisation activities. The BEs were able to license nearly 73 technologies that generated RM83.45 million in revenue in 2018 (Table 12.6). Likewise, product commercialisation generated a revenue of RM979.66 million by commercialising around 1,064 products. Overall, the BEs generated wealth amounting to RM1.06 billion in 2018.

Table 12.6 Commercialization by BEs, 2018

Commercialisation	Technologies/Products (Numbers)	Amount (RM)
Patents licensing and technology know-how licensing	73	83,449,542.00
Commercialised products	1,064	979,659,713.00
TOTAL	1,137	1,063,109,255.00

Source: MOSTI, R&D Survey 2019

12.4.3 Public Research Institutions

Table 12.7 shows the commercialisation of the PRIs surveyed in the National R&D survey. A total of 15 patents were licensed and around 510 products were commercialised in 2018. The total income generation amounted to RM28.72 million with majority contribution from product commercialisation (96.89%) while technology licensing only accounted for 3.11% of the total revenue.

Table 12.7 Commercialisation of Public Research Institutions, 2018

Commercialisation	Technologies/Products (Numbers)	Amount (RM)
Patents licensing and technology know-how licensing	15	891,861.00
Commercialised products	510	27,830,965.89
TOTAL	525	28,722,827.00

Source: MOSTI, R&D Survey 2019

The ability of PRIs to commercialise should be given special attention since these institutions would be able to engage more actively in applied research by engaging closely with their stakeholders in an effort to commercialise and add value in the sectors that they operate. While there are clear roadmaps for the assessment and targets for the HLIs such roadmaps are absent for the PRIs. However, a balance should be maintained since some of the PRIs do need to engage in social missions. A recent study by the World Bank (2020) that assessed the PRIs' effectiveness to transfer technology provide additional insights. Box 12.1 illustrates the key challenges of PRIs in engaging in commercialisation activities.

Box 12.1 Key Challenges in Knowledge and Technology Transfer in PRIs

PRIs in Malaysia come in various sizes, governance structures, resource endowments, and mandates. Given this backdrop, the governing of the PRIs adds to the complexity in terms of operations of the PRIs as well as positioning of PRIs for commercialisation efforts. While few PRIs have performed well in commercialisation, others find it challenging to move forward. The complex landscape of PRIs resulted in different commercialisation outcomes in Malaysia. Indeed, there is a great variation in the achievements of the commercialisation outcomes and it is largely limited in many cases. Key challenges limiting the achievements of the potential commercialisation outcomes still remain. The National Science and Research Council (NSRC) as well as the World Bank study illustrates the key challenges. Among them include, inconsistent funding, ineffective implementation of incentives, cultural gaps between industry and research, technology transfer office (TTO) capacity and the autonomy level are the major issues. Additionally, the lack of incentives system, proper monitoring and evaluation framework, and support and facilitation system significantly add to the challenges.

The study suggests, among others, strengthening the TTO support systems. While the support varied across PRIs, many have provided support in terms of legal negotiation for licensing, searching partners and networking and arranging legal agreements. Nevertheless, support for assisting spin-offs, registering of other forms of IP rights, new technologies and patenting assessments are still limited. Limitations also exist in terms of staff with joint positions, research staff in industry, and industry staff in PRIs to actively engage in knowledge transfer activities.

Source:

World Bank (2020) Assessing the Effectiveness of Public Research Institutions, Kuala Lumpur, Malaysia available at <https://openknowledge.worldbank.org/handle/10986/34612>

NSRC. 2013. PRA Performance Evaluation: Unlocking Vast Potentials, Fast-Tracking the Future, National Science and Research Council. UiTM Press Shah Alam.

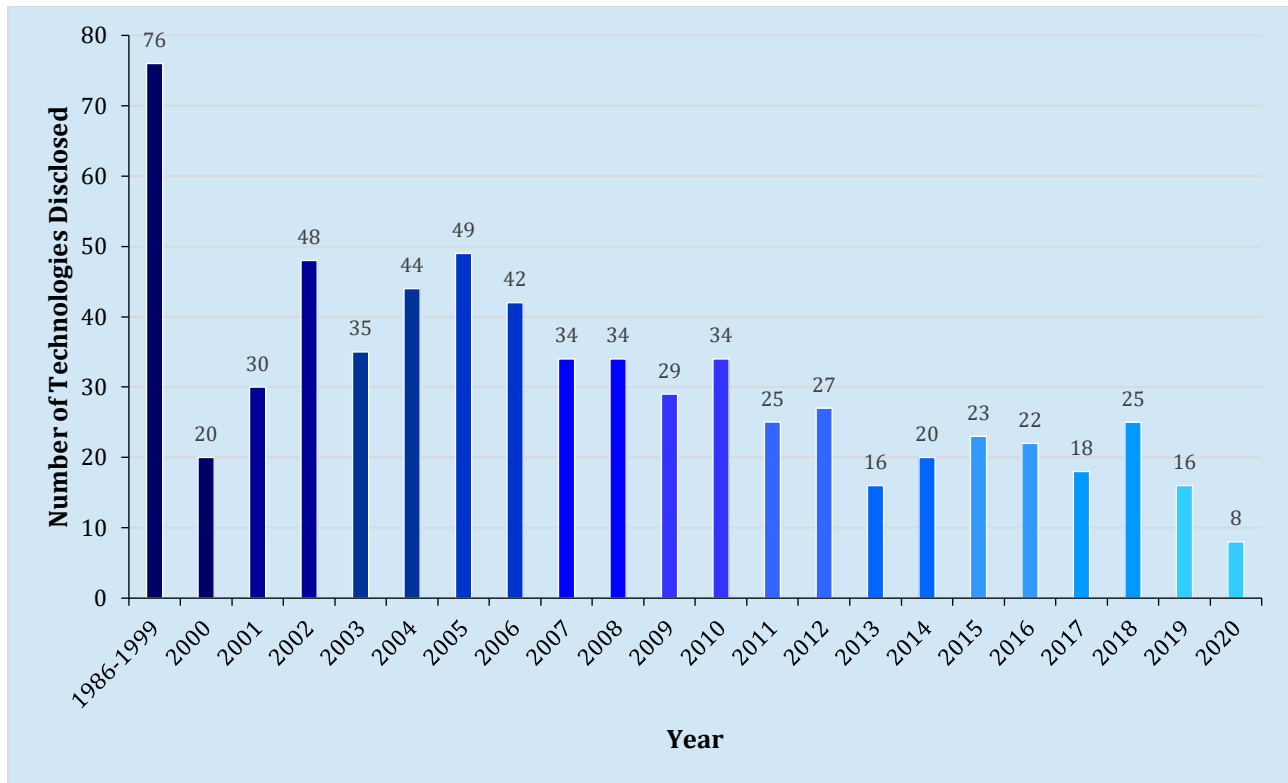
Few of the PRIs have also engaged actively in commercialisation efforts with a higher success rate. Selected success cases of PRIs are highlighted in this section to provide illustration on the commercialisation initiatives and its outcome.

12.4.3.1 Malaysian Palm Oil Board (MPOB)

Figure 12.4 shows the number of technologies disclosed by MPOB during 1986-2020. A total of 675 technologies and products were disclosed by MPOB. Out of the total, nearly 30.52% (206) of the technologies were successfully commercialised. Likewise, the patented technologies stood at 33.24%. Indeed, to date, MPOB has provided 192 services. The market value of the commercialisation efforts is nearly RM3 billion that would benefit the industry. These technologies aim to improve oil palm yields in the upstream sector and technologies that would also significantly contribute to the sustainability of the industry. For instance, the collaboration between MPOB and Techbond Greentech Sdn Bhd in the technology development of palm-

based polyol marks the effort to move into sustainable palm oil-based polyol for the production of new industrial grade polyurethane adhesives replacing the formaldehyde-based adhesives.

Figure 12.4 Technologies Disclosed, 1986 – 2020



Source: MPOB, 2020

12.4.3.2 MIMOS

MIMOS has been successful in patenting activities emerging as one of the top patenting institutions. Table 12.8 shows MIMOS efforts in monetising research and technologies developed by MIMOS. In the last 10 years, MIMOS has monetised RM1,605.58 million in revenue through the contracts awarded and purchase orders given by their customers for receiving the technologies developed by MIMOS. The highest monetisation value is recorded in 2014 amounting RM401.34 million. In recent years, the efforts to monetise seems to have reduced sharply with receipts of RM25.14 million and RM63.52 million in 2018 and 2019, respectively. MIMOS unique technology recipients programme allows MIMOS to license its technology to firms to strengthen the firm's abilities to be more competitive. The programme also allows MIMOS to provide training programmes to the recipients.

Table 12.8 Monetisation Efforts of MIMOS

Year	Monetisation (RM million) *
2010	0.17
2011	135.28
2012	263.38
2013	211.86
2014	401.34
2015	217.56
2016	152.02
2017	135.31
2018	25.14
2019	63.52
TOTAL	1,605.58

Note: * Ringgit worth of contracts awarded/purchase orders by technology recipients.
Source: MIMOS, 2020

12.5 Commercialisation at Programme Level

Commercialisation efforts at programme level is further discussed in this section. These programmes are specific initiatives established by the government to spearhead commercialisation activities. The section only reports the achievements of selected programmes.

12.5.1 CRDF

The CRDF programme is specifically designed to stimulate commercialisation of Malaysian owned firms, universities, and research institutions by providing grants to support qualified R&D projects. Table 12.9 shows the outcome of the funding in terms of sales generation, investment amount and the rate of commercialisation. During the period of 2006-2010, the total investment amounted to RM230 million (with private investment of RM418 million) and the revenue generated out of the investment totalled RM1,390 million. The total number of projects approved is 154 and around 84% of the projects were able to be commercialized. During the 2011-2016 period, the investment amount declined to RM120 million with lower private investments amounting RM96 million. Out of the 103 projects only 58 were able to be commercialized generating sales revenue of RM316 million. Similarly, the rate of commercialisation was lower at 41% of the 105 projects approved during the period 2017-2020 given the lower level of private investments. Sales revenue from the 43 projects that were commercialized during this period amounted to RM540 million.

Table 12.9 Commercialisation of CRDF Funding Scheme

Periods	Total sales generated (RM Million)	Total amount invested (RM Million)	Rate of Commercialisation	Private sector investment (RM Million)
2006-2010	1,390	230	84% (129 out of 154 projects)	418.00
2011-2016	316	120	56% (58 out of 103 projects)	96.32
2017-2020	540	133	41% (43 out of 105 projects)	39.90

Source: MTDC, 2020

12.5.2 BioNexus

The government recognised the importance of the biotechnology industry and spearheaded the BioNexus initiatives as part of the National Biotechnology Policy. The BioNexus status was instrumental to allow qualified companies to participate and improve the value addition in the biotechnology industry. The funded companies have engaged in wealth generation captured by the revenue generation (Table 12.10). From 2015 to 2020, a total of RM12,103.28 million was generated by the BioNexus companies. The bio industry segment contributed the largest share of the total revenue generation amounting to RM6,635.63 million in total. Relatively, agriculture related biotechnology segments contributed more than the healthcare related segments.

Table 12.10 Revenue of BioNexus Companies, (RM Million), 2011-2020

Segments	2015	2016	2017	2018	2019	2020*	TOTAL (RM)
AGBIOTECH	360.60	391.43	416.97	530.61	383.00	56.60	3,438.43
HEALTHCARE BIO	266.80	248.45	234.91	149.96	162.00	28.80	2,029.22
BIO INDUSTRIAL	903.90	934.25	818.70	802.01	972.00	244.90	6,635.63
TOTAL	1,531.30	1,574.13	1,470.58	1,482.58	1,517.00	330.30	12,103.28

Note: * Data as of June 2020

Source: BiotechCorp, 2020

12.6 Summary

Over the years, Malaysia has attempted to improve its commercialisation efforts and success. During the period of 2006-2010, the success was much better than other periods given the higher R&D spending and greater access to other resources. However, the challenges in commercialisation activities remained and more efforts are needed to revive the commercialisation ecosystem in Malaysia. Streamlining policy framework and engaging in targeted activities through mission-oriented innovation programmes may result in higher commercial success. Potentials of IPR in generating wealth and strengthening the capacity of the TTO should be further explored. Learning from success cases are crucial.

13

**CONCLUDING
REMARKS AND WAY
FORWARD**

CHAPTER 13: CONCLUDING REMARKS AND WAY FORWARD

13.1 Introduction

This concluding chapter presents an overview of the STI ecosystem of Malaysia based on the Education Advancements; Society and STI Progress; Digital Infrastructure; R&D Investment and Research Workforce; Public Sector R&D Investment; Innovation in the Manufacturing and Services Sectors; Knowledge and Technology Intensive Industries; Energy and Green Technology; Bibliometrics; Intellectual Capital; and Commercialisation. The discussion examines where we are in these thematic areas particularly aspects that we are doing well, our gaps and deficiencies as well as our international standings by gauging our STI performance against selected countries. A scorecard to summarise the findings in comparison to what we achieved in these thematic areas in 2016 as well as international benchmarking is presented. Some key takeaways and recommendations that emerged from the findings are detailed.

13.2 Summary of Key Findings

This section summarizes the main findings of the earlier chapters according to positive trends, gaps and international comparisons.

13.2.1 Education Advancements

Positive Trends - The performance achievement for all Science subjects at SPM and STPM has remained almost unchanged over the period 2016 to 2019. For STPM Mathematics (T), however, improvements in achievement are recorded with higher percentage of achievers in band A and reduced failures in band F over the period 2016-2019. ICT continues to gain traction over the years with more than 40% increased enrolment in 2019 compared to that of 2015, although enrolment in ICT is relatively small compared to other STPM Pure Science subjects. At the tertiary level, enrolment at the twenty public universities has increased slightly at the undergraduate (first degree) level. The enrolment of undergraduates at private universities has increased by almost 35% from 2014 to 2019 where enrolment in Science-based programmes at these universities is approximately 38% of the annual enrolment.

Gaps - There is a significant declining trend in the percentages of students registered for selected SPM Science and Mathematics subjects in 2019 compared to 2011. In terms of performance in Pure Science subjects, rural students' achievements are lower than their peers in the urban areas. Similarly, there is a gender disparity in terms of subject and grade achievement. In public Higher Learning Institutions, the number of enrolments for Science courses is consistently less than for non-Science courses at the

undergraduate levels – at a ratio of 45:55. This declining trend is also evident at the Masters and Doctoral levels.

International comparisons - Malaysia's performance in the OECD's PISA and TIMSS surveys has always been significantly below OECD and TIMSS global score averages. A comparison of scores shows that 15-year-olds in Singapore, South Korea, Hong Kong and Shanghai are performing as though they have had three or more years of schooling than 15-year-olds in Malaysia.

13.2.2 Society and STI

Positive Trends - Overall, Malaysians continue to exhibit increasing awareness of STI in 2019. Interest in STI topics (79.6% in 2019) has been on the upward trend with environmental pollution issues registering highest level of interest (85.2%). 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. Television and newspapers are the two leading and most trusted sources of STI information with the Internet gaining in prominence. These suggest to planners that these media especially the new media can be mobilized to raise awareness and interest.

Gaps - Despite these positive trends, the average public knowledge of STI (45.9% in 2019) in Malaysia has been below 50% for the past 19 years. The 2019 survey findings recorded the lowest percentage (38.2%) of Malaysians since 2000 saying the benefits of STI are greater than its harmful effects. Another area of concern is the marked difference of public interest and perceived knowledge in STI topics amongst rural and urban dwellers.

International Comparisons - Public interest in STI in Malaysia (79.6%) is comparable to the level displayed in China (75.3%) and in the USA (85.0%). Overall, knowledge and understanding of STI concepts and ideas among the public in Malaysia is well below that of developed nations.

13.2.3 Digital Infrastructure

Positive Trends - Malaysia's digital economy has expanded in recent years, but many challenges remain. The ICT industry contributed about 19.1% to the national economy in 2019. The MSC programme has led businesses in Malaysia to generate RM473 Billion. The programme has created 99,590 jobs in 2009, 147,568 jobs in 2014 and 182,538 jobs as of 2018. Adoption rates of broadband for internet access and mobile cellular telephone subscription have reached above 100 per 100 inhabitants.

Gaps - Despite impressive gains in recent years, Malaysia's broadband infrastructure connection speed is well behind that of many of her neighbours. There is disparity in terms of household computer access across states. Lack of market competition has resulted in high prices and poor coverage in the fixed broadband segment. Much of the digital economy continues to be dominated by large firms whilst their impact on business practices of SMEs is minimal.

International Comparisons - Within the region, only Japan, the Republic of Korea and Singapore have higher internet penetration rates and Malaysia outperforms most ASEAN countries in terms of mobile cellular subscriptions. These positive trends are mitigated by relatively low adoption by businesses and poor fixed broadband quality.

13.2.4 R&D Investment and Research Workforce

Positive Trends - Malaysia's R&D investment declined sharply in 2018. The BE sector contributed the largest share (38.2%) of the R&D expenditure. BERD in Malaysia in 2018 was mainly contributed by in-house R&D conducted by majority foreign-owned large BEs.

Gaps - The GERD stood at RM15,060 million- a decline of 14.8% from the expenditure in 2016. The ratio of GERD/GDP also plunged by some 27.8% to 1.04% in 2018. There was a 15.4% decrease in total number of R&D personnel from 145,741 persons in 2016 to 123,362 persons in 2018; and 20.4% decrease in the researchers per 10,000 labour force from 74.0 in 2016 to 58.9 in 2018.

International Comparisons - In terms of GERD, Malaysia is currently ranked 19th in the world behind most of the developed countries while its research intensity (1.04%) is below the world average (1.72%). Malaysia's investments in higher education expenditure on R&D as percentage of GERD was 42.6%. This placed Malaysia fifth relative to OECD countries.

13.2.5 Public Sector R&D Investment: Major Grants and Programmes

Positive Trends -An extensive range of R&D grants, programmes and incentives are made available to promote and support R,D&C activities in the country. Revisions to the funding mechanisms have been undertaken frequently to make sure the grants and programmes are relevant to the needs of researchers and firms. New grants have been introduced by several ministries such as MOSTI and MOHE. A number of successful public funded projects have created significant impacts to the society.

Gaps - BEs faced issues on the lack of information on R&D incentives, the definition of R&D incentives is not clear, and the application procedures are not simple. HLIs, GRIs and NGOs reported that they suffered from insufficient government funding. There was

a significant decrease in terms of number and amount of R,D&C projects approved in the 11th MP in comparison to 10th MP.

International Comparisons – Leading innovation countries have sound institutional structures for promoting, for example, R&D support programmes. In Sweden, VINNOVA is the main agency for promoting innovation and its focus is on strengthening research cooperation between academia, companies and public sector in the Swedish innovation system. In Taiwan, the Ministry of Economic Affairs is responsible for all assistance programmes/incentives to SMEs.

13.2.6 Manufacturing and Service Sector Innovation

Positive Trends - A striking theme from NSI-18 is that increasing number of companies reported engaging in innovation in both these two sectors than in NSI-15. More (>22%) companies expended more than RM4 million on innovation-related activities compared to less than 2% in NSI-15. Additionally, more firms indicated spending a minimum amount of RM25,000 on innovation than in NSI-15. A greater number of companies (> 16%) have indicated that their product innovations are new to the world – far more than the 1% reported in NSI-15 for the same item.

Gaps - Despite these positive trends, the uptake on government incentives and support measures is minimal (< 10%). Most firms (75%) reported being unaware of the incentives provided by the authorities. Even more disturbing is the view held by firms that universities and GRIs are one of the least important partners for collaboration although they are important sources of information. Another area of concern is the weak adoption rate (<10%) of IPRs by enterprises from both sectors as well as the poor adoption of IR 4.0 technologies. High cost reported to be the most important factor hampering innovation activities as in NSI-15.

International Comparisons - Comparatively, Malaysia is the best performing country in the region (after Singapore) for both GCI (27th, 2019) and GII (33rd, 2020) rankings. Malaysia is placed 5th in the CIS ranking of countries with innovative enterprises with a score of 65% (we were ranked 31st in NSI-2015).

13.2.7 Knowledge and Technology Intensive Industries

Positive Trends - The overall Malaysia's KTI value added has grown steadily in recent years. Among the KTI industries, computer, electronic, and optical products; chemicals and chemical products; and motor vehicles are among the top three sectors in terms of value-added between 2011 and 2018. Export shares of KTI industries increased by

26.94% between 2011 and 2018. Likewise, the overall export of commercial services has grown by 3.42% during the same period.

Gaps - Despite these upbeat trends, the export share of these industries to GDP fell slightly. The insurance and financial services export share are extremely small, contributing 1% - 2% to the overall commercial services sector.

International Comparisons - In 2018, Malaysia's KTI industries value added share of GDP (11.13%) has surpassed the world share. However, as a share of world value added, Malaysia's contribution is still low given its size of the industry. Malaysia's medium-high R&D intensive industries contribution is lower than her ASEAN neighbours like Singapore, Thailand and Indonesia. However, Malaysia's high R&D intensive industries have dominated other ASEAN counterparts (Indonesia, Philippines, Singapore and Thailand) by registering significant trade surplus.

13.2.8 Energy and Green Technology

Positive Trends - Since 2006, Malaysia experienced a drastic decline in GHG emissions declining from the peak of 374 tonnes in 2005 to 161 tonnes of CO₂ equivalent of GHG emissions in 2016 due to sound management of land-use and forestry. Additionally, the exports of photosensitive semiconductor devices products have significantly increased from USD2,599 million in 2010 to USD4,677 million in 2019. Malaysia has the potential to become the regional hub for green sukuk financing.

Gaps - Targets in achieving the renewable energy mix to total energy supply is falling short. Indeed, Malaysia needs to strategize the demand side management and adoption of green technology in critical sectors namely energy, transportation and industrial sectors. Moreover, the demand side management of the electricity consumption intensity is crucial in improving energy efficiency especially demand from the industry. Likewise, low carbon energy related technology capabilities, measured by international patenting activities, remained low.

International Comparison - On average, the international scientific collaboration in related green technologies stands at 37% between 2008 and 2016. It is also noticeable that Malaysia's energy intensity is relatively lower than Indonesia, Thailand and Vietnam. However, Malaysia's final energy consumption per capita is higher than many other ASEAN countries.

13.2.9 Bibliometrics – Publications and Citations

Positive Trends - Malaysia achieved impressive performance in scientific publications in recent years. A total of 136,124 articles was recorded between the period of 2001 and 2019 – an increase from 53,954 in 10th MP to 55,418 in 11th MP (2016-2019). The top 5

research universities produced a total of 105,641 articles (or 77.6% of total published articles) from 2001 to 2019. The leading multidisciplinary fields include “materials science-multidisciplinary”, “Engineering Electrical Electronic” and “multidisciplinary sciences”. There has been a general increasing trend in citations since 2001 although the volume of citation is still low. Malaysia’s vast and diverse networks for publication implies its interest in pursuing advanced scientific knowledge with those from both advanced and developing countries.

Gaps - An area of concern is the low growth of publishing between 2016 and 2018. Our commitment towards appropriating science to learn and control COVID-19 is commendable. However, Malaysia still lacks in terms of capacity in COVID-19 related research results.

International Comparisons - In the ASEAN region Malaysia with 112,663 articles and 1,338,623 citations leads many countries in publishing performance. However, it is well behind the publishing performance of Singapore (136,336 articles and 2,998,455 citations).

13.2.10 Intellectual Capital

Positive Trends - Malaysia’s efforts in boosting the counts for local IPR applications between 2008 and 2018 have yet to witness tangible results. Public research institutions (for example, MIMOS) and universities (UTM, UPM and UM) emerged as the top organizations in domestic patenting. Malaysia has a total of 265 AI-related PCT patents between 2001 and Aug 20th 2020. MIMOS (52 patents), Continental AG (11 patents) and INTEL (8 patents) are among the top assignees in Malaysia.

Gaps - There are six times more foreign patenting applications in 2008 (4,539 applications) than local ones. In 2018, the number of foreign applications increased to 6,245 and they continue to remain as the key driver for patenting growth.

International Comparisons - Malaysia’s PCT patenting record is second in the ASEAN region (after Singapore) but is well behind countries like Japan, China and Republic of Korea. Similarly, Malaysia is performing well below that of the advanced countries in AI-related PCT patenting.

13.2.11 Commercialisation

Positive Trends - Overall commercialisation rate has improved slightly from 8% to 9% during the 10th MP. The highest revenue generation of the publicly funded research was during the 9th MP amounting RM3,431.98 million. At institutional level, MPOB and MIMOS have actively and successfully commercialised and monetised their research

outputs. Likewise, between 2011 and 2015, CRDF and BCG generated the highest revenue by commercialising the potentially viable projects.

Gaps - The income generation is declining over the years due to limited funding. And, the flow of royalties and licensing fee remains in deficit indicating that Malaysia should also improve its technology licensing abroad. The key challenges in commercialisation remains and efforts to improve the commercialisation ecosystem is needed.

International Comparisons - Malaysia is an active user of foreign technology recording deficit in royalties licensing payments and receipts. Within ASEAN, Singapore and Indonesia have more IPR receipts than payments.

The central message is that Malaysia has attained satisfactory progress according to the framework of four important pillars of STI, namely, basic supporting environment; public and private investments; industrial development; and scientific capabilities. The nation's STI system is blessed with unflinching support from the government; a robust industry; a population supportive of STI; a sound infrastructure; and growing competency as reflected in increased publications and patenting. However, Malaysia's path to success is not without its red flags. These include, among others, weak management of programmes, funding and execution; ineffective and inadequate linkages among the key actors of the ecosystem; uneven digital infrastructure across states; declining enrolment in STEM courses; poor adoption of IR 4.0 technologies and IPRs by SMEs and uncertainties over continued funding support for STI.

Malaysia's STI performance on the four pillars for the year 2020 – in comparison to year 2016 as well as international benchmarks - is mixed as can be seen from Table 13.1 The country has maintained or improved its performance for the various categories under the pillar of Basic Supporting Environment. Though proportionately our Science and Engineering enrolment at tertiary level is much higher than the level found in the OECD, a worrying trend is the continuing less than satisfactory performance by Malaysian students in the internationally conducted PISA and TIMSS assessments. Our 2018 mean scores for Mathematics, Science and reading are much lower than the corresponding mean OECD scores. Our digital infrastructure indicators are on the upward trend and well above the world averages. The Malaysian society is generally supportive of science and displays a level of interest in STI issues that is comparable to the developed countries. However, our proficiency in more abstract STI concepts and ideas is well below the standards achieved by the more advanced countries. The various indicators – such as R&D intensity; industry R&D expenditure as proportion of GERD - under the pillar of Public and Private Investments in R&D have all declined sharply in 2020 excepting the category of proportion of female researchers where we have maintained parity and a level that is well above that found in the developed world. The bright spot in the 2020 scorecard is the positive trends indicated in almost all the indicators under the pillar of Industrial Development although the low rate of adoption of IR 4.0 technologies by the SMEs is an area of concern. A healthy trend is the increasing number of firms engaged in innovative activities as well as launching products that are new to the world. Exports of our knowledge and technology intensive industries have also registered positive trends as is the case of the adoption of

renewable energy in our total energy supply mix. Our performance in the Scientific Capabilities pillar as reflected in the indicators of publications and patenting is almost unchanged from the levels reached in 2016. Internationally, however, Malaysia has much to do to achieve global standards in these areas. A perennial problem is the continuing negative balance in the payments for licences and royalties.

It must be stressed that the scorecard is not exhaustive. Several other indicators that capture the performance of the STI system are not included. However, the scorecard serves as a useful barometer in highlighting where we are doing well and where we are declining. The challenge for the policy makers is to build on the gains and address the deficiencies of the STI system as described in this report. The next section will examine these recommendations in detail.

Table 13.1 Selected STI Performance Scorecard, Malaysia, 2020

Pillar	Category	Indicator	Year 2016	Year 2020	International Comparison
BASIC SUPPORTING ENVIRONMENT	Education Advancement	Science and Engineering enrolment as % of total First Degree enrolment	44.0	42.2	OECD average 25%; Germany 35%
		Science and engineering enrolment as % of total post-graduate enrolment	32.0	39.8 *	China - 46.7%
		Average PISA score (Mathematics; Science; Reading) 2015 and 2018	446; 443; 431 Ranking 45;47 50 (72 countries)	440; 438; 415 Ranking 48;49 57(88 countries) ***	Average OECD score (2018): 489; 489; 487
	Digital Infrastructure	No. of households with computer	66.48	71.30 (2019) *	World: 47.10 (2019)
		Internet users (% of population)	78.8	84.2 *	World: 51.4 (2018)
		Cellular phone subscription per 100 inhabitants	141.7	140.0 ***	World 109.4 (2019)
		IMD world digital ranking	24 (63 countries)	26 (63 countries) ***	2020 ranking: Singapore-2; China -16
	Society and STI	Mean Score of public interest in selected STI issues	77.7 (2014)	79.6 (2019) ***	US -85% (2018); China - 75.3%(2018)
		Mean Score of STI concepts and ideas	46.1	45.9 ***	US – 66 (2018); Singapore – 66 (2015)
	PUBLIC AND PRIVATE INVESTMENT	Research Investment and Workforce	Overall R&D Intensity	1.26 (2014)	1.04 (2019) **
Industry R&D expenditure as % of GERD			56.5(2016)	43.9 (2018) **	71 (OECD average, 2019)
Researchers per 10,000 labour force			74.0	58.9 (2018) **	89.0 (OECD 2018)
Proportion of female researchers to total researchers (%)			48.2	49.1 (2018) ***	World – 30% (2017); Germany – 28% (2017); UK – 39% (2017); Singapore – 30% (2018)
Public R&D Investment		R&D/Technology grant/programme/investment funded under 10 th and 11 th MP	3,567.20 million (10 th MP)	2,142.75 million (11 th MP) ***	
		MIDA R&D Investment Incentives	874.19 million (10 th MP)	750.88 million (11 th MP) **	
INDUSTRIAL DEVELOPMENT		Manufacturing and Services innovation	Expenditure of RM4 million and above on innovation-related activities	< 2%	> 22% *
	Product innovations that are new to the world		1%	> 16% *	In the median OECD country, 53% of firms introduced a new product or business process in 2014-16.
	Global Innovation Index; Community Innovation Survey (CIS-10) ranking on percentage of innovative enterprises.		35; 31 (2015)	33; 5 (2018) *	
	Adoption of IR 4.0 technologies by SMEs		-	<10%	Germany – 19%; US – 16% (2016)

Note: * Positive trend; ** Negative trend; *** Almost unchanged

Source: OECD (2020); Statista (2021); World Bank (2020); IMD (2020); WoS (2020); UNESCO (2020); Asian Scientist (2015); Cornell University, INSEAD, and WIPO (2020); WIPO (2021); US Science and Engineering Indicators (2020); Eurostat (2018).

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Pillar	Category	Indicator	Year 2016	Year 2020	International Comparison
INDUSTRIAL DEVELOPMENT	Knowledge and Technology Intensive Industries	Value added of KTI industries (USD million)	32,990	39,907 (2018) *	Value added share of GDP at 11.13% surpassed world's share but share of world value added is very low; Singapore – 5.6%; China – 6%
		Exports of KTI industries (USD millions)	97,876	132,323 *	Export share of GDP (36.9%) much higher than world share (9.94%); Singapore - 69.3%; Thailand – 27.6%
		Insurance and financial services (% of commercial service exports)	2.28	2.29 ***	World average – 10.9% (2019); Singapore – 18%; China – 4%
	Energy and Green Technology	Renewable energy in Total Energy	3.41% (2015)	6.01% (2019) *	OECD – 10.91% (2019)
		Exports of PV products (USD million)	4,387	4,677 (2019) ***	China (62.9% of total shipment in 2019); Malaysia (12.1%)
SCIENTIFIC CAPABILITIES	Bibliometrics: Publications and Citations	Publications output	53,954 publications (10 th MP)	55,418 publications (11 th MP) *	In ASEAN, Malaysia is second to Singapore in terms of articles produced during period 2009-2019
		COVID-19 related publications (1st January -10th August 2020)	-	87	Taiwan and South Korea to-date produced 224 and 292 COVID-19 related articles respectively
	Intellectual Capital	Domestic Patents and Utility Innovations Application Filed	1,375	1,248 (2018) ***	2019: China (1.63 million); US (621,453); Korea (224,422)
		AI-related Patents Filed in PCT	15	19 (2019) *	China (4,636); US (1,416)
	Commercialisation	Overall commercialization rate of public R&D funded projects	8% (10 MP)	9% (11 th MP) ***	
		Net balance between IP Payments and Receipts	- USD1,233 million	-USD1,738 million **	Singapore (- USD7.8 billion); Korea (-USD 1.68 billion); Japan (USD23.6 billion)

Note: * Positive trend; ** Negative trend; *** Almost unchanged

Source: OECD (2020); Statista (2021); World Bank (2020); IMD (2020); WoS (2020); UNESCO (2020); Asian Scientist (2015); Cornell University, INSEAD, and WIPO (2020); WIPO (2021); US Science and Engineering Indicators (2020); Eurostat (2018).

13.3 Way Forward

The findings of this report have revealed that Malaysia's present proficiency in STI needs to be further enhanced to ensure that the nation is not seriously disadvantaged by the exponential pace in scientific and technological developments that we are witnessing today. Our present inadequacies cannot remain unresolved. Instead, we need to adopt bold and creative solutions to confront our STI shortcomings holistically. We must be prepared to abandon approaches that have not served us well and build upon those that have yielded positive results. As a whole, the trends and gaps indicate that Malaysia needs to further improve the policy and institutional framework, create more STI awareness, promote the market enablers, human capital and industrial R&D&C. Accordingly, this report has identified six key takeaways and recommendations for consolidating the four pillars of STI which are in alignment with the thrusts of STIE embedded in the NSTIP 2021-2030. Policy makers can further prioritise and align the recommended actions into their existing plans and set short, medium and longterm targets based on their engagement with stakeholders.

PILLAR 1: BASIC STI SUPPORTING ENVIRONMENT

KEY TAKEAWAY 1: *Elevate quality of STEM education and STEM career pathways in order to enhance STEM proficiency levels as well as ensuring sustainability of STI talent pipeline.*

Despite impressive achievements at all levels of education, the STEM enrolment continues to exhibit a declining trend in particular Science-based subjects at the school level as well as greater proportion of enrolment in non-Science-based courses at the tertiary level. Additionally, there are disparities in performance in Pure Science subjects between rural and urban students. At the international level, Malaysia's performance in the OECD's PISA and TIMSS surveys has been less than satisfactory. These issues suggest, among others, a pressing need for the improvement of the teaching of Science in schools at all levels as well as ensuring that STEM career pathways are as rewarding as non-STEM jobs.

Actions:

- (i) Establish task force to review all relevant initiatives and recommendations pertaining to enhancing quality of STEM education in schools, colleges, universities including addressing associated gender and locational disparities.
- (ii) Introduce improved and continuous career development pathways to attract and retain STEM talent as detailed in ASM's 2017 Science Outlook document.
- (iii) Implement all recommendations pertaining to nurturing and retention of STEM talent as detailed in Strategic Thrust 4 of the NSTIP 2021-2030 Action Plan.

KEY TAKEAWAY 2: *Promote STI awareness and elevate digital infrastructure and skills for industry transformation and an inclusive Malaysia.*

Malaysians have shown much interest and acceptance of STI. Nevertheless, there are many shortcomings that require attention. Similarly, despite Malaysia being a highly digitally networked nation, with 90% of households using the internet, to-date, it has not been able to narrow the gap between underserved areas and the rest of the country due to structural connectivity problems. Digitalizing SMEs will enhance their competitiveness, and productivity but only less than 10% have adopted IR 4.0 technologies.

Actions:

- (i) Review existing STI enculturation programmes to enhance their effectiveness to raise Malaysians' knowledge of STI.
- (ii) Mobilize and leverage partnerships with various stakeholders in popularising science to society including using various platforms and STI-based content development.
- (iii) Strengthen the governance framework for enculturation of science to streamline programmes and resources.
- (iv) Implement the strategies and programmes for enhancing enculturation and application of STI as detailed in Strategic Thrust 5 of the NSTIP 2021-2030 Action Plan.
- (v) Promote demand-side initiatives (such as incentives for skills enhancement) to foster greater adoption of digital and other IR 4.0 technologies by SMEs.
- (vi) Support collaborative ventures between industry and universities/research organisations to experiment with new approaches to enhance connectivity in underserved areas.
- (vii) Support initiatives to drive upgrading of digital infrastructure and skills provision to SMEs as detailed in Malaysia Digital Economy Blueprint and action plans of JENDELA.
- (viii) Intensify efforts to narrow the digital divide between developed and underdeveloped states.
- (ix) Improve funding support and its access to reenergise industry and human workforce in ICT.

PILLAR 2: Public and Private Investment

KEY TAKEAWAY 3: *Ensure sustained investments in R&D through alternative funding mechanisms and greater international funding.*

Recent years have witnessed a decline in government R&D funding as well as reduced expenditure by industry in R&D due to the global economic downturn. This recession is exacerbated by the COVID-19 pandemic and will severely impact the capacity of several nations to invest in risky activities such as R&D in the coming years. Given this difficult operating

environment, policy makers will do well to focus on sustainability issues. New funding mechanisms are needed to promote a smarter mix of funding that embraces the participation of several stakeholders.

Actions:

- (i) Increase public and private sector R&D investments targeting for gross national R&D expenditure levels of at least 2.5% of GDP by 2025 and 3.5% by 2030 as documented in Strategic Thrust 2 of the NSTIP 2021-2030 Action Plan.
- (ii) Initiate evaluation of following alternative financing mechanisms – such as consortium funding; crowdfunding; angel funding; philanthropy; co-investment; debt financing instrument; innovation bonds; Islamic sustainable financing (waqf), Malaysia Science Endowment - for possible adoption.
- (iii) Attract International and matching funding collaboration focusing on sustainability.
- (iv) Establish appropriate metrics for all RUs to achieve in terms of international funding of their R&D effort.

KEY TAKEAWAY 4: *Restructure STI funding system to be more streamlined, responsive, results-driven and strategy-linked to advance nation's STI agenda.*

An inordinate number of schemes characterise our public funding support system for STI. Our funding system needs to be rationalised and results driven. A recent initiative to promote a more focused and collaborative approach towards research and technology development is the identification of 30 niche areas by the Academy of Sciences Malaysia under its 10-10 MySTIE Framework which has been adopted by the government to support the implementation of the NSTIP 2021-2030. Enhanced management of these schemes is vital to ensure that our limited resources are utilised well to advance industry as well as socio-economic objectives. Additionally, these schemes need to be well publicised and easily accessible by the relevant target groups.

Actions:

- (i) Launch review of public funding system to be, among others, more streamlined, promote development of capabilities in new technologies; achieve balance among fundamental, mission-oriented, near market as well as Social Sciences and Humanities, foster excellence and partnerships and support commercialisation and IPR initiatives of researchers in alignment with Strategic Thrust 2 of NSTIP 2021-2030.
- (ii) Initiate more targeted strategies to disseminate information on the grants and incentives to firms through collaboration with intermediaries such industry associations and science (or business and industrial) parks.

- (iii) Enhance management of funding system/grant schemes with attention to, among others, monitoring and evaluation, competent assessment of proposals, improved awareness and access to the scheme, guidelines on IPR and royalty sharing.
- (iv) Critically examine the 30 niche areas under the 10-10 MySTIE Framework developed by the Academy of Sciences Malaysia with a view to implementation.
- (v) Conduct specific training workshops for firms to enhance their knowledge and know-how on grants and incentives applications.

PILLAR 3: Industrial Development

KEY TAKEAWAY 5: *Strengthen the Governance Framework for effective management of STI support measures for industry.*

Despite years of bridge-building efforts by the government, universities and GRIs are still considered one of the least important partners by industry in innovation cooperation. New forms of partnerships such as open innovation and co-innovation should be explored to promote sharing of risks and resources with industry. Another distinctive feature of our innovation ecosystem is that far too many organisations and schemes have been established by the government to promote STI in industry. It is vital that an effective monitoring and evaluation initiative be undertaken to appraise, among others, all these schemes and rationalise them so that they are more focused, accessible, results-driven and forward-looking. Strengthening the governance framework for industrial development assumes urgency particularly at a time when resources are much reduced. Additionally, efforts to promote the energy and green industry as well as the KTI sectors become critical in our quest to deepen our industrial base as well as expand our export earnings.

Actions:

- (i) Launch comprehensive review of existing STI for industry programmes to enhance their effectiveness.
- (ii) Establish separate inter-agency committees for STI funding for industry to streamline programmes, resources and priorities in addition to recommendations to enhance governance framework for responsive STI as detailed in Strategic Thrust 1 of NSTIP 2021-2030.
- (iii) Strengthen initiatives for the adoption of IR 4.0 technologies by SMEs.
- (iv) Promote more effective university-industry partnerships.
- (v) Establish close collaborations with foreign counterparts through knowledge and technology transfer in energy and green technologies as well as other technology areas identified in Strategic Thrust 3 of the NSTIP 2021-2030.
- (vi) Strategize development of niche KTI industries to leverage on transformation of Malaysia's manufacturing sector in line with IR 4.0.
- (vii) Strategize and leverage on the private green financing initiatives such as sukuk to propel Malaysia to become the regional hub.

- (viii) Accord emphasis for efforts on demand-side management and adoption of green technologies among the energy, transportation and industrial related sectors.

PILLAR 4: Scientific Capabilities

KEY TAKEAWAY 6: *Leverage partnerships for successful management of STI capability development and commercialisation.*

This study has revealed that Malaysian universities have largely collaborated with their partners abroad in terms of publications. These collaborations have contributed towards the upward trend in publications. However, a worrying trend is the low citation count despite the increase in publications. Similarly, Malaysia needs to forge strategic collaborations with foreign partners in order to enhance its competencies in selected technologies such as AI and COVID-19 related research. There is a wide disparity between foreign and local patenting in the country. Additionally, royalties and licensing fees remain in deficit indicating that Malaysia should improve its technology licensing abroad. While commercialisation rate of public funded research projects has improved marginally during the 10th MP, much remains to be done in terms of enhancing the commercialisation ecosystem in the country. Additionally, new forms of partnerships such as open innovation and co-innovation should be explored to promote sharing of risks and resources with industry.

Actions:

- (i) Redesign approaches and incentives to promote more effective engagement with industry as well as collaborative models for specific STI programmes.
- (ii) Promote strategic approach to developing technological capabilities through forging technology partnerships/knowledge transfer programmes with external partners as detailed in Strategic Thrust 6 of the NSTIP 2021-2030.
- (iii) Prioritise high impact and multidisciplinary research via collaborative activities.
- (iv) Introduce measures to enhance research publication productivity (including citation counts) among researchers in public HLIs.
- (v) Initiate effective approaches to boost local patenting particularly among local firms.
- (vi) Intensify efforts in building local capabilities through R&D in areas such of IoTs, Big Data Analytics and Artificial Intelligence.
- (vii) Critically re-examine the commercialisation ecosystem including the support system at various institutional and programme levels incorporating the recommendations of the NSTIP 2021-2030 aimed at enhancing the commercial value of locally produced products and STI services.
- (viii) Implement regulatory reforms in areas such as IPR, researcher and student mobility, industrial engagement, and other critical areas.
- (ix) Establish monitoring and evaluation system for better tracking of commercialisation efforts.

13.4 Summary

We are confident that effective implementation of these and other related recommendations will contribute towards building a robust, resilient and responsive STI framework that will enhance the nation's innovative capacity and propel the country forward towards its vision of shared prosperity.

REFERENCES

- Andreas Schleicher (2019). PISA 2018 - Insights and Interpretations. OECD 2019.
- Asian Scientist (2015) A Survey of Public Views and Attitudes Towards S&T Issues in Singapore, from <https://www.asianscientist.com/wp-content/uploads/2015/11/A-survey-of-public-views-and-attitudes-towards-science-and-technology-issues-in-Singapore.pdf>
- BP (2020) Statistical Review of World Energy, available at <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>
- Chandran VGR (2020) Measuring and Benchmarking of Policy Factors Influencing I4R: A Reality Check for ASEAN, in Anbumozhi V., Wyse, H and Ramanathan K. (eds), Assessing the Readiness for Industry 4.0 and the Circular Economy, Economic Research Institute for ASEAN and East Asia, Jakarta, Indonesia.
- Chandran VGR, Rasiah R & Lim, T.H. (2020) Driving Labor Productivity: The Role of Capability And Human Capital In Malaysia's Food Manufacturing Firms, The Singapore Economic Review, available at <https://doi.org/10.1142/S0217590820500502>
- Cornell University, INSEAD, and WIPO (2020). The Global Innovation Index 2020: Who Will Finance Innovation? Ithaca, Fontainebleau, and Geneva.
- Economic Planning Unit (2015). Strategy Paper 15 for 11MP. Retrieved from <https://www.epu.gov.my/sites/default/files/2020-02/Kertas%20Strategi%2015.pdf>
- Eurostat. (2018). Community Innovation Survey - Eurostat. [online]. Available at: <http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>
- IMD (2020) IMD World Digital Competitiveness Ranking 2020 from <https://www.imd.org/wcc/world-competitiveness-center-rankings/world-digital-competitiveness-rankings-2020/>
- Kamp, A. (2019). Science and Technology Education for 21st Century Europe: discussion paper. CESAER. Available at <https://doi.org/10.5281/zenodo.3582544>
- Lee, K., Wong, C. Y., Intarakumnerd, P., & Limapornvanich, C. (2019). Is the Fourth Industrial Revolution a window of opportunity for upgrading or reinforcing the middle-income trap? Asian model of development in Southeast Asia. *Journal of Economic Policy Reform*, forthcoming.
- Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education), Ministry of Education Malaysia 2013.
- Malaysia Education Blueprint 2015 - 2025 (Higher Education), Ministry of Education Malaysia 2015.

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- Malaysian Investment Development Authority. (2020). Kontron Malaysia: Joint Collaboration in High Technology Industries. Retrieved September 15, 2020 from <https://www.mida.gov.my/home/kontron-malaysia:-joint-collaboration-in-high-technology-industries/posts/>
- Malaysia Science and Technology Information Centre (2010), STI Indicator Report. Putrajaya: Ministry of Science, Technology and Innovation.
- Malaysia Science and Technology Information Centre (2013), STI Indicator Report. Putrajaya: Ministry of Science, Technology and Innovation.
- Malaysia Science and Technology Information Centre (2015), National Survey of Innovation. Putrajaya: Ministry of Science, Technology and Innovation.
- Malaysia Science and Technology Information Centre (2016), STI Indicator Report. Putrajaya: Ministry of Science, Technology and Innovation.
- Malaysia Science and Technology Information Centre (2018), National Survey of Innovation. Putrajaya: Ministry of Science, Technology and Innovation.
- Malaysia Science and Technology Information Centre (2019), National Survey of R&D in Malaysia. Putrajaya: Ministry of Science, Technology and Innovation.
- Ministry of Education Malaysia (2018b), Research Universities 2007-2016: Our Story, University Malaya Press, Kuala Lumpur, Malaysia.
- Ministry of Economic Affairs, (2019) Shared Prosperity Vision 2030, Kuala Lumpur.
- OECD (2020). "OECD Main Science and Technology Indicators from <https://www.oecd.org/sti/msti.htm>
- Schwab, K. (ed) (2019). The Global Competitiveness Report (GCR), 2019. Geneva: World Economic Forum.
- Statista (2021) Share of households with a computer at home worldwide from 2005 to 2019 from <https://www.statista.com/statistics/748551/worldwide-households-with-computer/>
- The World Bank. (2020) World Bank Indicators. Retrieved September 10, 2020 from <https://data.worldbank.org/indicator>
- UIS.Stat (2020) (http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&lang=en), 19 September 2020)
- UNESCO UIS.Stat (2020). Retrieved October 28, 2020 from <http://data.uis.unesco.org/>)
- US Science and Engineering Indicators. (2020). Retrieved August 19, 2020 from <https://nces.nsf.gov/pubs/nsb20201/global-science-and-technologycapabilities>
- WIPO (2021) WIPO IP Facts and Figures 2020 Retrieved from: <https://www.wipo.int/publications/en/details.jsp?id=4533>

- Wong, C. Y., & Fung, H. N. (2019). Caught-In or Breaking-Free from the Middle-Income Trap: The Case of Malaysia. *Seoul Journal of Economics*, 32(1), 1-22.

ABBREVIATION

9 th MP	Ninth Malaysia Plan 2006-2010
10 th MP	Tenth Malaysia Plan 2011-2015
11 th MP	Eleventh Malaysia Plan 2016-2020
ADIF	AXIATA Digital Innovation Fund
AI	Artificial Intelligence
ASEAN	The Association of Southeast Asian Nations
ASM	Academy of Sciences Malaysia
ATI	Angel Tax Incentive
B3DF	Biotechnology & Bio-Industry Development Fund
BBGP	Broadband for General Population
BCF2.0	Biotechnology Commercialisation Fund 2.0
BCG	Biotechnology Commercialisation Grant
BE	Business Enterprises
BERD	Business Expenditure on R&D
BGF	Business Growth Fund
BNM	Bank Negara Malaysia
BSF	Business Start-up Fund
BTP	Bioeconomy Transformation Programme
CCGF	Commercialisation Gap Fund
CGP	Coach and Growth Programme
CIP	Cradle Investment Programme
CIS	Community Innovation Survey
COVID-19	Coronavirus Disease 2019
CRDF	Commercialisation of R&D Fund
CREST	Collaborative Research in Engineering, Science and Technology
DEL	Direct Exchange Line
DEQ800	Direct Equity 800
DOSM	Department of Statistics Malaysia
E&E	Electrical and Electronics
EPU	Economic Planning Unit
ESCS	Economic, Social and Cultural Status
EU	European Union
FOR	Field of Research
FRGS	Fundamental Research Grant Scheme
FTE	Full-time Equivalent
GCI	Global Competitiveness Index
GCR	Global Competitiveness Report
GERD	Gross Expenditure on R&D
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GII	Global Innovation Index
GRI	Government Research Institute
HLI	Higher Learning Institution
HSBB	High-Speed Broadband
ICT	Information and Communications Technologies

IER	Innovation Efficiency Ratio
IIUM	International Islamic University Malaysia
IoT	Internet-of-Things
IP	Intellectual Property
IPC	International Patent Classification
IPFS	Intellectual Property Financing Scheme
IPR	Intellectual Property Rights
IR 4.0	Fourth Industry Revolution
ITU	International Telecommunication Union
JENDELA	Jalanan Digital Negara
KI	Knowledge Intensive
KTI	Knowledge and Technology-Intensive
LRGS	Long Term Research Grant Scheme
MASTIC	Malaysian Science and Technology Information Centre
MAVCAP	Malaysia Venture Capital Management Bhd
MCI	Malaysia Customise Incentive
MDEC	Malaysia Digital Economy Corporation
MDV	Malaysia Debt Ventures Berhad
MEB	Malaysia Education Blueprint
MGS	Malaysia R&D Grant Scheme
MIDA	Malaysian Investment Development Authority
MIMOS	MIMOS Berhad
MMU	Multimedia University
MP	Malaysia Plan
MOE	Ministry of Education
MOH	Ministry of Health
MOHE	Ministry of Higher Education
MOSTI	Ministry of Science, Technology and Innovation
MPOB	Malaysian Palm Oil Board
MRG	MOH Research Grant
MSC	Multimedia Super Corridor
MTDC	Malaysian Technology Development Corporation
MTUN	Malaysian Technical University Network
MyLAB	Malaysia Laboratories for Academia-Business Collaboration
MySI	Malaysia Social Innovation Fund
NEC	National Education Code
NESDC	National Entrepreneur and SME Development Council
NGO	Non-Governmental Organisation
NPA	National Priority Area
NSTIP	National Science, Technology and Innovation Policy
NSI	National Survey of Innovation
NSRC	National Science and Research Council
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
PISA	Programme for International Student Association
PhD	Doctor of Philosophy
PIKOM	National Tech Association of Malaysia

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PPP	Purchasing Power Parity
PRGS	Prototype Research Grant Scheme
PRI	Public Research Institution
PV	Photovoltaic
R&D	Research and Development
RE	Renewal Energy
RI	Research Institute
RISE	Research Incentive Scheme for Enterprises
RM	Ringgit Malaysia
S&T	Science and Technology
SCIE	Science Citation Index Expanded
SDG	Sustainable Development Goal
SEO	Socio-Economic Objective
SIRIM	Standard and Industrial Research Institute of Malaysia
SMEs	Small and Medium-sized Enterprises
SPM	Sijil Pelajaran Malaysia
SSCI	Social Science Citation Index
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
STIE	Science, Technology, Innovation and Economy
STPM	Sijil Tinggi Pelajaran Malaysia
TAF	Technology Acquisition Fund
TIMSS	Trends in International Mathematics and Science Study
TRGS	Trans-disciplinary Research Grant Scheme
TRL	Technology Readiness Level
TTO	Technology Transfer Office
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UPM	Universiti Putra Malaysia
USA	United States of America
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
UTP	Universiti Teknologi Petronas
UiTM	Universiti Teknologi MARA
WCY	World Competitiveness Yearbook
WIPO	World Intellectual Property Organizations

APPENDICES

APPENDICES

APPENDIX 1

Pillar 1: Basic Supporting Environment

Indicators	
STI Education Advancement	
1.	Registration for Pure Science subjects, SPM 2011 – 2019
2.	Registration for Technical Subjects at SPM, 2011 – 2019
3.	Grades Attained for Pure Science Subjects at SPM, 2016 – 2019
4.	Grades Attained for Technical Subjects at SPM, 2016 – 2019
5.	Grades by gender, Mathematics and Science at SPM, 2016 – 2019
6.	Registration for Science & Mathematics at STPM, 2013 – 2015
7.	Registration by Urban-Rural Regions at STPM, 2011 – 2019
8.	Grades for Mathematics and Science at STPM
9.	Grades by Gender for Mathematics and Science at STPM
10.	STEM Enrolment, Matriculation Programmes
11.	STEM Performance Achievement in Matriculation Programmes
12.	Enrolment and Graduations in TVET Diploma Courses
13.	Enrolment and Graduations in TVET Diploma Courses at Polytechnics
14.	Enrolment and Graduations in TVET Diploma Courses at Community Colleges
15.	Enrolment and Graduations in TVET Certificate Courses at Community Colleges
16.	First Degree Enrolment, Public HLIs by Fields of Study
17.	First Degree Graduation by Programme of Study (NEC), Public HLIs
18.	Master's Degree Enrolment by Courses, Public HLIs
19.	Master's Degree Courses Enrolment and Graduations, Public HLIs
20.	Doctoral Degree Courses Enrolment and Graduations, Public HLIs
21.	Science and Technology Courses Enrolment by Gender, Public HLIs
22.	First Degree Enrolment and Graduation, Private HLIs
23.	Master's Degree Enrolment and Graduation, Private HLIs
24.	Doctoral Degree Enrolment and Graduation, Private HLIs
25.	Mathematics performance and GDP per capita (USD)
26.	Science performance and GDP per capita (USD)
27.	Performance in Mathematics and Science, Selected Countries, 2012 – 2018
28.	Performance in Mathematics for selected countries, 1995 – 2019
29.	Performance in Science for selected countries, 1995 - 2019
Society and STI	
1.	Public Interest in Selected STI Issues
2.	Public Interest in Selected STI Issues, 2004 – 2019
3.	Public Perceived Knowledge in Selected STI Issues
4.	Correct Answers to Questions on STI Concepts and Ideas (2000-2019)
5.	Understanding of Pseudoscientific Practices
6.	The Malaysian Public's Attitude towards Science
7.	Public Assessment of Scientific Research 2000-2019
8.	Reasons for Low Enrolments in Science
9.	Interest in Science among Malaysian Adults and School-Going Students
10.	Concern for Environmental Pollution among Malaysians
11.	Plastic Waste Pollution is a Serious Problem in Malaysia
12.	Support for the Government's Initiative to Reduce Plastic Use
13.	Concern for Climate Change among Malaysians
14.	Malaysians' Understanding of the Effects of Climate Change
15.	Malaysians' support for Renewable Energy
16.	Top 5 Most Trusted Sources of STI Information among Malaysians

17. STI Places Visited by Malaysians in the Last 12 Months
18. Awareness and public participation of 13 STI-related programmes
19. Awareness of STI-Related Government Policies among Malaysians
20. Awareness of STI-Related Government Policies, 2014 & 2019
21. Public Opinion on Government Spending on STI-related matters
22. International Comparison of Concern for Climate Change
23. Public Attitudes towards STI and Scientific Research, 1998 – 2019
24. Assessment of STI impacts on various aspects, 1998 – 2019
25. Sources of Information, 1998 – 2019
26. STI Places Visited by Malaysians in the Last 12 Months, 2000-2019
27. International Comparison of Public Interest in Selected STI Topics
28. Correct Answers to Questions on STI Concepts and Ideas: International Comparison
29. Understanding of Astrology: International Comparison
30. Public Assessment of Scientific Research by Selected Countries
31. Public Attitudes towards STI in selected countries
32. International Comparison of Concerns for Environmental Pollution
33. Responses on Information Sources for STI by Selected Countries (%)
34. Responses on Government Spending by Selected Countries (%)

Digital Infrastructure

1. Contribution of ICT to the National Economy
2. Share of ICT Exports, 2019
3. Share of ICT Imports, 2019
4. Number of Employees in the ICT Industry
5. Penetration rate for ICT Devices, 2010-2020Q1
6. Modes of Broadband Internet Access, 2010-2020Q1
7. Cellular Telephone, Subscriptions and Penetration Rates, 2010-2020 Q1
8. Direct Exchange Lines (DEL) Subscriptions and Penetration Rates, 2010-2019
9. Fixed Phone Subscriptions per 100 Inhabitants
10. Percentage of Computer Access by Household by State
11. Digital Infrastructure Achievement- FKM and Terminals
12. Broadband for General Population (BB)- FKM
13. Proportion of Households with Internet Access at Home, 2018
14. Percentage of individuals using the Internet, 2018
15. International Internet bandwidth per Internet user (Bit/s), 2016
16. Total MSC Status Companies and Jobs (Cumulative), 2009, 2014 and 2019
17. Cyber Security Incidents, 2010-Sept, 2020
18. Funding Allocation and Approved Projects under 9th MP and 10th MP

Pillar 2: Public Investment in STI

R&D Investment and Research Workforce

1. GERD in Malaysia, 2008-2018
2. GERD by Sector, 2008-2018
3. GERD by FOR, 2018
4. GERD by SEO, 2018
5. GERD by NPA, 2018
6. GERD by Type of Research, 2018
7. Type of Research by Sectors, 2018
8. Source of R&D Fund, 2018
9. Source of R&D Funds by Sectors, 2018
10. BE with R&D Activities by Economic Sector, 2018
11. BERD by Economic, 2018
12. BE with R&D Activities by Firm Size, 2018
13. BERD by Firm Size, 2018
14. R&D Personnel and Researchers per 10,000 Labour Force 2008-2018
15. Proportion of Researchers by Qualification, 2008-2018

16. Headcount of Researchers by Qualification, 2008-2018
17. Full-Time Equivalent of R&D Personnel, 2008-2018
18. Headcount of Researchers by Gender, 2008-2018
19. Number of Registered Engineers, 2011-2019
20. Registered Engineers by Field (as of end 2019)
21. Registered Technologists and Technicians, 2017-2020
22. Registered Technologist and Technicians by Fields
23. GERD by Country
24. GERD per GDP by Country
25. BERD per GERD by Country
26. Higher Education Expenditure on R&D as Percentage of GERD
27. BERD by Size, Ownership and Research Method, 2018

Public R&D Investment – Major Grants & Research Programmes

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7. Bioeconomy Transformation Programme (BTP), 2013-2017
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9. Approved and Realised Investment by BioNexus Companies, 2011-2020
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12. HIP2 Concept to Commercialisation Gap Fund, 2014-2020
13. AXIATA Digital Innovation Fund, 2015-2020
14. MAVCAP Venture Capital Fund, 2013-2020
15. Intellectual Property Financing Scheme (IPFS), 2014-2016
16. Bumiputra, Biotechnology & Bio-Industry Development Fund (B3DF), 2016
17. RMK 10 - Pre-Commercialisation Financing, 2012-2019
18. Malaysia Social Innovation Fund (MySI), 2016-2020
19. Electronics & Electrical Fund (E&E Fund), 2013-2019
20. Cradle Funds, 2011-2020
21. Cradle Programmes and Incentives, 2018-2020
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11. Global Key Exporters of KTI Industries, 2011-2018
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2. CO2 Emissions, 2000-2016
3. Primary, Final and Electricity Energy Consumption Intensity, 2000-2017
4. Renewable Energy in Total Energy (%)
5. Exports PV Products, 2010-2019
6. Total Primary Energy Supply by Fuel Types, ktoe
7. Power Generation (MWh) of Commissioned RE Installations, 2012-2018
8. Source of Fuel Mix in Power Station, ktoe, 2000-2017
9. Energy and Sustainable Science and Technology Knowledge, Malaysia
10. Low Carbon Energy Related Patents, Malaysia, 2011-2019
11. Number of Products & Services and Companies
12. International Collaboration in Technology Development (%), 2008-2016
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3. Articles by Top Institutions, 2001-2019
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1. Domestic Patent and Utility Innovation Applications, 2008-2018
2. PCT National Phase Entry- Applied Patent Counts by Resident, Non-resident and Abroad, 2010-2018
3. Top Countries by Applications Filed for Domestic Patents and Utility Innovations, 2012, 2015 and 2018
4. Counts of Domestic Granted Patents and Utility Innovations, 2008-2018
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1. Royalties and Licensing Fees, Malaysia
2. Income Generated by Public Universities
3. Total Number of Product Licensed, Public Universities
4. Technologies Disclosed, 1986 – 2020
5. Commercialisation of Publicly Funded Projects
6. Commercialisation of Publicly Funded Projects
7. Commercialisation by Types of Funds, 2011-2015
8. Intellectual Property as Payments and Receipts, Selected Countries, Million
9. Commercialisation of Higher Learning Institutions, 2018
10. Commercialization by Business Enterprises, 2018
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12. Monetisation Efforts of MIMOS
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14. Revenue of BioNexus Companies, (RM Million), 2011-2020

APPENDIX 2

DEFINITION AND TECHNICAL NOTE

Gross Value Added of ICT Industry (GVAICT)	GVAICT is a measure of the contribution (value of output) to GDP by ICT Industry.
Gross Expenditure on R&D (GERD)	Total intramural expenditure on R&D performed in the national territory during a specific reference period. GERD is the main aggregate statistic used to describe a country's R&D activities and covers all expenditures for R&D performed in the economy. GERD is a primary indicator for international comparisons of R&D activity (Frascati Manual, 2015).
Current Expenditure	Expenditures on day to day running costs, such as wages, utility bills, rent, office supplies and raw materials, which is short-term and has to be renewed each year.
Capital Expenditure (CAPEX)	Spending on increasing physical assets such as acquire, upgrade and maintain equipment and infrastructure, which is considered as long-term investment.
Business Expenditure on R&D (BERD)	Represents the component of GERD incurred by units belonging to the Business enterprise sector. It is the measure of intramural R&D expenditures within the Business enterprise sector during a specific reference period (Frascati Manual, 2015).
Full time-equivalent (FTE)	FTE of R&D personnel is defined as the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group (Frascati Manual, 2015).
R&D Expenditure by Field of Research (FOR)	R&D expenditure by Field of Research is categorised according to knowledge domains using the Field of Research (FOR) from the 6th Edition of the Malaysia Research and Development Classification System (MRDCS). There are 9 main Field of Research namely: Natural Sciences; Biotechnology; Engineering and Technology; Information, Computer and Communication Technology; Medical and Health Science; Agriculture and Forestry; Social Sciences; Humanities; and Economics, Business and Management.
R&D expenditure by Socio-Economic Objective (SEO)	R&D expenditure by Socio-Economic Objective is categorised according to knowledge domains using the Socio-Economic Objective (SEO) from the 6th Edition of the Malaysia Research and Development Classification System (MRDCS). There are 6 main Socio-Economic Objectives namely: Defence and Security; Society; Sustainable Economic Development; Environment; Advancement of Knowledge; and Advance Experimental and Applied Science.
h-index	h-index is a metric that measures both the productivity and citation impact of the publications produced by an author/institution/

	journal. The performance of an author/institution/ journal is measured by the maximum value of h number of publications that of each been cited at least h times.
Growth Rate	Growth Rate is calculated as (Current value - initial value)/initial value x 100%
Average Annual Growth rate	Annual Average Growth Rate = [(Growth Rate) year1 + (Growth Rate) year+1 + ... (Growth Rate) y+n] / N
KTI Industries	KTI industries cover high R&D intensive and medium-high R&D intensive industries whereby the industries equally deploy significant amount of their revenue on R&D related activities. In details, high R&D intensive comprise several crucial industries namely aircraft; pharmaceuticals; computer, electronic, and optical products; scientific R&D services; and software publishing.
Commercialisation Rate	Commercialisation rate refers to number of projects that has been commercialised (generated sales) out of the total projects during the periods.

APPENDIX 3

Public Interest in Selected STI Issues by Demographics

Public attitudes towards STI issues may vary based on the demographics of the respondents. There are some differences in terms of the main STI topics of interest across genders (Figure 3.3). For males, the top three STI topics of interest are environmental pollution (46.4%), use of new technologies and inventions (45.8%), and food security (45.7%). Female respondents, on the other hand, are more interested in food security (49.1%), environmental pollution (48.8%) and climate change (46.2%). The respondents' interest in STI issues varies by locality. For every STI issue, there is a marked difference between the amount of interest expressed by rural and urban respondents, with higher percentages of interest recorded for the latter (Figure 3.4). For example, environmental pollution has about half of urban respondents expressing an interest in, where 50.0% said they are interested and very interested in the issue. In contrast, only 42.0% of rural respondents are interested in environmental pollution. The marked difference is consistent across all STI topics, where rural interest is consistently at least 10% lower than urban interest in STI.

Interest levels in STI topics also vary across age groups (i.e., among children, youth, and adults). Among adults, a higher percentage of public interest (i.e., very interested and interested) is seen in environmental pollution (49.0%), food security (48.7%), and climate change (47.4%). More youths expressed interest in use of new technologies and inventions (48.4%), food security (46.8%), and environmental pollution (46.6%). Children, on the other hand, are more interested in use of new technologies and inventions (41.7%), new scientific discoveries (38.9%), and new medical discoveries (38.2%). All the three age groups, however, agree on the topic that they are least interested in, which is nuclear technology. This topic has the highest percentages of respondents across age groups expressing a non-interest in, i.e., 36.5% of adults, 31.5% of youth, and 40.8% of children. Rural-urban differences in public interest in STI topics can be attributed to the respondents' level of education, and thus, their level of exposure to the STI topics. There is a strong correlation between the percentages of public interest in STI topics with the level of education of the respondents. Respondents with tertiary education show higher percentages of public interest in STI compared to those with lower levels of education, such as secondary, primary and no formal education.

Malaysian interest in STI topics also varies by ethnicity. More than half (51.0%) of Malay respondents expressed an interest in food security, followed by environmental pollution (49.3%) and climate change (47.0%). Chinese respondents are more interested in environmental pollution (47.6%), new scientific discoveries (45.2%), and food security (45.2%). More than one out of two (51.5%) Indians expressed an interest in use of new technologies and inventions, followed by climate change (50.3%), and food security (49.7%). The Bumiputera group shows lower interest in the specific STI topics, with the most interest expressed in environmental pollution (41.4%), climate change (39.7%), and use of new technologies and inventions (37.9%). It can be seen that environmental pollution is of most concern for all ethnicities, except for Indians. All the races are homogenous in the topic of least interest where nuclear technology is ranked the highest in terms of having non-interested respondents (i.e., 35.9% of Malays, 30.5% of Chinese, 23.0% of Indians, and 45.7% of Other Bumiputera).

Source : Malaysian Science and Technology Information Centre (2020) Public Awareness
2019. Ministry of Science, Technology and Innovation. Draft Unpublished Report

