KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI
MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

NATIONAL SURVEY OF RESEARCH AND DEVELOPMENT (R&D) IN MALAYSIA 2016

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CONTENTS

PREFACE

Malaysia's R&D landscape has grown tremendously over the last decade. Malaysia has put serious efforts in improving its research, development and innovation activities. As a result, Malaysia has managed to stand at par with many developed countries with regard to its competitiveness through adopting science and technology policies and taking significant actions to increase the research and development infrastructure in the past decades. The country has also witnessed a marked increase in a number of R&D activities.

In every cycle of Malaysia Plan, emphasis is given to R&D. During the Tenth Plan, series of actions to strengthen ecosystem were undertaken, among others include shaping a supportive ecosystem by creating enabling environment for stakeholders to carry out innovation activities, and providing funds for research development and commercialisation (R,D&C) initiatives. This is due to the fact that innovation is crucial for the development agenda to increase productivity and improve competitiveness into new wealth for the nation. For the Eleventh Plan, Malaysia has outlined series of efforts to be undertaken to translate innovation into new wealth for the nation. Strategies will be targeted at two levels - the enterprise and society with the aim of translating innovation to wealth. One of the measures of a developed country is the ability to produce quality research that can benefit the entire nation and improve the national gross domestic product. This is what the National Survey of R&D seeks to measure and the survey has been conducted by the Malaysian Science and Technology Information Centre (MASTIC) since 1994.

The National Survey of R&D 2016 was based on the financial year of 2015 unless specified otherwise. The data was collected between 2015 and 2016 utilizing both primary and secondary data. The survey comprised of Business Enterprises (BEs), Higher Learning Institutions (HLIs) and Government and Research Institutes (GRIs). Unfortunately, no Non-Governmental Organisations (NGOs) were included in the survey as they did not conduct R&D based on the parameters of Frascati Manual, 2015.

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Under-Secretary
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EXECUTIVE SUMMARY

This report will present the findings, analysis and interpretation of the analysed data for the three sectors target in the study.

The National Survey of Research and Development (R&D) 2016 highlights the performance of R&D activities in Malaysia for financial year 2015. National Survey of R&D 2016 was conducted through face to face, mail and email with additional BEs from two databases. Participating Business Enterprises (BEs), Higher Learning Institutions (HLIs) and Government Agencies and Research Institutes (GRIs) submitted their data via the three methods mentioned which was administered by a team of consultant from International Islamic University Malaysia (IIUM).

This overview highlights the development of R&D over the years with respect to Gross Expenditure (GERD), Field of Research (FOR), Socio-Economic Objectives (SEO), Sources of Funds, Human Resource Development and Research Output. In addition, the National Survey of R&D 2016 also solicited feedback from the BEs, HLIs and GRIs on the location of their R&D activities, outsourced R&D expenditure within and outside Malaysia as well as internal and external factors limiting their R&D activities. This survey serves as an important tool to gather data from BEs, HLIs and GRIs to be used for informed decision-making, particularly regarding policies, action plans and implementation strategies to address challenges for R&D in Malaysia.

A total 2,399 respondents were included in this survey comprising 2,021 Business Enterprises (BEs), 109 Higher Learning Institutions (HLIs), and 269 Government Agencies and Research Institutes (GRIs). A total of 23 Non-Governmental Organisations (NGOs) were invited to participate. However, they did not conduct R&D, and therefore were not included in the survey. The response rate for BEs, HLIs and GRIs in the survey were 25.73%, 100%, and 100% respectively.

The National Survey of R&D 2016 (financial year 2015) finds overall increase in the expenditures and headcounts, but decreases in research output. Gross Expenditures on Research and Development has been increasing gradually from RM6,071 million in 2008 to RM15,058 million in 2015. This can be translated into an average annual growth of 13.85% per year. In terms of percentage of GDP, GERD also records a gradual increment from 0.79% in 2008 to 1.30% in 2015.

Internationally, Malaysia's GERD of USD3,855.59 million placed it at the 30th out of 63 countries in the IMD world ranking in comparison to USA which was ranked first with GERD of USD502,893.00 million. Malaysia's GERD per GDP for 2015 was ranked 29th with 1.30%. The highest GERD per GDP was charted by Israel with 4.25%, and followed by the Republic of Korea with 4.22%. Other countries that recorded relatively high GERD per GDP above 3.00% were Japan (3.29%), Sweden (3.26%), Austria (3.07%), and Taiwan (3.05%).

In past surveys, BEs had contributed most towards R&D expenditure, and were the main driving force of economic growth. In 2014, BEs contributed RM6,379 million (45.66%) to GERD. In 2015, BEs contributions increased about RM1,444 million compared to 2014 and contributes 51.95% of the share to GERD. HLIs contributions have a decreasing trend with 46.13% in 2014 to only 24.48% in 2015. GRIs have become the third contributors with 19.57% in 2015 compared to just 8.21% in 2014. Sources of funds coming from BEs for R&D activities have shown an increment from 25.23% in 2014 to 49.60% in 2015. Likewise, funding by the Government significantly decreased from 44.96% to 35.77%.

Funding from other sources also decrease from 29.81% to 14.63% in 2015 compared to 2014.

R&D expenditure in terms of type of research was dominated by applied research (70.48%), basic research (20.94%) and experimental development research (8.58%). However, the contribution of applied research decreased to 70.48% from 75.53% compared to 2014. In contrast, basic research contribution increased to 20.94% from 16.93% and experimental development research also increased to 8.58% in 2015 from 7.54% in 2014.

In terms of the field of research for 2015, Information, Computer and Communication Technology contributed the most with 42.40%, followed by Engineering and Technology (19.84%) and Natural Sciences (10.74%). The other fields with significant contributions include Medical and Health Sciences (8.01%), Agriculture and Forestry (7.40%), Social Sciences (4.77%) and Biotechnology (3.73%). Whereas Economics, Business & Management and Humanities contributed together with just 3.11%.

There was a steady increment in R&D personnel, from 40,840 in 2008 to 136,683 in 2015. The total number of R&D personnel increases by 19.33% from 114,539 in 2014, to 136,683 in 2015. The breakdown of researchers by qualifications shows a decrease by 43.27% for Master holders and an increase of 122.80% for Bachelor's degree holders compared to 2014. The number of PhD researchers has increased by 33.10%, whereas Non-Degree/Diploma holders has decreased by 16.04%. These figures do not include 5,147 researchers whose qualifications are not specified in the completed questionnaires. Number of researchers by gender shows that female participation in R&D has steadily increased from 2008 through 2015. However, the proportion of female to male researchers has decreased marginally over the last two years with 48.78% in 2014 and 47.76% in 2015.

Internationally, Malaysia has experienced steady increment in terms of headcount of researchers. In 2014, Malaysia's headcount of researcher increased from 75,257 in 2012 to 84,516 in 2014. In 2015, total headcount of researchers further increased to 89,861. The headcount of researchers per 10,000 labour force also increases 60.66 in 2014 to 61.88 in 2015. In terms of R&D manpower, the total full time equivalent of R&D personnel increased from 22,287 in 2008 to 82,360 in 2015. For FTE per 1,000 people, in 2015, FTE R&D personnel per 1,000 people was 2.64. Female researchers headcount in the 2015, was 47.76%.

In terms of R&D outputs, 2015 demonstrated downward trends in relation to publications. The number of publications had fallen from 71,121 to 58,962 by a hopping 17.10%. In consequence, the sub-categories like Indexed Journal publications, Conference Proceedings and Books record decreased with 25.42%, 34.50% and 48.63%, respectively. Only the Non-indexed publications had increased (9.48%). The publications under Books Chapter (2,886) category remained unchanged in 2015 compared to 2014. Patents Awarded drops from 745 in 2014 to 388 in 2015. Similarly, Trademarks also decreased from 738 in 2014 to 390 in 2015. 143 number of Industrial Design had made in 2015 which is lesser than the number (183) in 2014.

BEs faced some unique problems in applying R&D incentives for their companies. Among the problems are no information is accessible on the available incentives, the definition of the R&D for the incentives is not clear, application procedures are not clear and interview panel is slow to approve the application. Among the reasons for BEs not taking advantage of R&D incentives offered by the government are lack of awareness of the availability of the incentives, and no knowledge about incentives application.

BEs, HLIs and GRIs were asked about R&D location and project outsourced, as well as internal and external factors limiting R&D. A majority of R&D projects of BEs, HLIs and GRIs are located in Selangor, Pulau Pinang and Federal Territory of Kuala Lumpur. A few BEs indicated that they also conducted R&D outside Malaysia, such as Germany, India, China, Thailand, Japan and United Kingdom. Among the reasons for outsourcing are lacking of facilities and equipment to conduct R&D activities.

The three sectors were asked for the internal and external factors limiting the R&D activities. BEs do not face serious internal factors limiting their R&D activities. Some of the external factors limiting the R&D activities are an increased capital costs, insufficient government funding, lack of R&D personnel with requisite expertise, and lack of support services for R&D. For GRI, the top three internal factors limiting R&D activities are limited financial resource, limited time to dedicate to R&D work, and poor reward system for R&D. As for external factors, the GRIs highlighted increasing capital costs, insufficient government funding and lack of R&D personnel with the requisite expertise. Similarly for HLI, the top three internal factors limiting R&D activities are limited financial resource, limited time to dedicate to R&D work, and lack of infrastructure. For external factors that limit the R&D activities are increasing capital costs, insufficient government funding and poor physical infrastructure to support R&D.

In conclusion, the National Survey of R&D 2016 finds overall increase in the expenditures and headcounts, but decreases in research output. Based on a trend analysis of GERD per GDP since year 2000, Malaysia could only achieve 1.84% GERD per GDP in year 2020, which is far from the target 2.0% in the NPSTI 2013-2020 (Malaysia, 2013). The R&D survey for financial year 2015 shown that Malaysia's performance in global R&D arena needs improvement especially in GERD and BERD.

KEY INDICATORS OF R&D ACTIVITIES IN MALAYSIA, 2008-2015

Year	2008	2010	2012	2014	2015
Labour Force (Million)	11.03	12.30	13.12	13.93	14.52
Total Population (Million)	27.60	28.60	29.30	30.60	31.20
GDP (RM Million) – Based on Current Price	769,949	795,037	941,237	1,106,580	1,157,139
OVERVIEW OF NATIONAL SURVEY OF R&D					
ORGANISATIONS SURVEYED WITH R&D	**2008**	**2010**	**2012**	**2014**	**2015**
Business Enterprise (BEs)	944	1,171	1,234	1,338	1,407
Higher Learning Institutions (HLIs)	37	39	49	58	74
Government Agencies and Research Institutes (GRIs)	52	34	44	62	78
Non-Government Organisations (NGOs)	N/A	N/A	1	0	0
TOTAL	**1,033**	**1,244**	**1,328**	**1,458**	**1,559**
GROSS EXPENDITURE ON R&D (GERD) (RM Million)	**6,070.80**	**8,510.70**	**10,612.81**	**13,971.56**	**15,058.34**
Current Expenditure (RM Million)	5,134.10	6,732.50	8,559.48	10,265.07	12,340.15
Capital Expenditure (RM Million)	936.70	1,778.20	2,053.33	3,706.49	2,718.19
Percentage of GERD/GDP (%)	0.79	1.07	1.13	1.26	1.30
Percentage of BERD (%)	70.49	64.99	64.45	45.66	51.95

HUMAN RESOURCE IN R&D	2008	2010	2012	2014	2015
Total Headcount of R&D Personnel	40,840	88,314	103,986	114,539	136,683
Total Headcount of Researchers	31,442	67,412	75,257	84,516	89,861
Total Headcount of Technicians and Support Staff	9,398	20,902	28,729	30,023	46,822
Total FTE of R&D Personnel	22,287	50,484	62,807	75,062	82,360
Total FTE of Researchers	16,345	41,253	52,052	61,351	69,864
FTE per R&D Personnel	0.55	0.57	0.60	0.66	0.60
FTE per Researcher	0.52	0.61	0.69	0.73	0.77
Headcount of Researchers per 10,000 Labour Force	28.50	55.40	57.45	60.66	61.88

N/A – Not Available

FIELD OF RESEARCH AND SOCIO-ECONOMIC OBJECTIVE	2010	2012	2014	2015
Three Main Field of Research (FOR)	1. Information, Computer and Communication Technology (45.50%)	1. Engineering and Technology (33.65%)	1. Information, Computer and Communication Technology (39.04%)	1. Information, Computer and Communication Technology (42.40%)
	2. Engineering and Technology (27.60%)	2. Natural Sciences (25.63%)	2. Engineering and Technology (24.48%)	2. Engineering and Technology (19.84%)
	3. Biotechnology (6.60%)	3. Information, Computer and Communication Technology (10.79%)	3. Natural Sciences (8.19%)	3. Natural Sciences (10.74%)
Three Main Field Socio-Economic Objectives (SEO)	1. Sustainable Economic Development (36.20%)	1. Sustainable Economic Development (49.61%)	1. Sustainable Economic Development (31.35%)	1. Sustainable Economic Development (35.59%)
	2. Advanced Experimental and Applied Science (18.80%)	2. Advanced Experimental and Applied Science (17.68%)	2. Advanced Experimental and Applied Science (29.41%)	2. Society (19.94%)
	3. Advancement of Knowledge (18.10%)	3. Advancement of Knowledge (16.79%)	3. Society (20.49%)	3. Advanced Experimental and Applied Science (19.06%)

R&D IN BUSINESS ENTERPRISES

YEAR	2008	2010	2012	2014	2015
Total R&D Expenditure (RM Million)	4,279.40	5,531.50	6,839.67	6,379.09	7,823.54
Current Expenditure (RM Million)	3,586.80	4,304.00	5,416.60	5,405.47	6,234.68
Capital Expenditure (RM Million)	692.60	1,227.50	1,423.07	973.62	1,588.86
HUMAN RESOURCE IN R&D	**2008**	**2010**	**2012**	**2014**	**2015**
Headcount of R&D Personnel	6,166	9,858	11,724	10,952	14,621
Headcount of Researchers	3,661	5,741	6,247	6,581	9,849
Headcount of Technicians and Support Staff	2,505	4,117	5,477	4,371	4,772
FTE of R&D Personnel	5,575.70	9,117.57	10,170.73	9,793.25	11,015.44
FTE of Researchers	3,320.70	5,477.62	5,596.36	6,289.62	8,613.71
FTE per R&D Personnel	0.90	0.92	0.87	0.89	0.75
FTE per Researcher	0.91	0.95	0.90	0.96	0.87

FIELD OF RESEARCH AND SOCIO-ECONOMIC OBJECTIVE	2010	2012	2014	2015
Three Main Field of Research (FOR)	1. Information, Computer and Communication Technology (66.60%)	1. Engineering and Technology (34.88%)	1. Information, Computer and Communication Technology (75.18%)	1. Information, Computer and Communication Technology (76.60%)
	2. Engineering and Technology (23.40%)	2. Natural Sciences (29.07%)	2. Engineering and Technology (16.49%)	2. Engineering and Technology (17.38%)
	3. Biotechnology (6.70%)	3. Information, Computer and Communication Technology (12.79%)	3. Biotechnology (6.26%)	3. Biotechnology (2.92%)
Three Main Field Socio Economic Objectives (SEO)	1. Sustainable Economic Development (36.10%)	1. Sustainable Economic Development (62.30%)	1. Sustainable Economic Development (43.70%)	1. Sustainable Economic Development (43.07%)
	2. Advanced Experimental and Applied Science (23.50%)	2. Advancement of Knowledge (13.20%)	2. Society (18.96%)	2. Society (18.17%)
	3. Environment (15.00%)	3. Environment (13.20%)	3. Advanced Experimental and Applied Science (15.49%)	3. Advancement of Knowledge (16.70%)

R&D IN HIGHER LEARNING INSTITUTIONS

YEAR	2008	2010	2012	2014	2015
Total R&D Expenditure (RM Million)	1,188.30	2,464.40	3,042.28	6,445.48	4,288.84
Current Expenditure (RM Million)	1,077.80	2,093.80	2,544.12	3,943.27	3,483.35
Capital Expenditure (RM Million)	110.50	370.60	498.16	2,502.21	805.49
HUMAN RESOURCE IN R&D	**2008**	**2010**	**2012**	**2014**	**2015**
Headcount of R&D Personnel	28,775	71,579	83,919	92,975	103,045
Headcount of Researchers	24,131	58,699	64,962	73,385	73,291
Headcount of Technicians and Support Staff	4,644	12,880	18,957	19,590	29,754
FTE of R&D Personnel	13,702.50	37,251.45	46,700.09	56,906.56	62,164.79
FTE of Researchers	11,457.60	33,372.75	42,919.60	51,097.26	54,529.29
FTE per R&D Personnel	0.39	0.52	0.56	0.61	0.60
FTE per Researcher	0.47	0.57	0.66	0.70	0.74

FIELD OF RESEARCH AND SOCIO-ECONOMIC OBJECTIVE	2010	2012	2014	2015
Three Main Field of Research (FOR)	1. Engineering and Technology (40.70%)	1. Engineering and Technology (37.38%)	1. Engineering and Technology (32.94%)	1. Engineering and Technology (29.74%)
	2. Natural Sciences (15.20%)	2. Natural Sciences (17.29%)	2. Natural Sciences (16.12%)	2. Natural Sciences (17.34%)
	3. Medical & Health Sciences (11.90%)	3. Social Science (9.58%)	3. Social Science (11.45%)	3. Medical & Health Sciences (13.86%)
Three Main Field Socio-Economic Objectives (SEO)	1. Sustainable Economic Development (29.40%)	1. Sustainable Economic Development (26.28%)	1. Advanced Experimental and Applied Science (43.71%)	1. Advanced Experimental and Applied Science (34.39%)
	2. Advanced Experimental and Applied Science (28.80%)	2. Advanced Experimental and Applied Science (25.94%)	2. Society (24.13%)	2. Society (21.53%)
	3. Society (23.90%)	3. Advancement of Knowledge (25.26%)	3. Sustainable Economic Development (18.20%)	3. Sustainable Economic Development (17.64%)

R&D IN GOVERNMENT AGENCIES AND RESEARCH INSTITUTES

YEAR	2008	2010	2012	2014	2015
Total R&D Expenditure (RM Million)	603.10	514.80	729.96	1,146.99	2,945.96
Current Expenditure (RM Million)	469.50	334.70	597.95	916.33	2,622.12
Capital Expenditure (RM Million)	133.60	180.10	132.01	230.66	323.84
HUMAN RESOURCE IN R&D	**2008**	**2010**	**2012**	**2014**	**2015**
Headcount of R&D Personnel	5,899	6,877	8,339	10,612	19,017
Headcount of Researchers	3,650	2,972	4,045	4,550	6,721
Headcount of Technicians and Support Staff	2,249	3,905	4,294	6,062	12,296
FTE of R&D Personnel	3,009.09	4,114.96	5,932.19	8,362.16	9,180.10
FTE of Researchers	1,566.23	2,403.00	3,533.49	3,964.12	6,721.00
FTE per R&D Personnel	0.51	0.60	0.71	0.79	0.48
FTE per Researcher	0.43	0.81	0.87	0.87	1.00

FIELD OF RESEARCH AND SOCIO-ECONOMIC OBJECTIVE	2010	2012	2014	2015
Three Main Field of Research (FOR)	1. Agriculture and Forestry (44.90%)	1. Natural Sciences (28.15%)	1. Agriculture and Forestry (39.33%)	1. Agriculture and Forestry (25.00%)
	2. Natural Sciences (15.70%)	2. Biotechnology (27.39%)	2. Engineering and Technology (21.39%)	2. Natural Sciences (23.97%)
	3. Biotechnology (14.30%)	3. Agriculture and Forestry (26.31%)	3. Information, Computer and Communication Technology (13.76%)	3. Medical and health sciences (20.00%)
Three Main Field Socio-Economic Objectives (SEO)	1. Sustainable Economic Development (69.70%)	1. Sustainable Economic Development (27.98%)	1. Sustainable Economic Development (36.56%)	1. Sustainable Economic Development (41.84%)
	2. Society (13.90%)	2. Advanced Experimental and Applied Science (25.08%)	2. Advanced Experimental and Applied Science (26.56%)	2. Society (22.31%)
	3. Advancement of Knowledge (7.50%)	3. Environment (19.12%)	3. Environment (16.73%)	3. Environment (11.60%)

LIST OF FIGURES

LIST OF TABLES

LIST OF ARTICLE BOXES

INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1 Introduction

Globalisation and rapid economic growth in this recent age has made it compelling if not a necessity for nations, organisations, institutes and other bodies to pay more attention on the field of research and development, and innovation. Research and Development (R&D) in a practical sense is the act of investigating and researching that are conducted by businesses or organisations with the intention of making new discoveries or findings in order to improve existing products, procedures, information and knowledge, policies, regulations and many more. Through research and development, innovations and novel ideas are propelled and encouraged by developing new products, processes or information hence leading to improvement and future economic growth. It is important to note that research and development is not constrained only for large commercial businesses or companies but it also refers to governmental bodies, institutions and also including academic activities designed to gather new knowledge.

Malaysia, being one of the most developing nations in South East Asia, is also putting more and more emphasis into the area of research and development, and innovation. In order to remain competitive, Malaysia needs to constantly generate and establish new sources of economic growth. This objective can be achieved if Malaysia is capable of increasing its capacity in the use as well as in the development of science, technology and innovation (STI) through research and development (R&D) programmes. It is through technology, for instance, that our local enterprises can achieve a higher level of efficiency that will enable them to compete internationally. Moreover studies have shown that one of the major factors for economic development and particularly for the success of industrialisation process is the attainment of confidence and competence in STI. Advancement of scientific and technological development is a key strategic factor to build capability in technology. Strengthening technological capability has been seen as a crucial element in enhancing a country's productivity and at the same time to stay competitive.

Malaysian government has come up with multiple policies and plans in order to achieve the national’s vision of heading towards becoming a high-income nation by 2020 which include the need of an all-inclusive and sustainable economy. The goal is to establish a progressive and forward-looking society, one that is scientific and innovative. Thus, the Malaysian government is committed to harnessing, utilising and advancing research, science and technology in pursuit of its national development agenda. R&D programmes can generate knowledge spillovers and then contribute to technological progress and eventually productivity and economic growth.

Developing a country with strong science and technology background requires heavy investment in R&D activities. The First National Science and Technology Policy (1986-1989), the Industrial Technology Development: A National Action Plan (1990-2001), The Second National Science and Technology Policy and Plan of Action (2001-2010), and the Third National Science, Technology and Innovation Policy (2013-2020) have formulated and implemented various initiatives and programs to enhance the national capabilities and capacities of research and innovation (R&I), to forge partnerships between publicly funded research organisations and industries, to enhance commercialisation of research outputs, and to develop new knowledge based industries (Olsson and Meek, 2012). Overall, R&D in Malaysia has shown positive progress since it was announced during the Fifth Malaysian Plan (1986-1990).

It is clear that the need and necessity of research and development and innovation in all fields is being given high importance and regarded highly from the perspective of Malaysia as an economically growing and developing nation. However, gaps and area of improvements remain still in terms of executions and opportunities. The attempt and effort given in order to raise the importance of research and development is also fairly recent being less than 30 years back since the first establishment of formal policies and plans, thus, might be seen as rudimentary or reaching only the early stages. Therefore, the R&D activities and achievement in the country are monitored systematically through annual national survey.

The National Survey of Research and Development (R&D) 2016 is a continuation of a series of survey that has been conducted since 1994. The survey aims to measure and monitor the achievement of R&D activities conducted by Business Enterprises (BEs), Higher Learning Institutions (HLIs), Government Agencies and Research Institutes (GRIs) in Malaysia. For 2016 survey, the measurement used is based on Frascati Manual 2015.

The data and information regarding R&D activities collected in the present survey are for the Financial Year 2015. The format of the survey follows the international standards of Frascati Manual 2015 (OECD, 2015). This survey is an effort to validate the effectiveness of relevant policies to strengthen STI agenda that had been put in place starting from the First National Science and Technology Policy (NSTP1; 1986-1989), the National Action Plan on Industrial Technology Development (1990-2001) and the National Policy on Science, Technology and Innovation (NPSTI; 2013-2020). This survey would serve as an important tool to gather data from the recipients of R&D grants as well as all players in the R&D landscape of the nation. The data gathered from this survey would be useful for informed decision-making particularly regarding policies, action plans and implementation strategies to address challenges in the R&D arena.

In this survey, the previous instrument was reviewed to reflect the changes in the light of Frascati Manual of 2015.

1.2 Objectives

The objectives of the present survey are:

i. To acquire statistics and key information regarding the national status, growth and transformation trends in R&D activities of the country comprehensively.

ii. To analyse the trends of national R&D expenditure from 2008 to 2015 in order to perceive the attainable progression in the R&D field.

iii. To identify the sources of endowment of R&D activities to recognise the government's role in enliven national R&D activities.

iv. To analyse the data and trends of human resources involved in R&D activities and analyse the causes of these changes.

v. To observe and analyse gaps that exist in R&D ecosystem including basic policy, financing and human capital.

vi. To articulate landscape / ecosystem of existing R&D funds and to examine the arising issues in relation to funds that are not optimised.

vii. To make a global comparison to observe the national R&D progress with other nations.

viii. To examine the annual allocation trends for R&D and to analyse the cause of upturn and reduction of R&D budgets in relevant organisations.

ix. To state the improvements in R&D activities based on government policies in order to increase the national R&D area in future.

x. To analyse the progress of the targets set in DSTIN to allow the achievement of the policy is to be calculated quantitatively; and

xi. To analyse the number of publications and intellectual property generated by the R&D activities carried out in 2015.

1.3 Scope of the Study

The scope of the present survey are as follows:

i. Using the Frascati Manual 2015 guidelines issued by the Organisation of Economic Cooperation and Development (OECD, 2015) as a reference to enable international comparisons.

ii. Using documents of Malaysian Research and Development Classification System (MRDCS), 6th Edition to classify the areas of national R&D.

iii. Propose improvements to the existing questionnaires and use it upon approval by the Steering Committee or the Technical Committee or MASTIC. The data collection is carried out manually and use the online application developed by MASTIC for the process of data entry with input from consultants.

iv. Identify respondents who are known to have involved in R&D activities in addition to the list of respondents provided by Department of Statistics Malaysia (DOSM), Malaysian Investment Development Authority (MIDA) and MASTIC. This is to collect as much as possible of R&D data through the census.

v. Ensure BE sector includes Government Link Companies (GLCs), Multi-National Companies (MNCs) and private companies whereas NGOs sector must be established separately (if necessary).

vi. Collect data of R&D in public sector according to the calendar year (January to December 2015) and the business sector in the financial year (June 2015 - June 2016).

vii. Ensure high rate of response by using any initiatives such as the collection of data in bulk according to organization, top-down approach, workshops, field trips and other appropriate methods.

viii. Manually collect data using the survey form provided through post, fax, email and face-to-face interviews or over the phone and then enter the data into the standard Excel spreadsheet for the purpose of inventory.

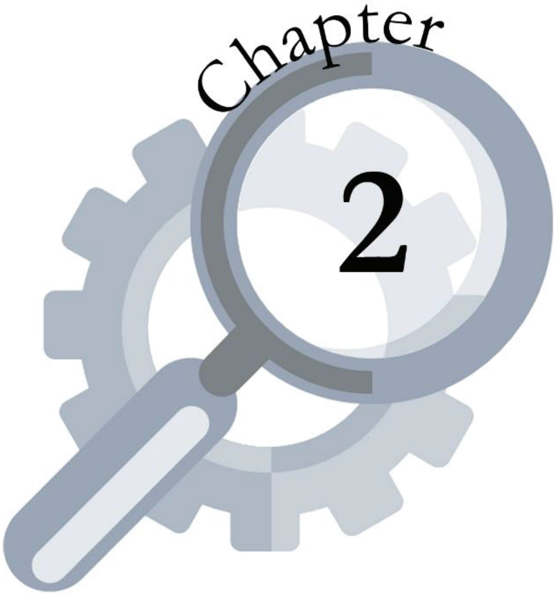
ix. Conduct a detailed analysis of the primary and secondary data from other sources in accordance with the objectives by using SPSS application or any application that is compatible with MASTIC approval.

x. Continuously validate and verify the quality of data reported by the respondents in order to fulfill the standards and requirements.

xi. Provide well-trained enumerators to do follow up, field work, visit and make Quality Assurance (QA) in order to get feedback from all respondents within the prescribed time.

1.4 Organisation of the Report

This report was organised into eight chapters. Chapter 1 is the introduction for the clarification of the report, followed by survey methodology for Chapter 2 , and along with overview of the R&D in Business Enterprise and Non-Governmental Organisations, Higher Learning Institutions and Government Agencies and Research Institutes for Chapter 3 to Chapter 6. International comparison was included to evaluate the R&D performance in Malaysia relative to other contries for Chapter 7. Finally, for Chapter 8, the report concluded with the recommendations.



SURVEY METHODOLOGY

CHAPTER 2: SURVEY METHODOLOGY

2.1 Introduction

This chapter discusses the methodology used to measure research and development (R&D) activity in Malaysia. It covers the description of the respondents or also known as institutions based on different sectors and the process involved in getting the data sample required. The steps taken throughout the process are guided by a technical document called Frascati Manual 2015 prepared by the Organisation for Economic Cooperation and Development (OECD). The objective is to standardise the process and analysis of the measurement that could serve as international mean to produce reliable statistical comparison of research and development (R&D) activities worldwide.

From the Frascati Manual 2015, R&D is defined as activities that,
"… *comprise creative and systematic works undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge*".

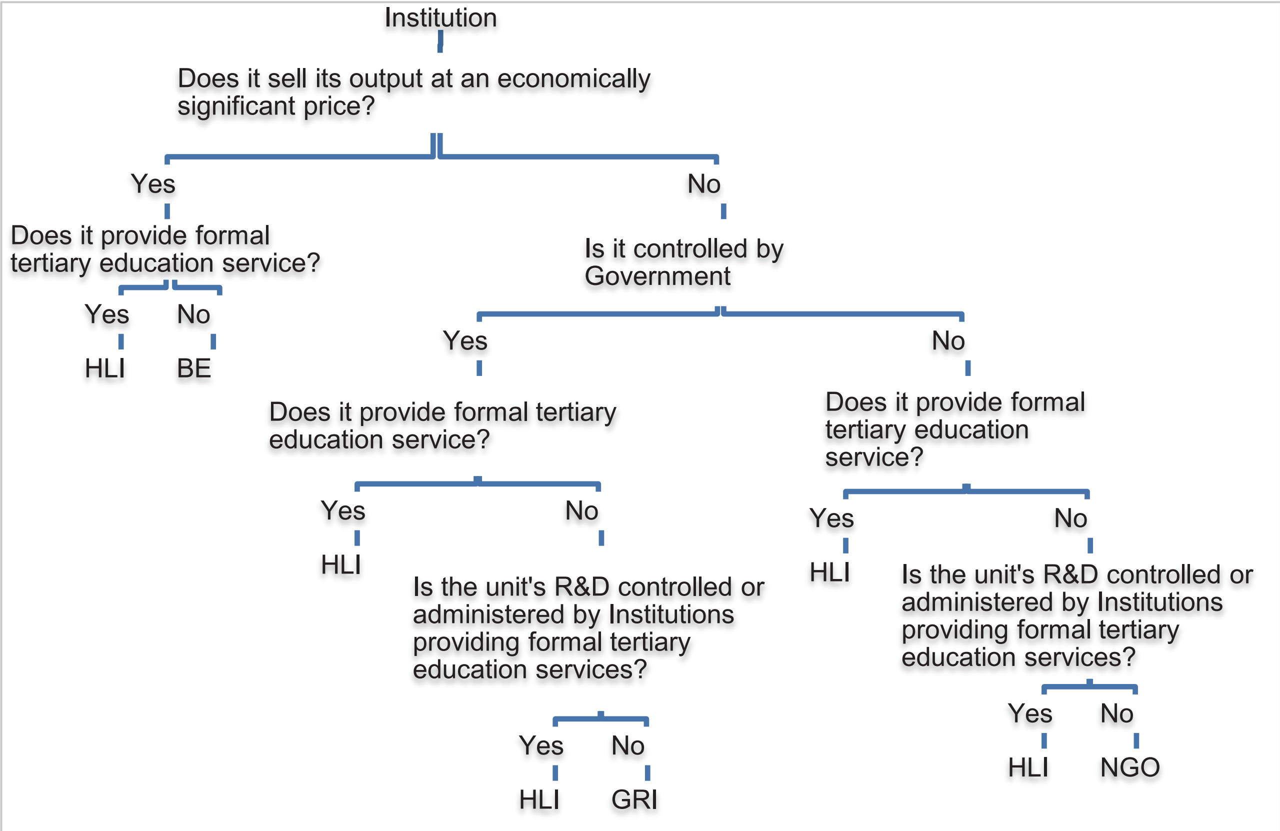
In general the method used to generate the measurement of R&D activities is based on quantitative approach where data are sampled directly from the institutions through a set of questionnaires in the survey form from three sectors, namely Business Enterprises (BEs) including Non-Government Organisations (NGOs), Higher Learning Institutions (HLIs), and Government Agencies and Research Institutes (GRIs). These are the three primary sources responsible to produce the data sample.

Trend analysis from the past 2008 to 2015 surveys is done to properly estimate the data sample from the institutions who failed to respond within the given time frame. Since the sample size is crucial to produce a good analysis on the data sample collected, several initiatives have been taken to ensure substantial number of responses of the survey form, such as follow-up calls, postal services, emails and site-visits.

2.2 Institutions by Sectors

The identification of institutions that are involved in the performing of R&D activities is fundamentally important to the process of data collection. Based on Frascati Manual 2015 interpretation, the institutions can be identified and classified into three main sectors that are Business Enterprises (BEs) including Non-Government Organisations (NGOs), Higher Learning Institutions (HLIs), and Government Agencies and Research Institutes (GRIs). The classification process is guided by a decision tree as shown in Figure 2.1. From this figure, it is clear that the definition of each of the three sectors can be derived.

Figure 2.1: Decision Tree for Institutions Classification (Frascati Manual 2015)



Note:
HLI: Higher Learning Institutions
BE: Business Enterprises
GRI: Government Agencies/Research Insitutes
NGO: Non-governmental organisations

2.2.1 Business Enterprises (BEs)

Based on Frascati Manual 2015, the BE sector comprises of firms, organisations and institutions whose primary activity is the market engagement of goods or services (other that HLIs) for sale to the general public at prices that are economically significant. It includes units capable of generating profit for their owners that are recognised by law as separate legal entities from their owners.

2.2.2 Higher Learning Institutions (HLIs)

Based on Frascati Manual 2015, the HLI sector comprises universities, college of technology and other institutions providing formal tertiary education programmes, regardless of their sources of finance or legal status as well as all research institutes, centers, experimental stations and clinics that have their R&D activities under the direct control of tertiary education institutions. University that sells their output at an economically significant price should still be categorised under HLI sector on the basis of their primary economic activity.

2.2.3 Government Agencies and Research Institutes (GRIs)

Based on Frascati Manual 2015, the GRI sector comprises of all government units including ministries, statutory boards, departments, offices and other bodies which furnish, but do not normally sell, the public common services which cannot otherwise be conveniently and economically provided. It also includes those that administer the states and the economic and social policy of the community. It does not include HLIs.

2.3 Survey Methodology

Proper planning with effective strategy is paramount in collecting the data sample through the survey exercise. This is to ensure the R&D activities are measured with full integrity following the guidelines prescribed in the Frascati Manual 2015. The data gathered should be able to represent the outlined indicators specified in the survey like the type of R&D expenditures and their sources of funds as well as the number and quality of research personnel to name a few. The method to conduct the survey is divided into different phases as shown in Figure 2.2.

2.3.1 Background Study and Planning

The first phase of the survey of R&D activities commenced with the reviewing process of previous relevant written reports on the topic. The process involved understanding all the aspects of the survey from Frascati Manual, 2015. The definition of variables or outlined indicators for the measurement of R&D activities was also clarified. This was particularly important to strategies the method to generate the required evidence to support the measured indicators.

During this phase the institutions were identified and classified into proper sectors as defined previously. The main list of the institutions under the three sectors namely BE, HLI and GRI was provided by MASTIC together with complementary list provided by Department of Statistics Malaysia (DOSM) for BE sector in particular.

The strategy to communicate with the institutions was detailed out so to identify different mechanisms to approach them based on the size of research activities including the research funding and research personnel involves in the R&D activities.

2.3.2 Questionnaires Development

Improvement on the questionnaire as the main tool to gather the data of R&D activities was a continuous process in enhancing the data sampled so the result could be used to support the generation of quality outlined indicators. This was to ensure the result to be consistent, if not better than the previous survey conducted. The phase was also important to introduce new questions to collect additional new data sample related to R&D activities.

The questionnaires in the survey comprised of six sections and tailored with two variations where the first variation was used to collect data for BE sector and the second was for HLI and GRI sectors. The difference behind the variation stemmed from the fact that some of the data variables were unique to the specific sector in terms of its objectives. Detailed survey guidelines with examples were provided as a reference to the institutions to respond to the survey with minimum hassle to understand the question requirements. The questionnaires were developed from the one used in the previous survey and enhanced based on the guideline specified in the latest version of Frascati Manual 2015. A new section was introduced to collect data sample on R&D projects outsourced and being outsourced including number of collaborative R&D projects conducted by the institutions. After a few series of discussions and revisions with MASTIC, the questionnaires were then presented to the Technical Committee meeting for comments before the final approval was given. Table 2.1 summarises the content of the questionnaires together with the major enhancements and additional questions.

Figure 2.2: Survey Process

Phase 1
Background study and planning

- Reviewing previous relevance written documentations
- Identify information required and evidence to support the outlined indicators
- Identify stakeholders
- Identify strategies to communicate with the stakeholders and the conduct of the survey

Phase 2
Questionnaire development

- Designing the survey questionnaires
- Preparing survey document
- Conducting consensus and statistical method
- Supervising site

Phase 3
Survey and data collection

- Contacting stakeholders
- Distributing and collecting data information
- Discuss preliminary findings and re-strategies if necessary

Phase 4
Data analysis

- Reception and storage of data information
- Input and verification of data
- Coding, tabulation and review

Phase 5
Report writing and dissemination

- Preparing report
- Disseminating report

Table 2.1: Content of Questionnaires

		Institutions	
Section	Type of data	HLI/GRI	BE/NGO
A. General information	Detailed of institutions	✓	✓*
B. R&D projects conducted	Field of Research (FOR)	✓	✓
	Socio-economic Objective (SEO)	✓	✓
	Type of research:		
	Basic research	✓	✓
	Applied research	✓	✓
	Experimental research	✓	✓
	Headcount/Fulltime equivalent(FTE)/Labour cost:		
	Researcher (Local/International)	✓	✓**
	Technician and support staff	✓	✓
	Headcount by age groups	✓ (new)	✓ (new)
	Headcount by R&D personnel flows	✓ (new)	✓ (new)
	Expenditure:		
	Current	✓	✓
	Capital	✓	✓
	Source of funds:		
	Government	✓	✓
	Business enterprise	✓	✓
	Institution own fund	✓	✓
	Foreign	✓	✓
	Location of R&D project	✓	✓
C. R&D Project(s) Outsourced, Being Outsourced and Collaborated Within/Outside Malaysia	R&D project outsourced:		
	Within Malaysia	✓	✓
	Outside Malaysia	✓	✓
	Reason of outsourcing	✓	✓
	R&D project being outsourced to institution:	✓ (new)	✓ (new)
	From BE and NGO	✓ (new)	✓ (new)
	From government agencies, HLI/GRI	✓ (new)	✓ (new)
	Number of Collaboration on R&D projects	✓ (new)	✓ (new)
D. R&D Output	Publication	✓	-
	Intellectual property (IP) and revenue	✓ (new)	✓ (new)
	Human capital	✓ (new)	-
E. Factors Limiting Organisation's R&D Activities	Factor limiting R&D activity	✓	✓
	Internal factors	✓	✓
	External factors	✓	✓
F. Suggestions		✓	✓

Note:
✓* - question for BE includes main activity in organisation, paid up capital, ownership, full time employee, gross sale, and parent organisation if any. The company registration number (SSM) is added as new field
✓**- students are not covered but replaced with special case such as volunteer

2.3.3 Survey and Data Collection

Data collection was a major phase in the survey process and the one which took the longest time to complete. The reliability of data sample must be ensured and the number of institutions to be surveyed must be enough and made random to guarantee no bias in the analysis towards final results and inferences. Nevertheless, a number of actions have been taken to further improve the data collection process within the time frame. This involved:

i. Fixing due dates for every process in data collection.
ii. Cleaning up of information on institution's person-in-charge (PIC) and address in which upon it, the institution was contacted to ensure they have completed the survey in the past years.
iii. Sending the questionnaire and guideline via normal postal service with an empty envelope for easy return of the document. Some of the institutions have requested for the questionnaire to be sent by email.
iv. Making a follow-up call to ask for any problem and coaxing the institution to respond before the given due date. This includes paying site visit to institution requesting for one.
v. Gradual meeting to look at the data from the institutions that have responded, and taking immediate course of actions if there was any problem arisen.
vi. Upon receiving the questionnaires from the institutions, an acknowledgement email is sent.

For BE sector in particular, the sheer numbers of institutions to be surveyed posed another challenge. In order to collect the data sample as random and independent, DOSM has determined and provided the list of institutions to be surveyed.

2.3.4 Data Analysis

The primary data was derived from the completed questionnaire and verified continuously for any outliers. In case of any ambiguity, the issue was fast referred to the PIC of the institution to get the clarification. For HLIs in particular, some data were referred to MyMoheS database particularly on the number of headcounts.

The data was then entered into a standard template based on Excel spreadsheet. It was important to make the template uniform for all data across sectors in order to standardise the format of the data sample. SPSS software package was then used to import and analyse the data.

2.3.5 Data Treatment

On top of data verification process applied to the primary data from the institutions surveyed, best estimate of data from unresponsive institutions known to conduct R&D activities were made statistically. Their previous surveyed data sample were studied and projected to estimate the 2015 data using statistical operator accordingly.

2.3.6 Report Writing and Dissemination

The report was prepared after the verification and approval of the survey data by MASTIC. The format of the report was consistent with the R&D reports from other countries. The report was then distributed to relevant stakeholders from various organisations.

2.4 Response from Institutions

The response from the Institutions surveyed has shown that the effectiveness of proper planning and the efficient execution of the strategy to collect and analyse the R&D data play an important role in producing the outline indicators of R&D activities from the survey exercise.

As the survey was conducted on the institutions which was categorised into three major sectors, the summary of the response including the sample size with the respective status is shown in Table 2.2. The response of each sector is described in subsequent sections and the analysis of these data are reported in Chapter 4, 5 and 6 respectively.

Table 2.2: Number of Response from Surveyed Institutions by Sector

Sectors	BEs	HLIs	GRIs
Number of samples	7,854	109	269
Institutions responded with R&D	1,407	74	78
Institutions responded without R&D	614	35	191
Total number of response	2,021	109	269
Response rate (%)	25.73%	100%	100%

2.4.1 Business Enterprise (BEs)

The involvement of BEs sector in the survey demonstrated great implication towards the performance of R&D activities in this country. This was due to the huge number of BEs participated and involved in generation of data sample in the survey. Hence, in analysing this sector, it was important to take into account the multiple approaches to get the data sample. Table 2.3 tabulated the characteristics of institutions that have responded to the National R&D survey from 2008 to 2015. It was noted that the response rate was showing a downward trend from 2012 survey. However, the total number of responses for 2015 R&D survey recorded a jump from 1,399 to 2,021 BEs responded as compared to the 2014 survey. The total number of BEs that conducted R&D activities from primary data has also shown a stark increase from 134 in 2014 survey to 1,407 for 2015 survey.

Table 2.3: Number of Response from BE in the National R&D survey, 2010-2015

Year	2010	2012	2014	2015
Number of BEs participated in the survey	2,038	2,142	3,552	7,854
Number of BEs that responded (primary)	1,313	1,437	1,399	2,021
Number of BEs that responded with R&D (primary)	1,171	1,234	134	1,407
Number of BEs that responded without R&D(primary)	142	203	132	614
Number of BEs in database (secondary)	-	-	2,425	-
Number of BEs that conducted R&D (secondary)	-	-	1,204	-
Number of BEs that did not conduct R&D (secondary)	-	-	1,221	-
Response rate (%)	64.43%	67.09%	39.39%	25.73%

2.4.2 Higher Learning Institutions (HLIs)

The HLI sector has been an important sector to contribute to the R&D activities in the country. This has been the result of efficient and effective R&D related policies adopted by the country tertiary education system in particular. For this sector a total number of institutions surveyed was 109, an increase of 45 institutions survey in the last survey exercise. Out of the total, 20 HLIs were public institutions and the remaining 89 were private institutions as tabulated in Table 2.4. The invitations were sent to all 109 HLIs with 100% response rate. It was also noted from the table, a gradual increase from 2008 survey on the number of HLIs that responded and involved in R&D activities where in 2015 survey, the number recorded was 74 institutions.

Table 2.4: Number of Response from HLIs in the National R&D survey, 2010-2015

Year	2010	2012	2014	2015
Number of HLIs participated in the survey	42	462	64	109
Number of HLIs that responded	40	444	64	109
Number of HLIs that responded with R&D	39	49	58	74
Number of HLIs that responded without R&D	1	395	6	35
Response rate (%)	95.24%	96.10%	100%	100%

2.4.3 Government Agencies and Research Institutes (GRIs)

The total number of GRIs involved in the survey was 269, a small decrease from 287 GRIs participated in 2014 survey as shown in Table 2.5. Invitations were sent to all the 269 GRIs and a 100% response rate was secured. Total number of GRIs that responded and involved in R&D activities has also increased to 78 GRIs in this survey as compared to only 62 GRIs in the last survey.

Table 2.5: Number of Response from GRIs in the National R&D survey, 2010-2015

Year	2010	2012	2014	2015
Number of GRIs participated in the survey	202	63	287	269
Number of GRIs that responded	196	63	161	269
Number of GRIs that responded with R&D	34	44	62	78
Number of GRIs that responded without R&D	162	19	99	191
Response rate (%)	97.03%	100%	56.09%	100%

2.5 Procedure to Increase Participation in the Survey

2.5.1 Follow-up Call

In order to increase the rate of response to the survey, follow-up call was identified as the most effective way to address the issue. The objective of the call serves mainly as a reminder of the due date of data submission and as a medium to explain and guide the institution on the proper way to answer the questionnaires.

2.5.2 Site Visits

From time to time a series of site visits especially to those R&D institutions which heavily involved in R&D activities and are large in size were conducted where appointments were made prior to the site visits. While visiting sites, the MASTIC's objectives of conducting the survey had been explained face-to-face.

2.5.3 Using Top-Down Approach for Companies

For BE sector in particular, the list of institutions was from various sources and agencies and included all companies that were in receipt of government grants such us the companies under the purview of Malaysia Bioeconomy Development Corporation (Bioeconomy Corp) and Malaysia Digital Economy Corporation (MDEC), as well as selected company provided by DOSM.

2.6 Reliability and Validity of R&D Data

The action to ensure the data sample collected from the survey to be reliable and valid was important and has to be done continuously and rigorously in order to produce the most accurate results. Thus, the following sections described the action taken to address the issue.

2.6.1 Understanding Research and Development Terms and Measurement

In responding to the survey, the institutions were expected to understand the questionnaire and be able to best respond to it. In order to achieve the objective, a properly written guideline was provided together with the questionnaire. The guideline was prepared and vetted by independent parties to ensure it is clear and easy to understand. Nevertheless, for some of the new institutions or new PIC of the institutions, the challenge to understand the R&D terms and measurement persist that required site visits, phone calls or emails to address the problem.

2.6.2 Accuracy and Consistency Check

For every set of questionnaires document received, the data sample was thoroughly checked in term of its completeness and consistencies. For incomplete data, the PIC of the respected institutions was contacted to complete the data submission. For data that was found to be inconsistence to each other, clarification would be obtained from the institution to fix the response before final data verification and approval were given by MASTIC.

2.7 Verification

2.7.1 Correction and Verification by Institutions

The data sample collected including the one after re-submission were verified before being submitted to MASTIC.

2.7.2 Institutional Level Verification

MASTIC as the owner of the National Survey of R&D 2016 has established a standard measure in checking the sample data collected and would only provide approval when the data is clean and free from inconsistency and ambiguity. The data that did not get the approval were verified again by the respective institutions.

2.7.3 Verification and Approval by MASTIC

MASTIC as the owner of the National Survey of R&D 2016 has established a standard measure in checking the sample data submitted by the consultants and would only provide approval when the data is clean and free from inconsistency and ambiguity. The data that did not get the approval had been returned to the consultants for another round of data verification process.

2.7.4 Verification and Approval by Technical Committee

The inception and final reports were submitted to the Technical Committee for verification and approval before submitting to the Steering Committee for endorsement.

2.7.5 Limitation of the Survey

1. As the rate of partipation of IHLs and GRIs recorded 100%, the rate of participation of BEs was not as high as the other two, as participation of BEs in this survey was on voluntary basis. Furthermore, some private business firms were reluctant to disclose their R&D activities, even though assurance of confidentiality of data was provided a priori. So, in the absence of data from all the BEs in Malaysia engaged in R&D activities, caution was exercised to generalise the findings on them.

2. After data collection and analysis for National R&D Survey for financial year 2015, it has been observed that certain statistical figures have significantly increased from the previous year, i.e., 2014. For example, the R&D expenditure for GRIs in 2014 was RM1,146.99 million, but in 2015 the amount increased to RM2,945.96 million, which is 156.84% increase compared to the previous year. The possible reasons for this increase have been provided. But in the questionnaires no specific question was asked regarding reasons for any increase or decrease of data across several years. Therefore, the actual reasons for increase of data from the viewpoint of the respondents are not available.

3. In all the three sectors, one common limiting factor for carrying out R&D activities is "limited time dedicated to R&D work". While this is understandable for BEs, but it is rather surprising for GRIs as GRIs researchers' main activities are to carrying out R&D related research. But no specific question was asked in the questionnaires regarding the reasons for having limited time, as the finding was noticed after data analysis.

OVERVIEW OF RESEARCH AND DEVELOPMENT (R&D) IN MALAYSIA

CHAPTER 3: OVERVIEW OF RESEARCH AND DEVELOPMENT (R&D) IN MALAYSIA

3.1 Introduction

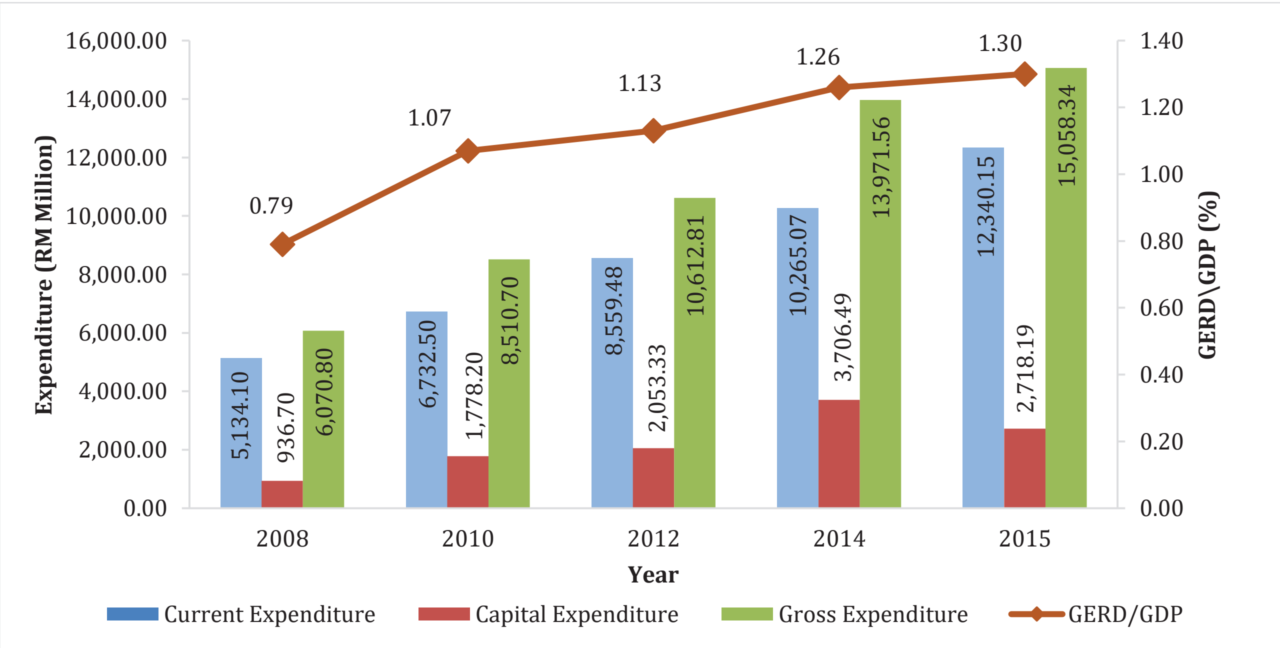
This chapter discusses and summarises the overview of research and development (R&D) achievements of three sectors in Malaysia namely, Business Enterprises (BEs), Higher Learning Institutions (HLIs) and Government Agencies and Research Institutes (GRIs) for the financial year of 2015. The discussion highlights developments in the national R&D activities in 2015 with respect to gross expenditure, research intensity, sources of funds, field of research (FOR) and socio-economic objectives (SEO), human resources, type of research, full-time equivalent (FTE), employees and research output in terms of publications and intellectual properties. A summary of R&D achievements of Malaysia in 2015 has been provided at the end of the chapter.

3.2 Gross Expenditure on Research and Development (GERD)

Gross Expenditure on Research and Development measures both current and capital expenditures in R&D, and is compared with the national GDP as one of the indicators for science and technology progress or development (The World Bank, 2016) in the country.

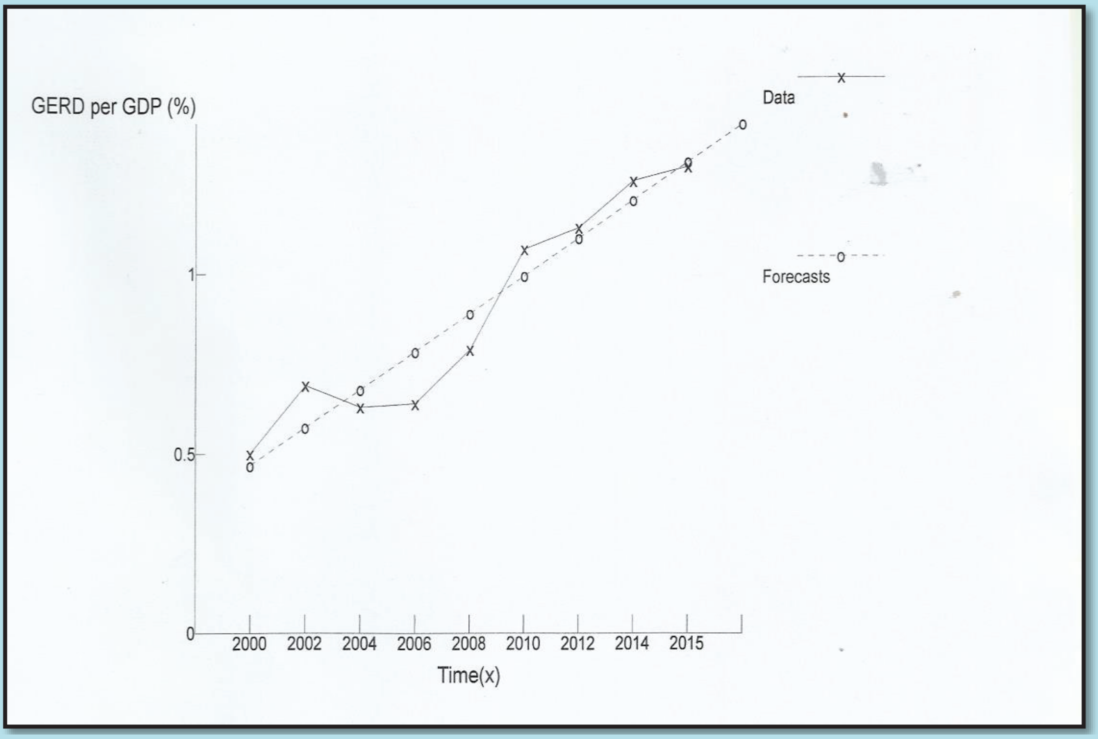
Over the last seven years, GERD has increased from RM6,071 million in 2008 to RM15,058 million in 2015 (Figure 3.1). This is reflected in the gradual increment of current expenditure (from RM5,134 million to RM12,340 million), and capital expenditure (from RM937 million to RM2,718 million) from 2008 to 2015. Therefore, as a percentage of GDP, GERD has increased from 0.79% in 2008 to 1.30% in 2015.

Figure 3.1: Gross Expenditure on Research and Development, 2008-2015



Box 3.1: GERD per GDP for 2020

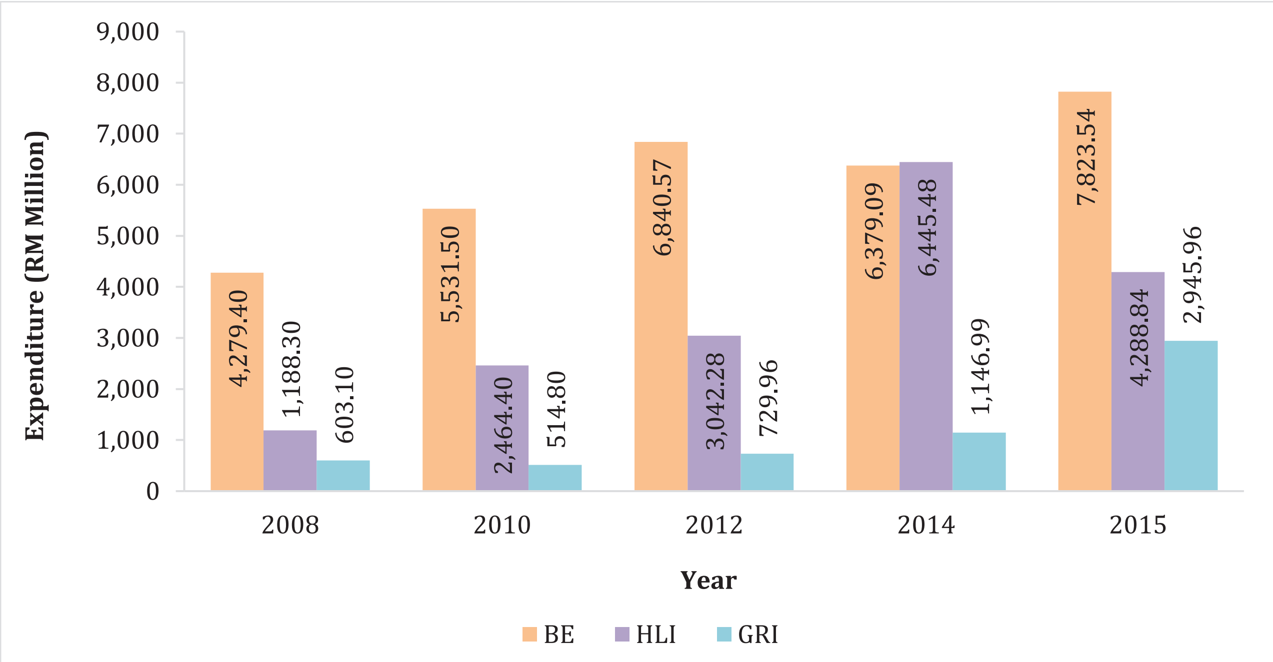
According to NSTPI (2013-2020), Malaysia is expected to achieve 2.00 for GERD per GDP by the year 2020. In order to ascertain the position of the country in achieving the target, a trend analysis has been performed using the data from 2000 until the year of the present survey, i.e., 2015. The results show that by 2020, Malaysia can achieve only 1.84 GERD per GDP. If the present rate of increase of GERD per GDP is maintained, then Malaysia can only achieve the target of 2.00 by another two years, i.e., 2022. Further, by 2030 Malaysia's GERD per GDP is expected to be 2.90. It is also noted that over the past several years, average increment of GERD per GDP is only 0.1057.



3.2.1 Expenditure by Sector

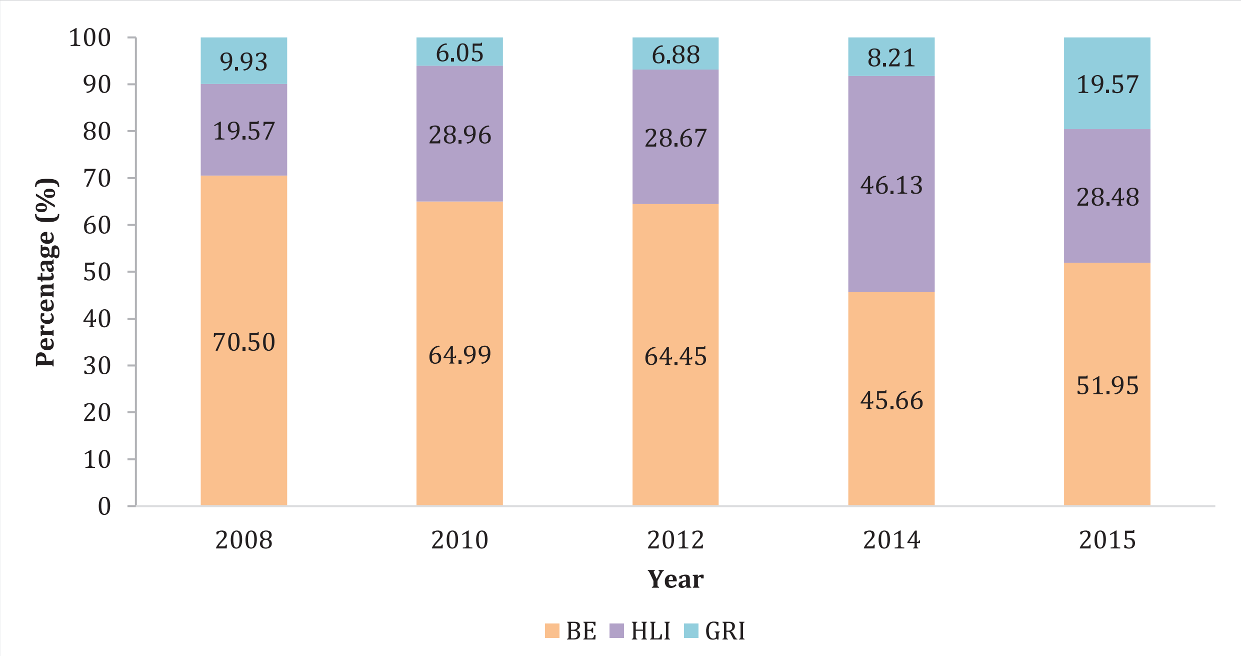
The year 2015 presents a different scenario in terms of expenditure as compared to previous years. As shown in Figure 3.2, in 2015 BEs contributed RM7,823.54 million which indicates an increase of RM1,444.45 million (22.64%) in BEs contributions compared to 2014 (RM6,379.09 million). Thus, it is a major contributor to GERD. However, HLIs contribution to GERD decreases 33.46% from RM6,445.48 million in 2014 to RM4,288.84 million in 2015. Meanwhile, GRIs contribution shows an increase from RM1,146.99 million (2014) to RM2,945.96 million (2015), the percentage of increase is 156.84%.

Figure 3.2: GERD by Sector, 2008-2015



In analysing GERD by sector, Figure 3.3 shows that BEs contributions have increased from 45.66% in 2014 to 51.95% in 2015. Likewise, GRIs contributions have also increased from 8.21% in 2014 to 19.57% in 2015. However, there was a significant drop of HLIs contributions from 46.13% in 2014 to 24.48% in 2015. A possible reason for this drop of R&D expenditures by HLIs could be the drop of country's economic growth from 6% (GDP-annual variation) to 5% (GDP-annual variation) which might have affected government spending especially on public universities. It is also observed that BEs contributions have been decreasing since 2008 until 2014 but again in 2015, the contributions have increased slightly.

Figure 3.3: GERD by Sector, 2008-2015 (Percentage)

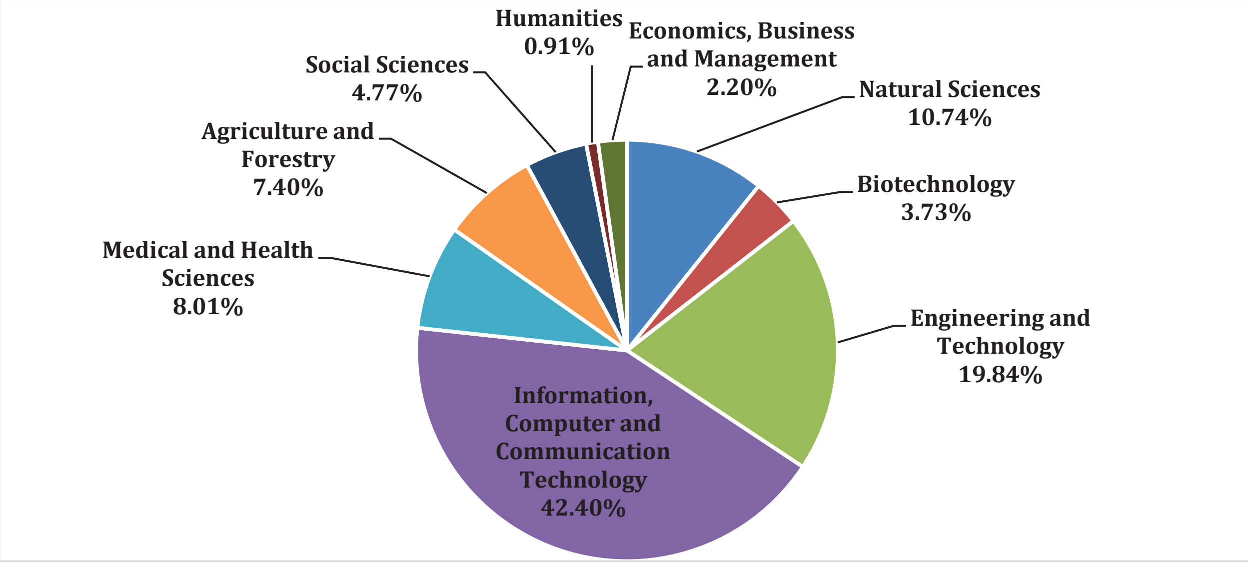


3.2.2 Expenditure by Field of Research (FOR) and Socio-Economic Objectives (SEO)

The R&D activities are classified into several Field of Research that comprise Information, Computer and Communication Technology; Engineering and Technology; Natural Sciences; Agriculture and Forestry; Biotechnology; Medical and Health Sciences; Social Sciences; Humanities; and Economics, Business and Management.

Figure 3.4 indicates the GERD distribution based on the Field of Research for 2015. Information, Computer and Communication Technology contributes the most with 42.40%, followed by Engineering and Technology (19.84%) and Natural Sciences (10.74%). The other fields with significant contributions include Medical and Health Sciences (8.01%), Agriculture and Forestry (7.40%), Social Sciences (4.77%) and Biotechnology (3.73%), whereas Economics, Business and Management and Humanities contribute together with just 3.11%.

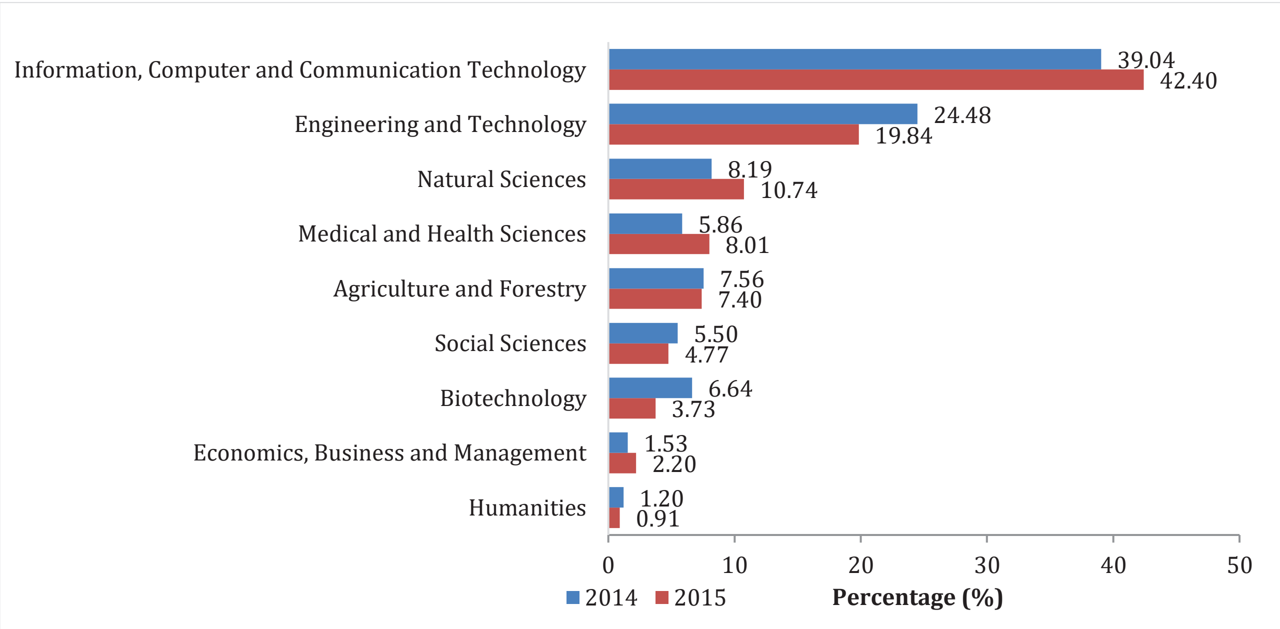
Figure 3.4: GERD by Field of Research, 2015



It is noted that there is an increasing contribution by ICT from 39.04% in 2014 to 42.40% in 2015 to GERD (Figure 3.5). On the other hand, the contributions of Engineering and Technology have dropped from 24.48% to 19.84% in the same period. The contribution of Natural Sciences and Medical and Health Sciences to GERD has slightly gone up from 8.19% to10.74% and 5.86% to 8.01%, respectively.

There is a significant reduction of expenditure in Biotechnology from 6.64% to 3.73%, however, Agriculture and Forestry contributes almost equally in 2014 (7.56%) and in 2015 (7.40%). Social Sciences records a decrease from 5.50% to 4.77%, whereas, the contribution of Economics, Business and Management and Humanities together has marginally increased from 2.73% to 3.11%.

Figure 3.5: GERD by Field of Research Comparison, 2014-2015



The Socio-Economic Objectives of R&D are categorised into six major groups namely Sustainable Economic Development, Advanced Experimental and Applied Science, Society, Advancement of Knowledge, Environment, and Defence and Security. Figure 3.6 indicates that the three main objectives of R&D activities are mainly focused on Sustainable Economic Development (35.59%), Society (19.94%) and Advanced Experimental and Applied Science (19.06%). Both Advancement of Knowledge and Environment also have a fair share contributing 15.01% and 8.27%, respectively, while Defence and Security only takes up 2.13% of the Socio-Economic objectives.

Figure 3.6: GERD by Socio-Economic Objectives, 2015

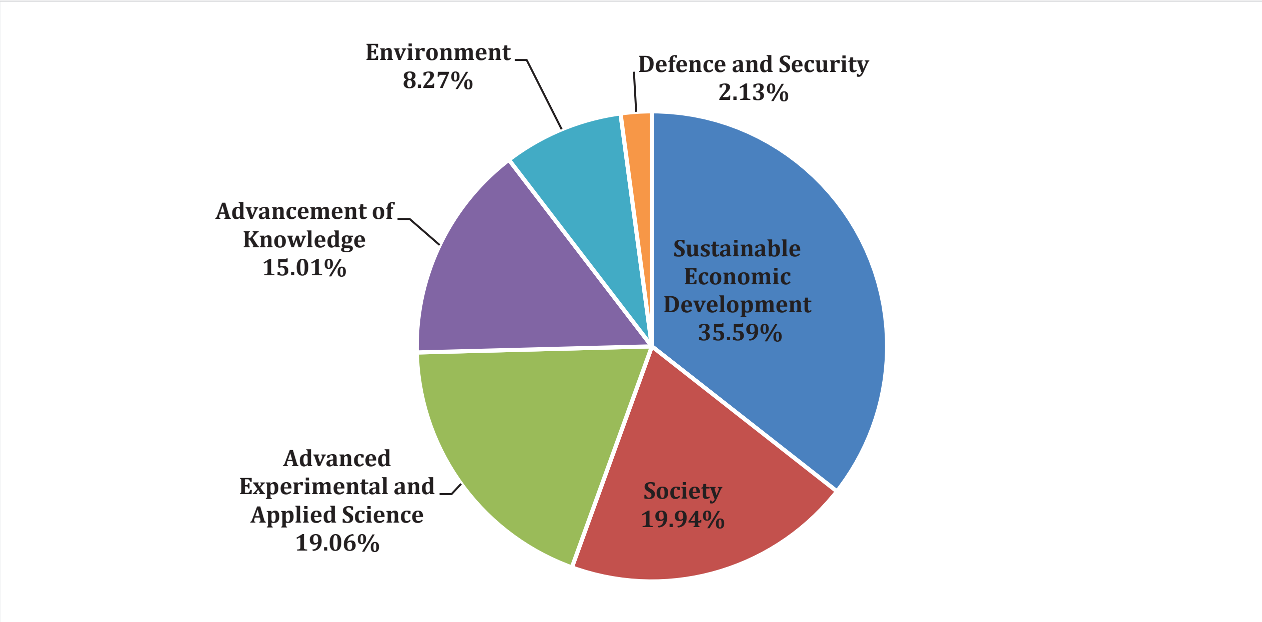
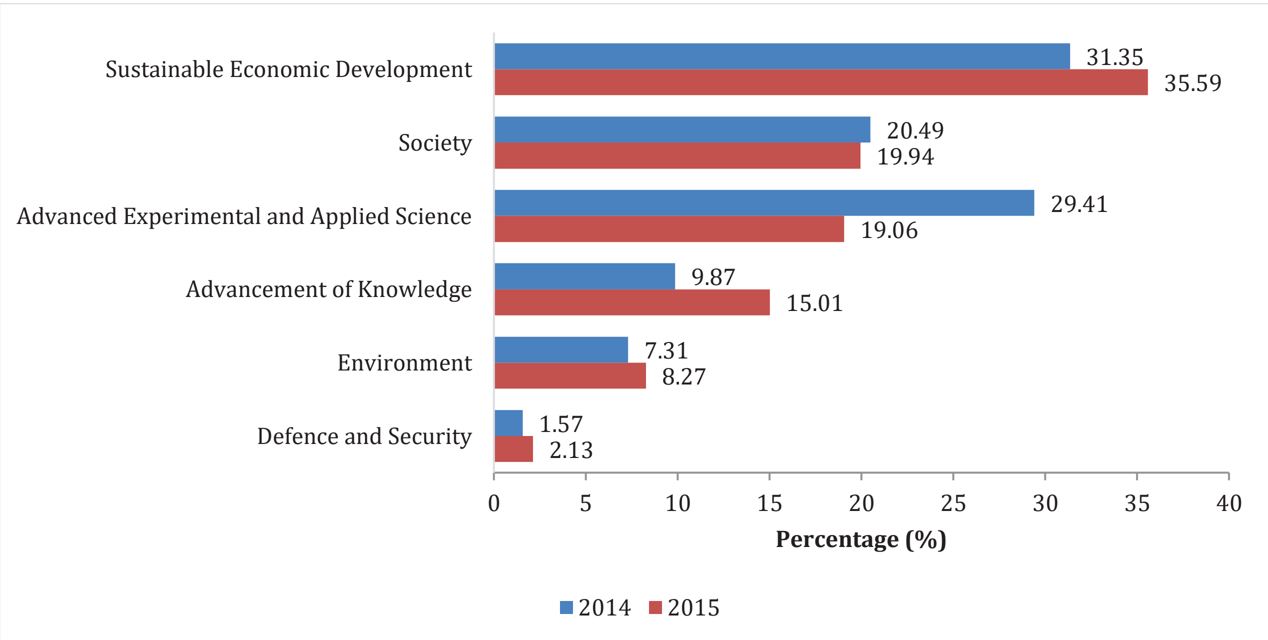


Figure 3.7: GERD by Socio-Economic Objectives Comparison, 2014-2015



The objective of R&D activities in 2015 has shifted significantly in 2015 in comparison with the previous survey in 2014. As shown in Figure 3.7, Advanced Experimental and Applied Science marks substantial decrease from 29.41% in 2014 to 19.06% in 2015. Likewise, Society also decreases from 20.49% to 19.94%. In contrast, Advancement of Knowledge and Sustainable Economic Development increased from 9.87% to 15.01% and 31.35% to 35.59%, respectively. Environment rose slightly from 7.31% to 8.27% as well as Defence and Security from 1.57% to 2.13% in 2015.

3.2.3 Expenditure by Type of Research

Applied research dominated the R&D activities in 2015 (Figure 3.8). However, the contribution of applied research decreased to 70.48% from 75.53% compared to 2014. In contrast, basic research contribution increased to 20.94% from 16.93% and experimental research also increases to 8.58% in 2015 from 7.54% in 2014.

Figure 3.8: GERD by Type of Research, 2014-2015

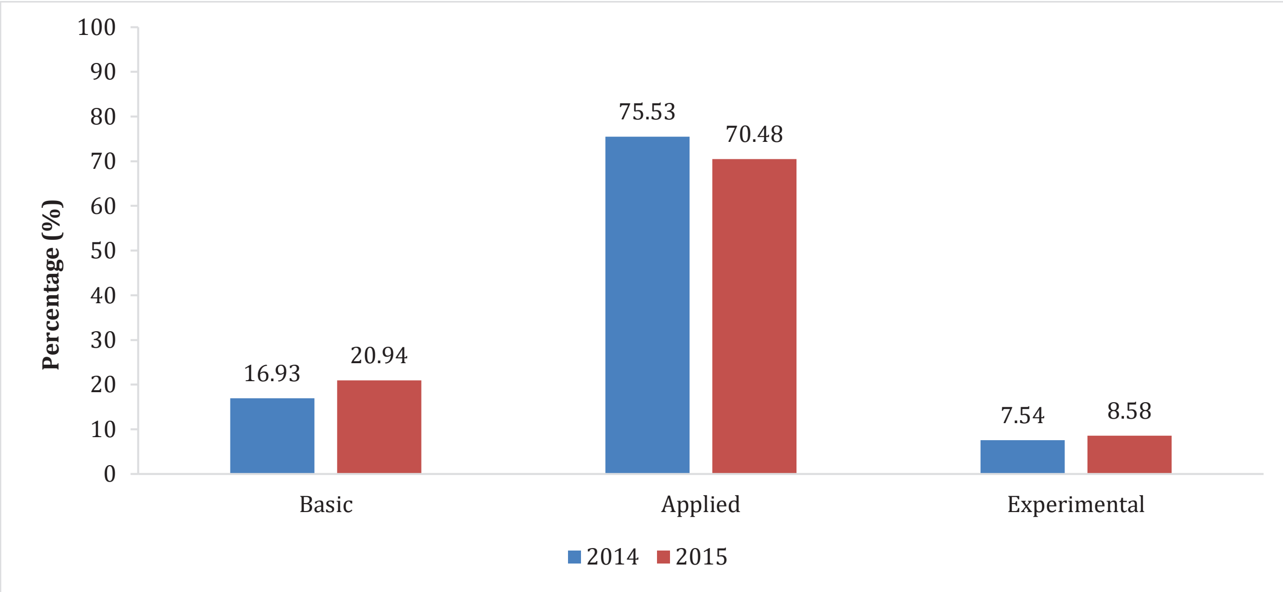
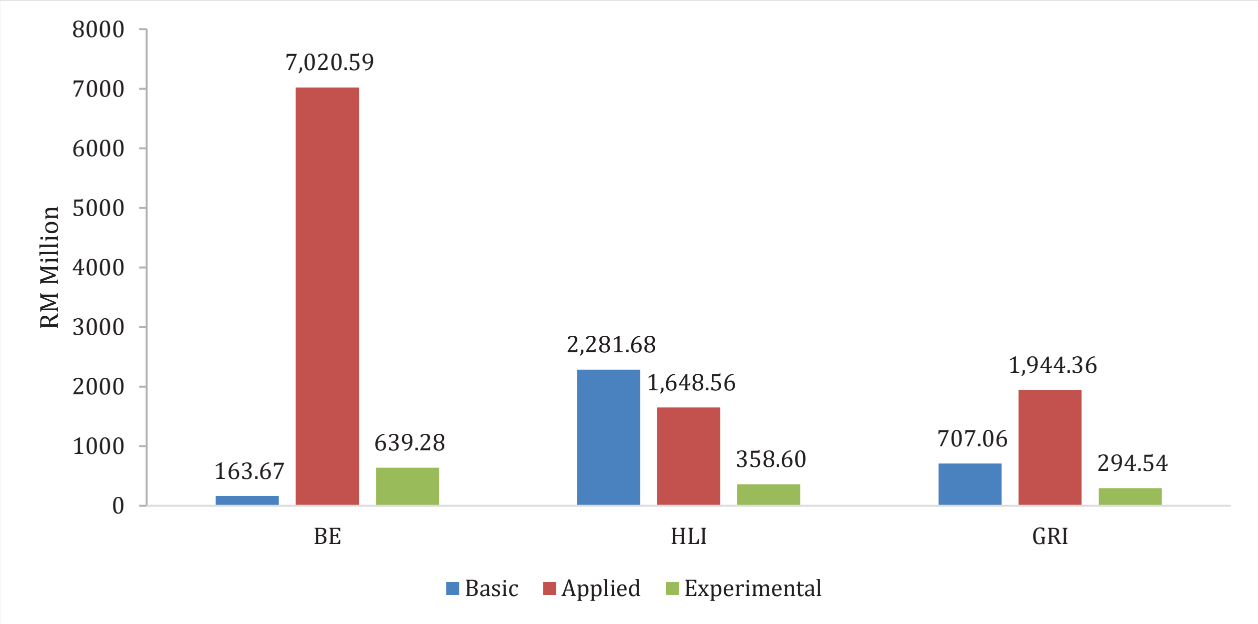


Figure 3.9 shows R&D expenditure based on the type of research conducted in each sector in 2015. Two sectors focus mostly in applied research like BEs (RM7,020.59 million) and GRIs (RM1,944.36 million). However, HLIs focus more on basic research with RM2,281.68 million compared to applied research with RM1,648.56 million. BEs (RM163.67 million) and GRIs (RM707.06 million) also spent significantly in basic research.

Experimental research on the other hand receives considerable attention from BEs (RM 639.28 million) as well. Meanwhile, the expenditure by HLIs and GRIs on experimental research is relatively lesser compared to their expenditure in other two sectors.

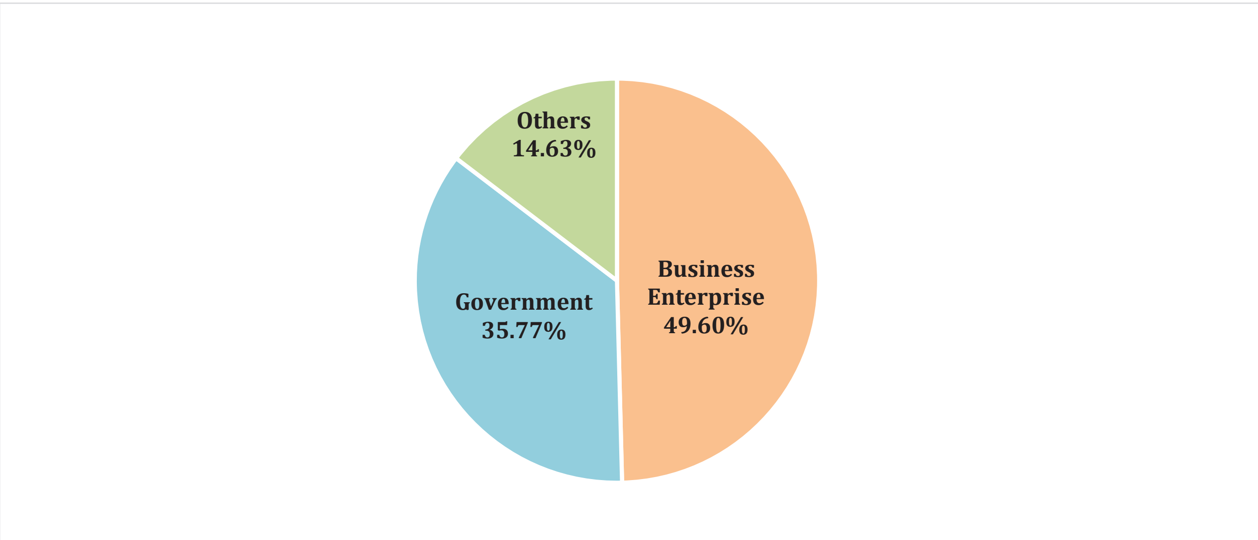
Figure 3.9: Type of Research by Sectors, 2015



3.3 Sources of Funds

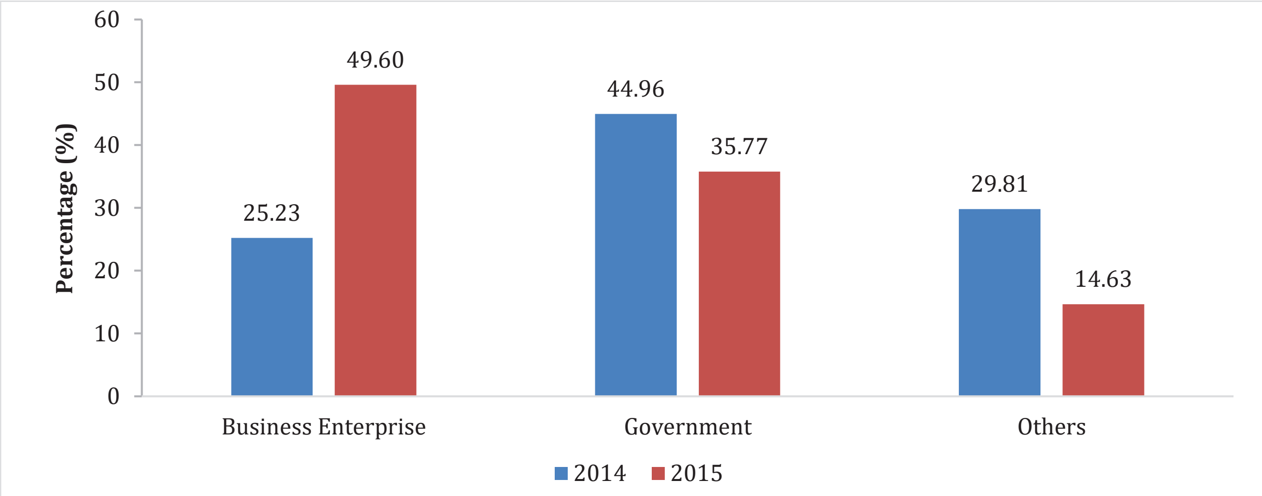
Figure 3.10 below indicates that the sources of funds came mostly from the Business Enterprises (49.60%) followed by the Government (35.77%). The others sources contribute only 14.63% which includes higher education, foreign funds and unspecified sources.

Figure 3.10: Sources of R&D Funds, 2015



Compared to previous survey in 2014 (Figure 3.11), there are significant increments in the Business Enterprises category (from 25.23% to 49.60%) but a sharp dive for the Government category (from 44.96% to 35.77%) and the Others category (from 29.81% to 14.63%).

Figure 3.11: Sources of R&D Funds Comparison, 2014 and 2015

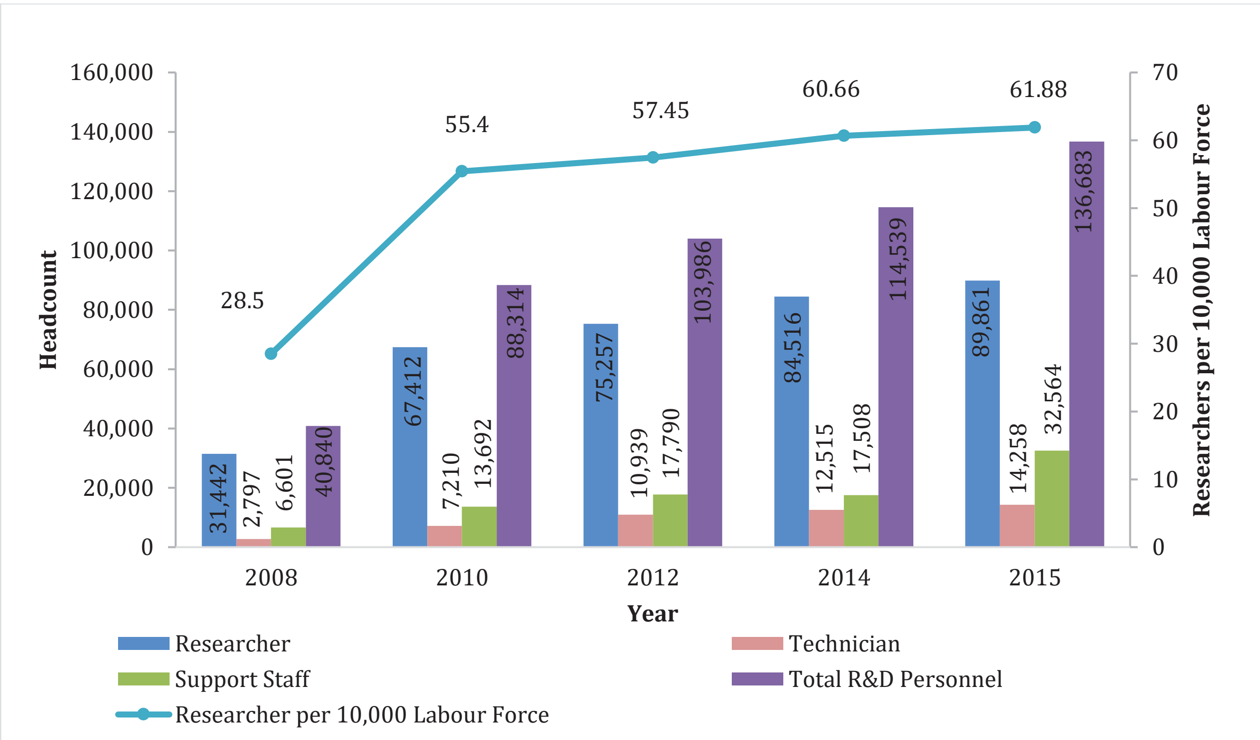


3.4 Human Resource Development

3.4.1 Research and Development Personnel and Researchers per 10,000 Labour Force (2008-2015)

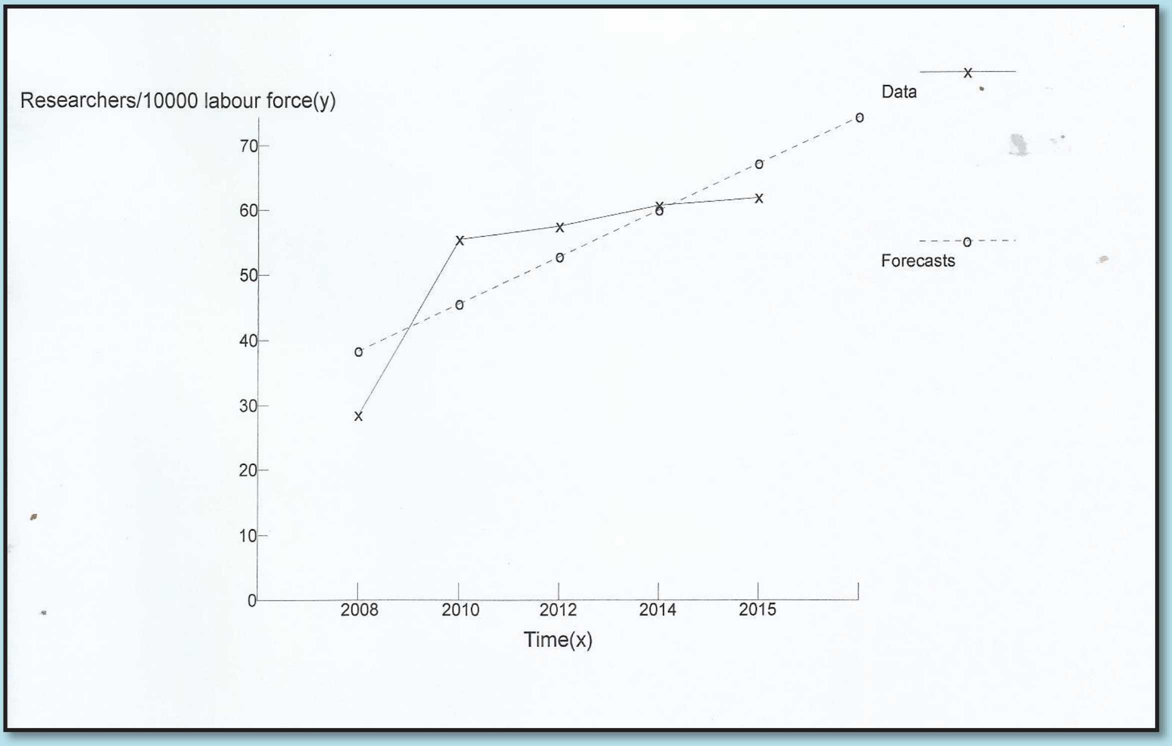
Since 2008 the number of R&D personnel has been increasing steadily with 2015 recorded a total headcount of 136,683. The number is made up mostly by Researchers (89,861) followed by Support Staff (32,564) and Technicians (14,258). The number of Researchers per 10,000 Labour Force also records an increase and stands at 61.88 in 2015 (Figure 3.12).

Figure 3.12: R&D Personnel and Researchers per 10,000 Labour Force, 2008-2015



Box 3.2: Number of Researchers per 10,000 Labour Force

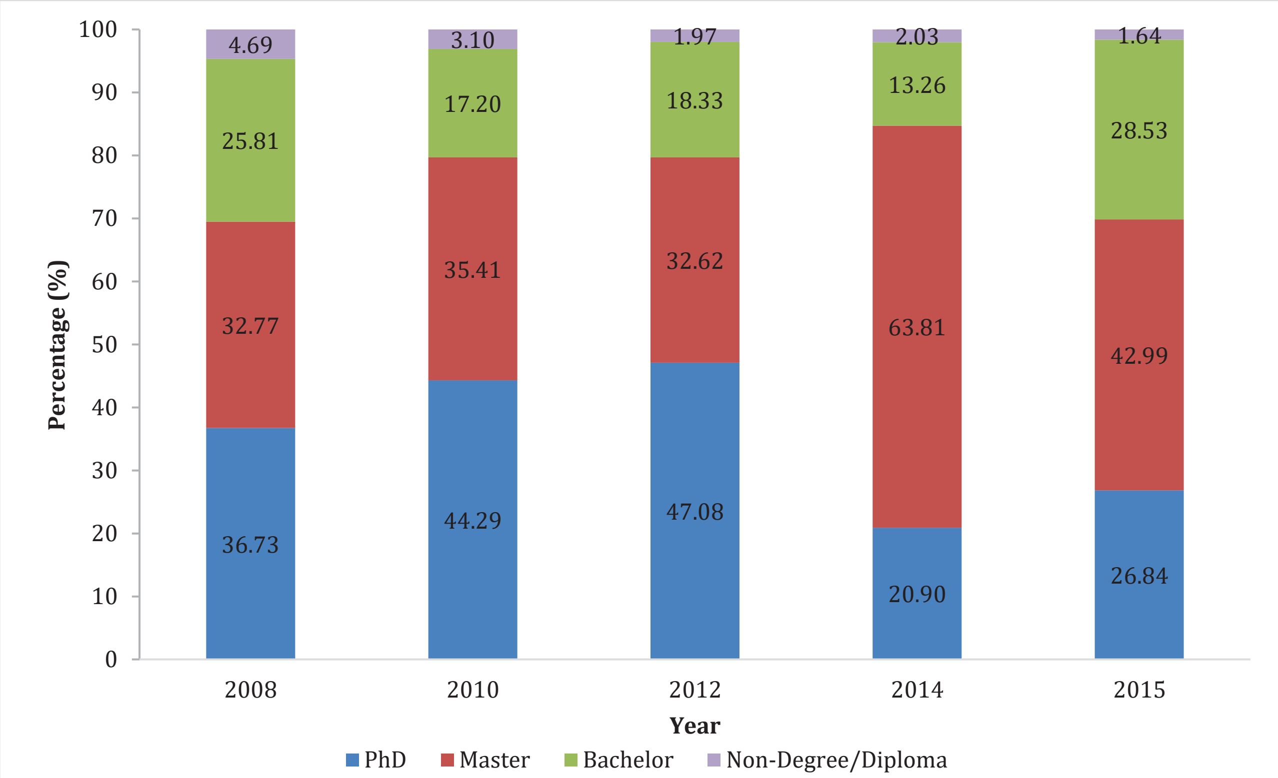
Using the existing data from 2008 until 2015, a time series trend analysis has been performed on the number of researchers per 10,000 labour force. It is observed that the increase of the number of researchers from 2008 to 2010 has been substantial, though beyond 2010, the trend line has been rather flat (the following figure can be referred to). Nevertheless, the average growth rate has been positive. Specifically, average increase of the number of researchers per 10,000 labour force per year is 7.20. On the basis of this average growth, by 2020, the number of researchers per 10,000 labour force would be 103.20 and by 2030 the figure would stand at 175.21.



3.4.2 Researchers Headcount of by Qualifications

In this survey, the researchers' qualifications are categorised as PhD, Master, Bachelor, and Non-Degree or Diploma as shown in Figure 3.13. In 2015, majority of the researchers are Masters (42.99%) followed by Bachelor's (28.53%) and PhD (26.84%) degree holders. Non-Degree/Diploma constitutes only 1.64% of the total population.

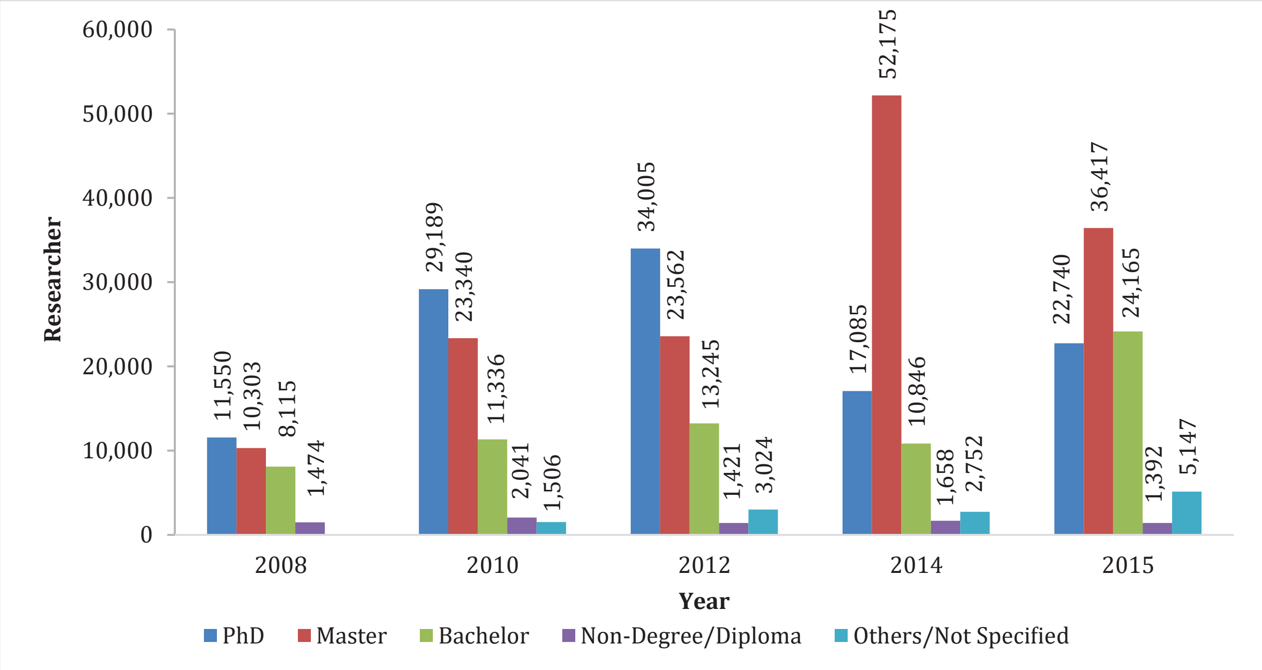
Figure 3.13: Proportion of Researchers by Qualification, 2008-2015



The number of headcounts over various categories has a mixed trend since 2008 to 2015. Notably, the 2015 survey observes a significant drop in terms of headcount in Masters category. The Masters researchers only charts 36,417 headcount in 2015 compared to the previous year survey in 2014 which represents 52,175 headcount of Masters. The Bachelor degree researchers records more than 122.80% increase from 10,846 in 2014 to 24,165 in 2015 (Figure 3.14). The PhD researchers category also increases by 33.10% to 22,740 in 2015 from 17,085 in 2014, while non-Degree/Diploma category records a decrease of 16.04% with 1,392 in 2015 from 1,658 in 2014. However, these figures do not include 5,147 researchers whose qualifications are not specified in the completed questionnaires.

From the data on the total number of researcher's holding various qualifications starting from the year 2008 until 2015, it is a common observation of substantial fluctuation from one year to the next. For example, the number of PhD holders has been significantly dropped from 34,005 in 2012 to 17,085 in 2014, whereas the number of researchers holding Masters degrees has been substantial increase from 23,562 in 2012 to 52,175 in 2014. Similar differences are also observed in terms of the number of researchers holding various qualifications in 2014 and 2015.

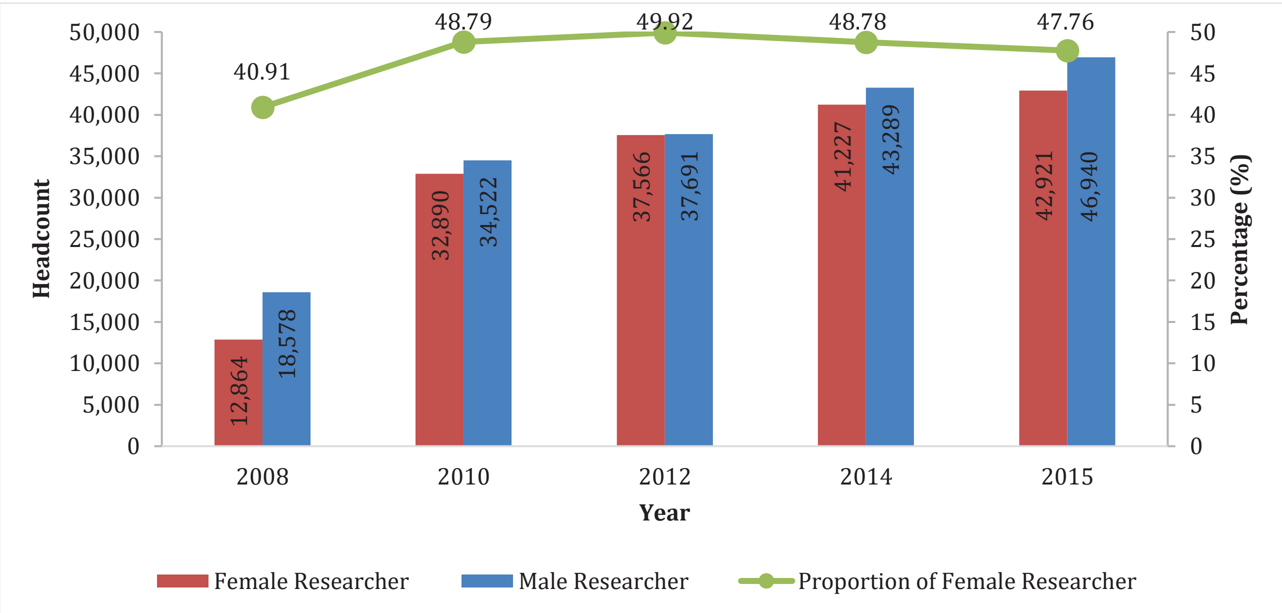
Figure 3.14: Headcount of Researchers by Qualification, 2008-2015



3.4.3 Researchers Headcount by Gender

An analysis of researchers by gender as shown in Figure 3.15 illustrates that female participation in R&D has steadily increased from 2008 to 2012, which records the highest female participation of 49.92% but subsequently dropped to 48.78% in 2014 and 47.76% in 2015. Even though there is an increase of 4.11 % in the number of female researchers from 2014 to 2015, it does not match the increase of male researchers by 8.43% during the same period.

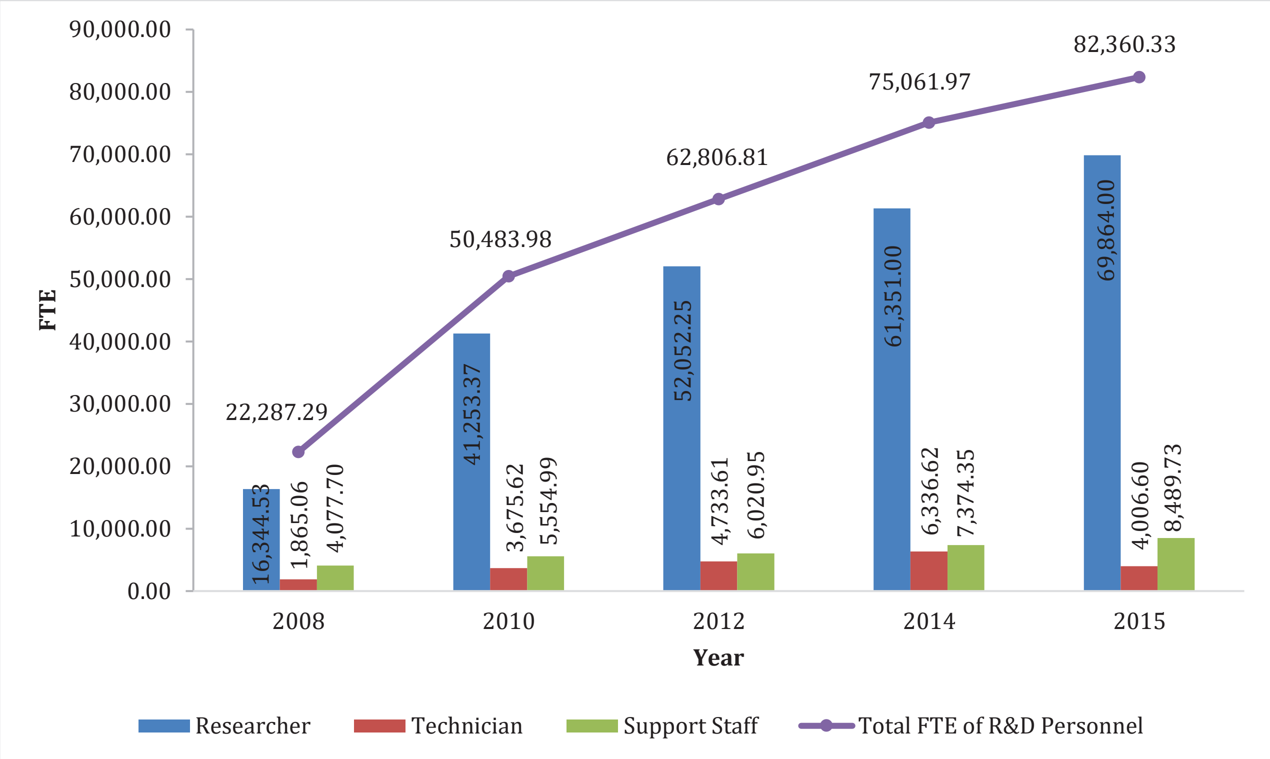
Figure 3.15: Headcount of Researchers by Gender, 2008-2015



3.4.4 Researchers Intensity and Full-Time Equivalent (FTE)

Full-Time Equivalent (FTE) is the amount of time in a year that a researcher devotes to R&D projects. As a rule of thumb, the greater the FTE for R&D personnel, the greater is his or her involvement in R&D. Figure 3.16 shows that the total FTE has increased gradually from 2008 (22,287.29) to 2015 (82,360.33). This translates to an average of annual growth of 20.53% in total FTE of R&D personnel from 2008 to 2015. Similarly, this gradual growth is reflected in each category of personnel. FTE of Researcher nearly quadrupled from 16,345.53 in 2008 to 69,864.00 in 2015. Technician and Support Staff grow more than double from 1,865.06 to 4,006.60 and from 4,077.70 to 8,489.73 respectively.

Figure 3.16: Full-Time Equivalent of R&D Personnel, 2008-2015



3.5 Research Output

3.5.1 Publications

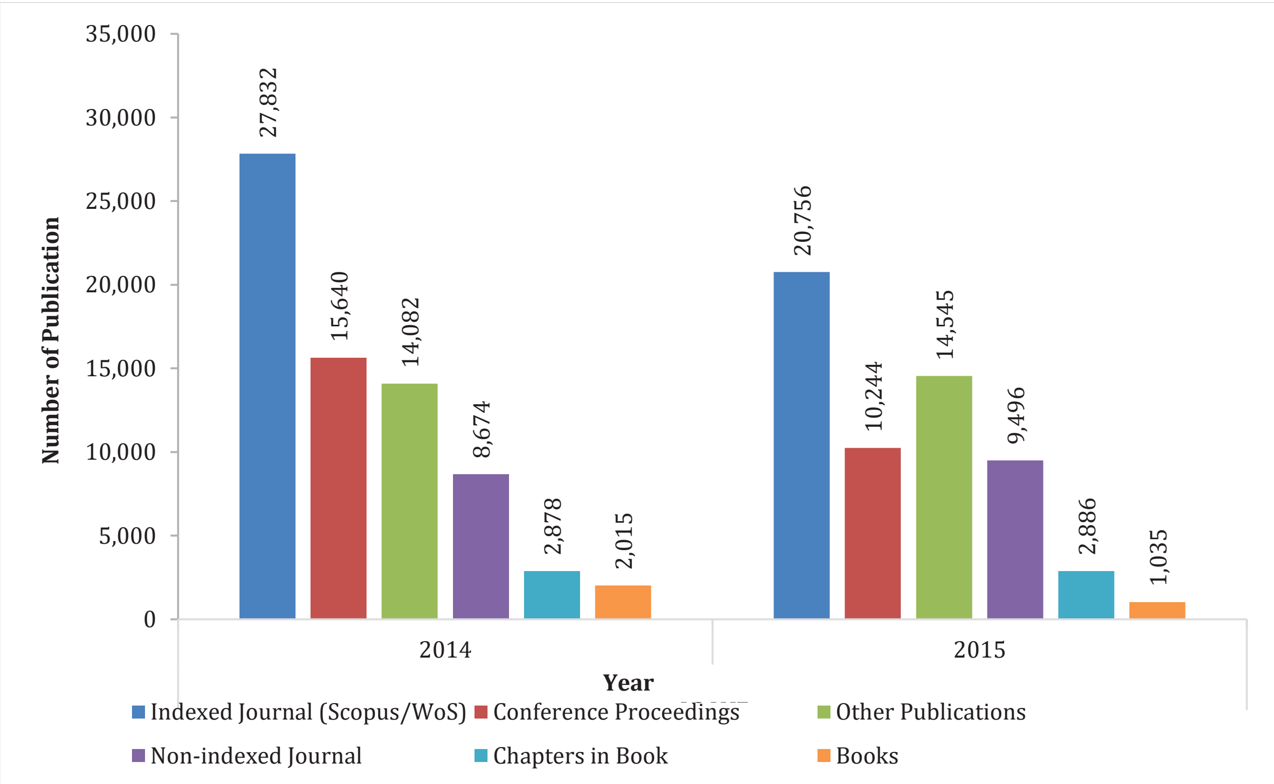
Table 3.1 shows the number of publications from HLIs and GRIs reported in both 2014 and 2015 R&D surveys. No publication is recorded from BEs in the present survey. A total of 58,962 publications in all types are recorded in 2015 which is 17.10% less than the publications recorded in 2014 with 71,121. All these publications comprise Journal Articles (30,252) with 20,756 Indexed and 9,496 Non-indexed/Unclassified followed by Conference Proceedings (10,244), Chapters in Book (2,886) and Books (1,035). In addition, 14,545 publications are classified as other type of publications.

Table 3.1: Number of Publications from HLIs and GRIs, 2014-2015

Publication	HLI		GRI		TOTAL	
YEAR	2014	2015	2014	2015	2014	2015
Indexed Journal (Scopus/WoS)	27,402	20,239	430	517	27,832	20,756
Conference Proceedings	14,501	8,760	1,139	1,484	15,640	10,244
Other Publications	12,525	11,811	1,557	2,734	14,082	14,545
Non-indexed Journal	8,214	8,529	460	967	8,674	9,496
Chapters in Book	2,765	2,785	113	101	2,878	2,886
Books	1,918	924	97	111	2,015	1,035

The sub-categories like Indexed Journal publications, Conference Proceedings and Books record decrease with 25.42%, 34.50% and 48.63%, respectively compared to same types of publications recorded in 2014 (Figure 3.17). This decrease of number of publications is corroborated by the statistics provided by SCImago (which in turn collects the publication data from Scopus database) as shown in Box 3.3. The statistics show that altogether 28,337 number of documents were published in Malaysia in 2014, whereas the number of documents published in 2015 was 26,796. Only Non-indexed publications records 9.48% increase from 8,674 in 2014 to 9,496 in 2015. Chapters in Book remains almost equal in 2014 (2,878) and 2015 (2,886).

Figure 3.17: Publication Output Comparison, 2014-2015



Box 3.3: Malaysia's Publications Record under SCImago

Every year SCImago ranks countries (as well as journals) with respect to a number of publications related parameters such as total number of documents published, total number of citable documents, total number of citations, H-index etc. Note that SCImago uses information contained in Scopus database of Elsevier, B.V. Among 239 countries in the world, Malaysia is ranked reasonably well. In both 2014 and 2015, Malaysia ranked 23rd. The following table shows the statistics contained in SCImago web portal. It may be noted that the data in this National R & D survey 2015 and the number reported in the SCImago differ. The reason of this difference is non-reporting of some HLIs and GRIs on publications. For example, many GRIs conveyed the message that they did not conduct any R&D in 2015 but the organisations might have published in 2015.For these organisations, since no questionnaires were filled up, the publication data were not captured. Further, SCImago data also show that there has been substantial amount of decrease of total number of publications in 2015 compared to 2014.

Rank	Year	Documents	Citeable documents	Citations	Citations/document	H-index
23rd	2015	26,796	25,832	61,575	2.30	224
23rd	2014	28,337	27,348	101,174	3.57	224

Source : SCImago Journal & Country Rank, http://www.scimagojr.com/

3.5.2 Intellectual Property

In terms of intellectual property (IP), there is a significant drop in the number of patents awarded in 2015 with 388 compared to 745 patent awarded in 2014 (Table 3.2). Similarly, trademarks also decreased from 738 in 2014 to 390 in 2015. Altogether 1,776 copyrights were recorded in 2015 but this figure cannot be compared with the similar figure in 2014 as in 2014, HLIs and GRIs did not report copyrights statistics. The other two categories record 1,201 number of patent applied and 143 number of industrial design are made in 2015.

Table 3.2: Number of Intellectual Property, 2014-2015

Intellectual Property	HLI		GRI		BE		TOTAL	
YEAR	2014	2015	2014	2015	2014	2015	2014	2015
Patent Applied	776	521	204	88	831	592	1,811	1,201
Patents Awarded	360	129	82	39	303	220	745	388
Copyright	N/A	1,545	N/A	72	186	159	186	1,776
Trademark	206	137	42	25	490	228	738	390
Industrial Design	66	90	24	6	93	47	183	143

3.6 Conclusion

The National Survey of R&D 2016 finds overall increase in the expenditures and headcounts, but decrease in research output. Gross Expenditures on Research and Development has been increasing gradually from RM6,070.80 million in 2008 to RM15,058.34 million in 2015. This can be translated into an average annual growth of 13.85% per year. In terms of percentage of GDP, GERD also records a gradual increment from 0.79% in 2008 to 1.30% in 2015. However, based on a trend analysis of GERD per GDP since year 2000, Malaysia can achieve only 1.84% of GERD per GDP by the year 2020. To achieve the target of 2.00% of GERD per GDP by 2020, the sources of funds should be diversified, i.e., increased funds may not necessarily come from the government.

In terms of GERD per sector, the year 2015 presents a mixed scenario compared to the previous surveys. In 2014, BEs contributed RM6,379 million (45.66%) to GERD. Further, in 2015 BEs contributions increased by RM1,445 million compared to 2014 and contributes 51.95% of the share to GERD. However, in 2008 BEs recorded 70.49% share of GERD. This may affect the target 70:30 share of BEs investment in R&D expenditures as espoused in the NPSTI, 2013-2020. Surprisingly, HLIs contributions have a decreasing trend with 46.13% in 2014 to only 28.48% in 2015. In contrast, GRIs have an increasing trend with 19.57% in 2015 compared to just 8.21% in 2014. Sources of funds coming from BEs for R&D activities have shown significant increment from 25.23% in 2014 to 49.60% in 2015. However, funding by the Government significantly decreases from 44.96% to 35.77%. Funding from other sources also decreases significantly from 29.81% to 14.63% in 2015 compared to 2014.

The number of R&D personnel headcounts has been increasing steadily from 40,840 in 2008 to 136,683 in 2015. The headcount of Researchers per 10,000 Labour Force also increases from 60.66 in 2014 to 61.88 in 2015. In terms of R&D manpower, the total full time equivalent of R&D personnel increased from 22,287 in 2008 to 82,360 in 2015.

The breakdown of researchers by qualifications shows a decrease by 30.20% for Master holders and an increase of 122.80% for Bachelor's degree holders compared to 2014. The number of PhD researchers has increased by 33.10%, whereas Non-Degree/Diploma holders has decreased by 16.04%. These figures do not include 5,147 researchers whose qualifications are not specified in the completed questionnaires.

In terms of R&D outputs, 2015 demonstrates downward trend in terms of publications. The number of publications has fallen from 71,121 to 58,962 by a hopping 17.10%. The sub-categories like Indexed Journal publications, Conference Proceedings and Books record decrease with 25.42%, 34.50% and 48.63%, respectively compared to same types of publications recorded in 2014. Only Non-indexed publications records 9.48% increase from 8,674 in 2014 to 9,496 in 2015. Chapters in Book remains almost equal in 2014 (2,878) and 2015 (2,886).

Patents awarded drops from 745 in 2014 to 388 in 2015. Similarly, trademarks also decreases from 738 in 2014 to 390 in 2015.

A more thorough analyses and discussions for each sector (BEs, HLIs and GRIs) individually are available in the subsequent chapters, namely chapter 4, 5 and 6.

RESEARCH AND DEVELOPMENT IN BUSINESS ENTERPRISES (BEs) AND NON-GOVERNMENTAL ORGANISATIONS (NGOs)

CHAPTER 4: RESEARCH AND DEVELOPMENT IN BUSINESS ENTERPRISES (BEs) AND NON-GOVERNMENTAL ORGANISATIONS (NGOs)

4.1 Introduction

Business enterprises (BEs) are very important to Malaysian economies. The government has identified business enterprises (BEs) as a driving force for growth of the country and R&D is instrumental in ensuring BEs contribution to the growth. This is evidenced in the 11th Malaysia Plan (11th MP) which focuses on strengthening relational capital by improving collaboration among all stakeholders especially between business enterprises, academia and government. At the enterprise level, initiatives will be demand-driven research, improve collaboration between researchers and industries, and encourage private investment in Research and Development, Commercialisation and Innovation. BEs role to drive growth through R&D was supported by the 1st National Science and Technology Policy (NSTP1; 1986-1989) and National Policy on Science, Technology and Innovation (NPSTI; 2013-2020).

This chapter presents an overview of the Business Enterprises (BEs) R&D activities which contributed to the national R&D performance discussed in the earlier chapters. The overview highlights the R&D progress in BEs sector since 2008 to 2015 with respect to Gross Expenditure, Field of Research (FOR), Socio-Economic Objectives (SEO), Sources of Funds, Human Resource Development and Research Output. In addition, the 2016 R&D survey also solicited feedback from the BEs on the location of their R&D activities, reasons for outsourcing R&D, R&D incentives as well as internal and external factors limiting their R&D activities. For financial year 2015 survey, there is no NGOs reported their R&D activities.

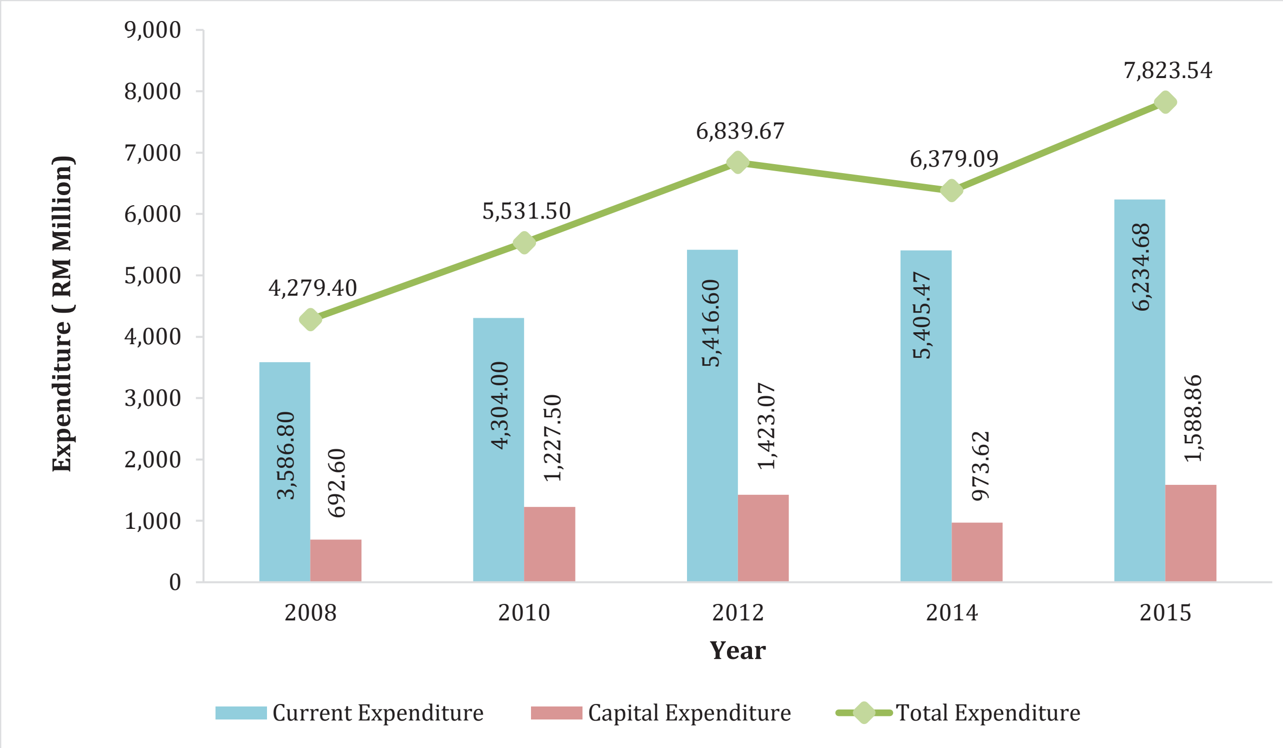
4.2 Gross Expenditure on Research and Development

4.2.1 Expenditure by Type of Cost

Figure 4.1 shows expenditure by type of cost in BEs, for the period of 2008-2015. In 2008, the R&D expenditure for BEs increased from RM4,279.40 million to RM6,839.67 million in 2012. However, in 2014 R&D expenditure slightly decreased to RM6,379.09 million. Upon further investigation, the decrease in the expenditure can be partly explained by the reclassification of four institutions from BEs (2012) to GRIs (2014). For 2014, current expenditure (RM5,405.47 million) in labour cost and operating cost counts for the majority (84.74%) of the BEs R&D expenditure (BERD) and recorded the highest percentage as compared to 2008 (83.82%), 2010 (77.81%) and 2012 (79.19%). Meanwhile, capital expenditure was only 15.26% (RM973.62 million) involving cost of fixed assets used to conduct R&D (land, building & other structure and vehicles, plants, software, machinery & equipment).

However for 2015, total expenditure for BEs increased to RM7,823.54 million. The increment was contributed by both current expenditure as well as capital expenditure. The increments were 15.34% and 63.19% respectively. Specifically, current expenditure was 79.69% (RM6,234.68 million) of the total expenditure. Meanwhile, capital expenditure was 20.31% (RM1,588.86 million).

Figure 4.1: Expenditure by Type of Cost in BEs, 2008-2015



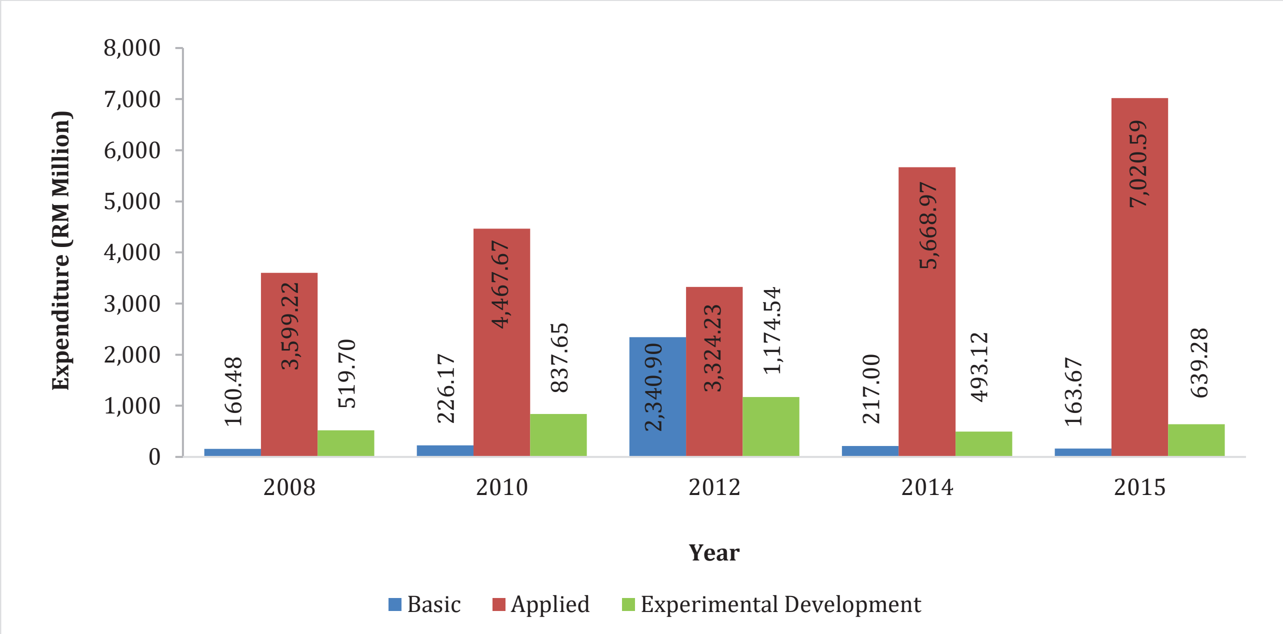
4.2.2 Expenditure by Type of Research

As reported in 2014, the participating BEs were involved in all three types of research with majority in applied research (RM5,668.97 million) followed by experimental research (RM493.12 million) and basic research (RM217.00 million) as shown in Figure 4.2. In 2015, BEs continued their spending in all three types of research. However, the amount spent was different in all the three types of research.

In 2015, the same spending pattern was observed where BEs spent the highest in applied research. There was significant upward trend in applied research in 2014 (RM5,668.97 million) from 2012 (RM3,324.23 million) which had earlier went down from 2010 (RM4,467.67 million). BEs in Malaysia may emulate those in Taiwan and South Korea that focused on applied research during the early stages of development (in 1980s and 1990s) to strengthen their R&D (Science Outlook, 2015). Conversely, the expenditure for basic research (RM2,340.90 million vs RM217.00 million) and experimental development (RM1,174.54 million vs RM493.12 million) drastically decreased from 2012 to 2014. In fact, the expenditure for experimental development in 2014 (RM493.12 million) is lower than in 2008 (RM519.70 million). Again, one plausible reason is that three of the five reclassified GRIs were conducting more basic research (RM373,735.94) and experimental research (RM4.34 million) in 2014 hence could have contributed for BEs in 2014.

In 2015, there was a drop of 24.58% in basic research. Basic research was RM163.67 million. One plausible reason was that the BEs were more interested in applied research. Furthermore as a business entity, BEs tend to spend more on applied research because it is very much link to their business strategies. Experimental research was RM639.28 million, an increase of 29.64% from the previous year.

Figure 4.2: Expenditure by Type of Research in BEs, 2008-2015

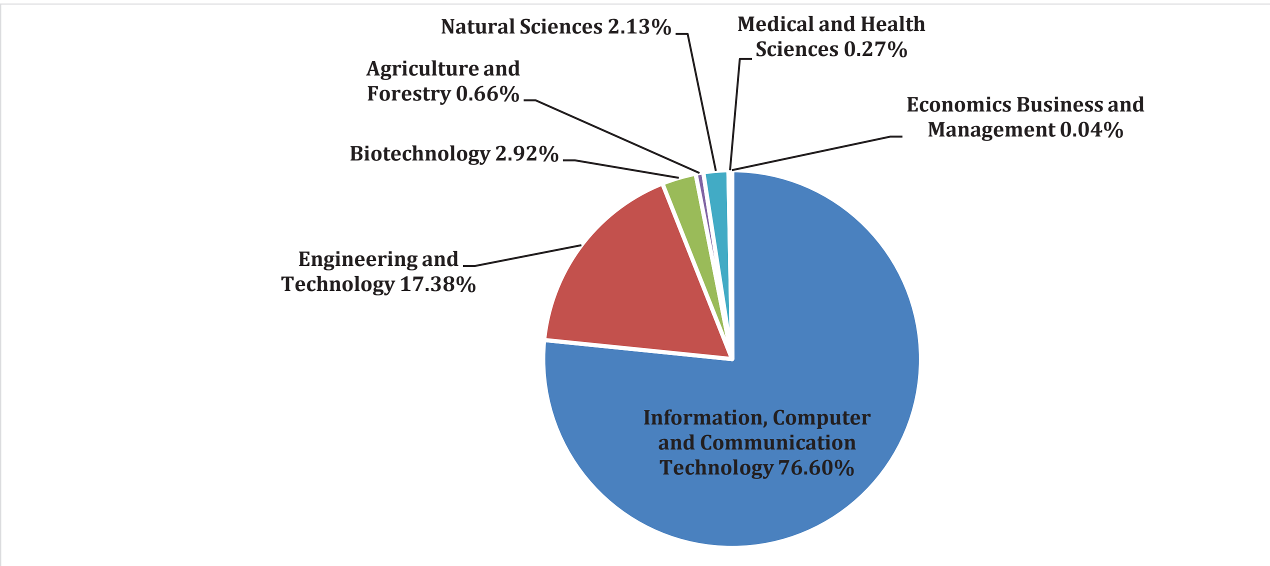


4.2.3 Expenditure by Field of Research and Socio-Economic Objectives

According to MRDCS (2011), there are nine divisions with 20 sub-divisions for Field of Research (FOR) and six divisions of Socio-Economic Objectives (SEO). In this survey, the BEs were asked to identify their FOR and SEO.

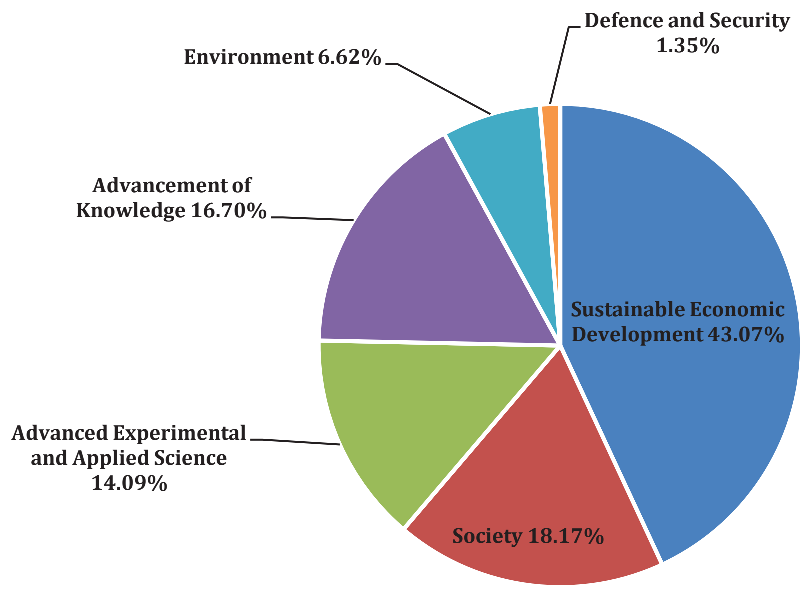
Out of 9 FOR divisions, only 7 divisions were applicable to BEs as shown in Figure 4.3. The top three highest R&D expenditure which made of more than 95% of the total expenditure, namely Information, Computer and Communication Technology (ICT)(76.60%), Engineering and Technology (17.38%) and Biotechnology (2.92%). As for Natural Sciences, six of the ten sub-divisions comprised 2.13% of total R&D expenditure and the rest of the FOR contributed 0.97% of the total expenditure.

Figure 4.3: Expenditure by Field of Research in BEs, 2015



As for Socio-Economic Objectives (SEO) (Figure 4.4), R&D expenditure for BEs was predominantly on Sustainable Economic Development (43.07%), Society (18.17%) and Advanced Experimental and Applied Science (14.09%). Further, Advancement of Knowledge (16.70%), Environment (6.62%) and Defence and Security (1.35%) contributed about 24.67% of the R&D expenditure for BEs.

Figure 4.4: Expenditure by Socio-Economic Objective in BEs, 2015

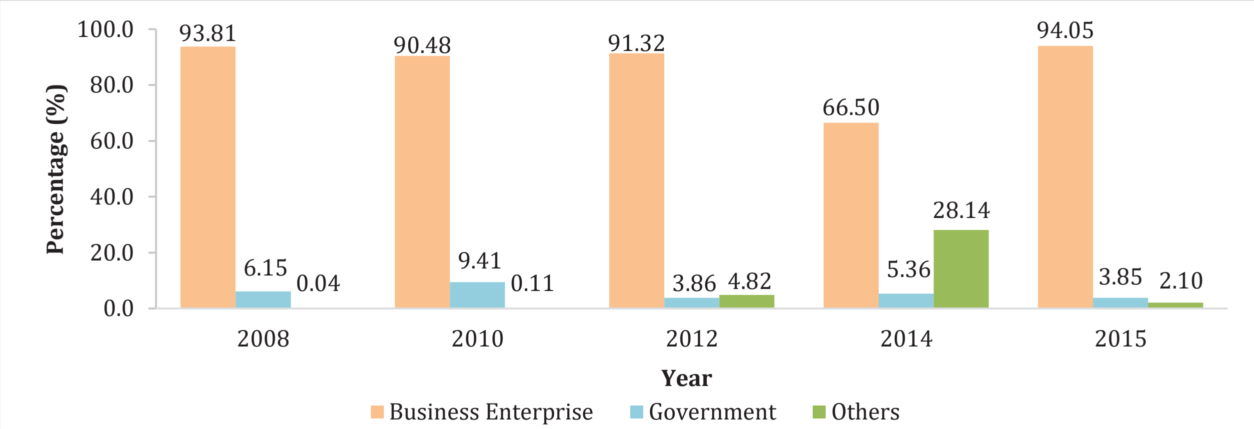


4.3 Sources of R&D Funds in BEs

Over the last seven years, BEs had been the main contributor of R&D funds with more than 90% since 2008 until 2012. As outlined in 11th MP, the Government has been encouraging the private enterprises to fund research, development, commercialisation and innovation and improve access funding by business enterprises. However for 2014, the percentage of funding by BEs decreased to 66.50% from 91.32% in 2012, whereas other sources of funds (specifically foreign funds and others) have increased gradually to 28.14% in 2014 as shown in Figure 4.5. On the other hand, funding from the Government has been minimal and fluctuates from 2008 to 2014 with the highest (9.41%) in 2010 and lowest (3.86%) in 2012 and increased slightly to 5.36% in 2014.

In 2015, the percentage of funding by BEs increased to 94.05% from 66.50% in 2014. The funding from government decreased from 5.36% in 2014 to 3.85% in 2015. The source of fund from others category has also dropped from 28.14% in 2014, to 2.10% in 2015. This drop might have actually due to a shift of reporting from others to BEs as the BEs in 2015 have a better understanding of defining their source of fund. In comparison to 2014, the other category reported 28.14% but BEs reported only 66.50%, the lowest among all the years. For 2015 however, the other category reported 2.10%, a drop from 28.14%, but BE reported an increase to 94.05% from 66.50% in 2014.

Figure 4.5: Sources of R&D Funds in BEs, 2008-2015



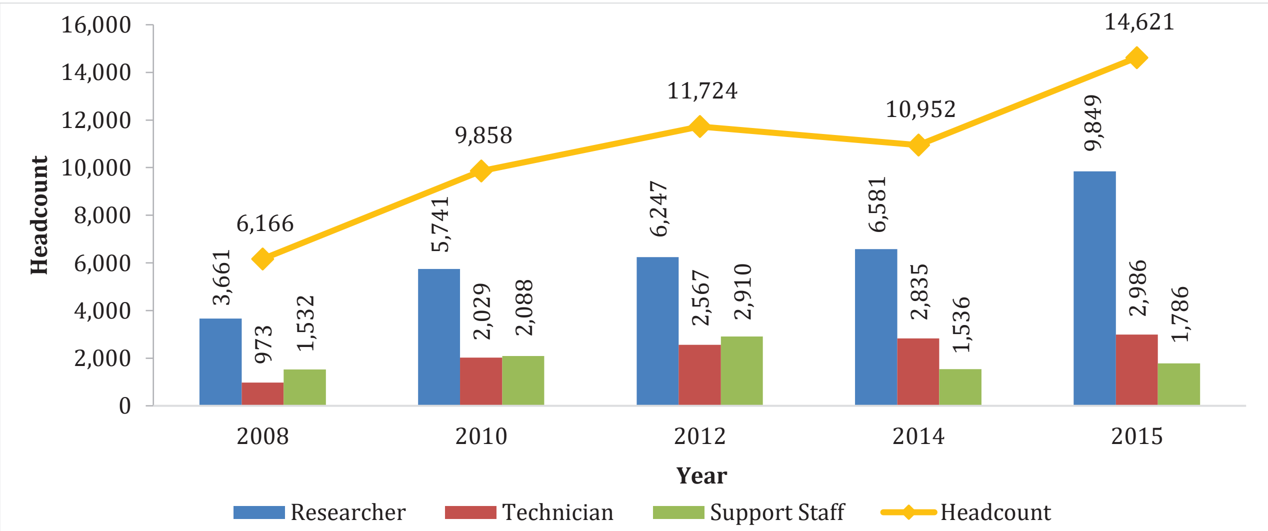
4.4 Human Resource Development

4.4.1 Headcount of R&D Personnel

As shown in Figure 4.6, since 2008, there was an noticeable increase in the total headcount for R&D personnel in BEs predominantly in the number of researchers. The number of R&D personnel has increased from 6,166 in 2008 to 11,724 in 2012, but decreased to 10,952 in 2014. From the total of R&D personnel in 2014, 6,581 (60.08%) were researchers, 2,835 (25.89%) were technicians and 1,536 (14.03%) were support staff, whereas the number of R&D personnel has decreased in 2014, the number of researchers (3,661 to 6,581) and technicians (973 to 2,835) has been increasing steadily from 2008 to 2014. Meanwhile for support staff, the number has decreased by half in 2014 (1,536) compared to 2012 (2,910).

The total number of R&D personnel in 2015 was 14,621, the highest for the past 7 years. It increased by 33.50% from 2014. There was an increase in all categories of personnel, namely, 49.65% in researcher, 5.33% in technician and 16.28% in support staff.

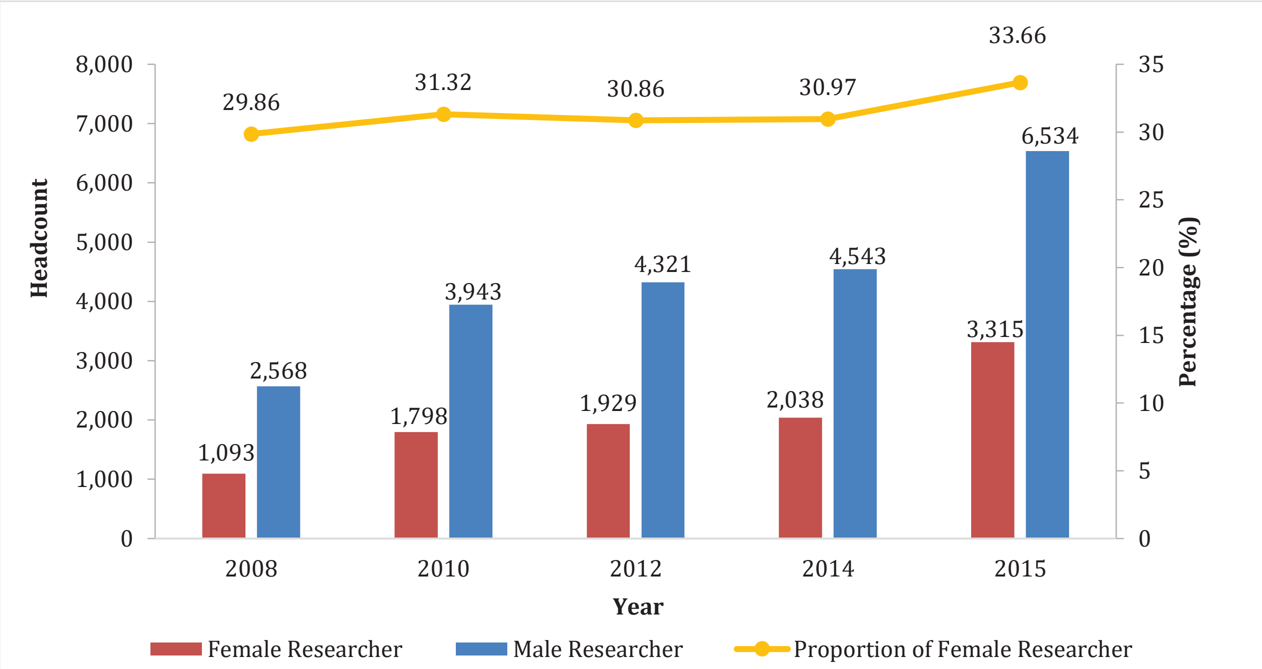
Figure 4.6: Headcount of R&D Personnel in BEs, 2015



4.4.2 Headcount and Proportion of Researchers by Gender

An analysis of researchers by gender as shown in Figure 4.7 illustrates that female participation in BEs R&D has steadily increased from 2008 to 2015. From the total 9,849 researchers reported in 2015, 6,534 (66.34%) were male and 3,315 (33.66%) were female. The numbers of female researchers increased from 1,093 in 2008 to 3,315 in 2015. In comparison to 2014, the numbers of female researcher has increased from 2,038 to 3,315 in 2015. The increment is by 62.66%. As shown in Figure 4.7, there was also an increase in the number of male researchers in 2015 in comparison to 2014. In 2014, the number of male researchers was 4,543. It increased to 6,534 in 2015. The male researchers participation increased by 43.82%.

Figure 4.7: Headcount of Researchers by Gender in BEs, 2008-2015



4.4.3 Proportion of Researchers (Internal) by Age Group

The 2016 survey requires the inclusion of headcount of researchers by age. As shown in Table 4.1, the highest percentage of researchers are in age range 25-34 years old (42.94%) followed by 35-44 years old (35.59%).

Table 4.1: Proportion of Researchers (Internal) by Age Group in BEs, 2015

Age group	Under 25	25-34	35-44	45-54	55 and more
Male (%)	1.74	26.26	25.07	11.01	1.96
Female (%)	1.36	16.68	10.52	4.96	0.44
Total (%)	3.10	42.94	35.59	15.97	2.40

4.4.4 Proportion of Researchers by Qualification

An analysis of researchers by qualification as shown in Table 4.2 demonstrates that bachelor degrees holders participation in BEs R&D is the highest percentage (30.96%). The second highest researchers are having "Others" qualifications (other than doctoral, master, bachelor and advanced diploma). The next highest percentage is master degrees holders (8.86%).

Table 4.2: Proportion of Researchers by Qualification in BEs, 2015

Qualification	Percentage
Doctoral	3.02
Master	8.86
Bachelor	30.96
Advanced Diploma	4.90
Others	16.22
Not Specified	36.04

4.4.5 Internal R&D Personnel Flow

The internal R&D personnel flow is measured by the number of staff recruited over the number of staff retiring. The total number of staff recruited in 2015, altogether was 377 personnel. Specifically, there were 233 researchers, 80 technicians and 64 supporting staffs recruited in 2015. In terms of retiring, in 2015, the total number of personnel retiring was 118 personnel. There were 61 researchers, 41 technicians and 16 supporting staffs.

In terms of internal personnel flow, for researchers it was 79.25% (233/294), for technician 66.12% (80/121) and for supporting staff 80.00% (64/80).

Table 4.3: Internal R&D Personnel Flow in term of New Recruitment and Retirement in BEs, 2015

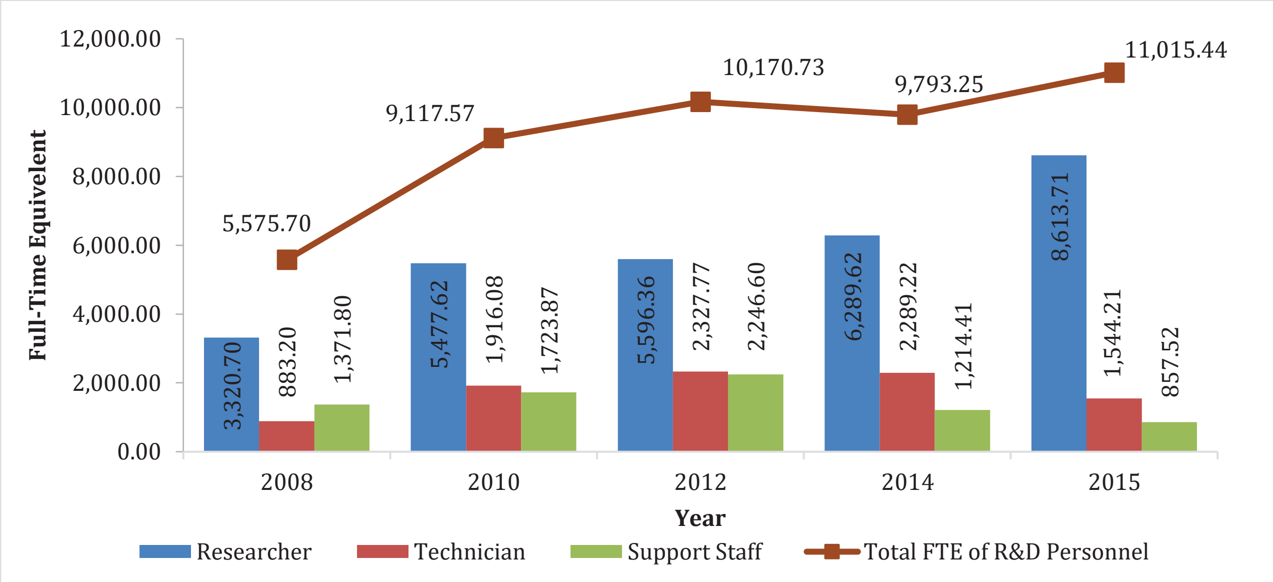
	Researcher	Technician	Supporting staff
Recruited in 2015	233 (79.25%)	80 (66.12%)	64 (80.00%)
Retiring in 2015	61 (20.75%)	41 (33.88%)	16 (20.00%)

4.4.6 Full-Time Equivalent of R&D Personnel

Full-time Equivalent (FTE) is the amount of time in a year that a researcher devotes to R&D projects. As a rule of thumb, the greater the FTE for R&D personnel, the greater is his or her intensity in R&D. Figure 4.8 shows the total FTE increased from 2008 to 2012 but slightly decreased in 2014 (9,793.25), and increased by 12.48% in 2015.

Although, the total FTE increased in 2015, the increment was only for researcher. There was a decrease of technician and support staff. The total FTE of researchers increased from 59.56% in 2008 to 78.20% in 2015. The total FTE of technicians increased from 15.84% in 2008 to 23.38% in 2014, but decreased to 14.02% in 2015. Meanwhile for support staff, total of FTE decreased from 24.60% in 2008 to 7.78% in 2015. Figure 4.8 illustrates the breakdown of the FTE of R&D personnel in BEs by database for 2015.

Figure 4.8: Full-Time Equivalent of R&D Personnel in BEs, 2008-2015



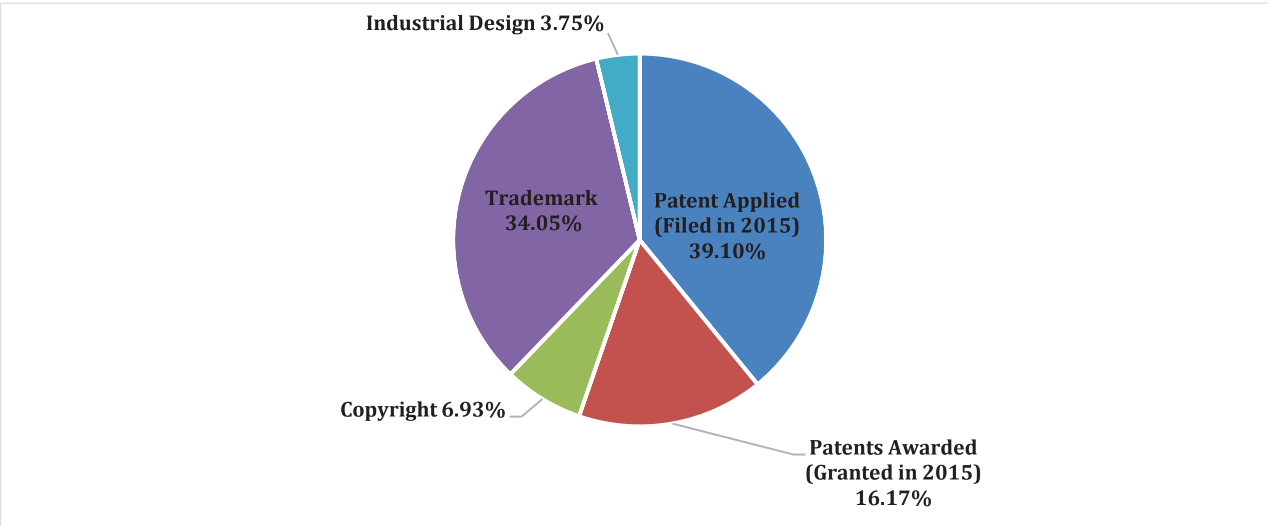
4.5 Research Output

4.5.1 Intellectual Property and Revenue Generated

For 2015, the intellectual property data sought was in terms of patent applied (filed), patent awarded (granted), copyright, trademark and industrial design. The present survey also asked additional information about the number of patents licensing, number of commercialised products and their revenue. This additional information was not covered in 2014 report.

As shown in Figure 4.9, in 2015 patent applied was the highest among all the IPs with 39.10%. Next, is trademarks which made up 34.05%, patent awarded which recorded a 16.17%, copyrights (6.93%), and industrial design is the lowest accounted for 3.75%.

Figure 4.9: Number of Intellectual Property in BEs, 2015



Referring to Table 4.4, in 2015 the total Intellectual Property was 2,294. There was a general increase in all types of intellectual property when compared to 2014 report except for copyright and industrial design. For comparison purposes, the number of each intellectual property is referred and not the percentages. In 2014, BEs reported 1,903 total number of intellectual property. Overall, there was 20.5% increase. Specifically, the achievements for BEs in 2015, there were 897 patent applied compared to 831 in 2014, 371 patent awarded compared 303 in 2014, 159 copyright as compared 186 in 2015. 781 trademark were reported for 2015 as compared 490 in 2014. Finally, 86 industrial design were recorded in 2015, while in 2014, industrial design were 93.

BEs also reported that they obtained 161 patents licensing and 48,611 of commercialised products which generated RM14.68 million and RM115.50 million revenue respectively in 2015 (Table 4.5).

Table 4.4: Comparison of Intellectual Property in BEs, 2014-2015

Intellectual Property	2014	2015
Patent Applied (Filed)	831	897
Patents Awarded (Granted)	303	371
Copyright	186	159
Trademark	490	781
Industrial Design	93	86
TOTAL	**1,903**	**2,294**

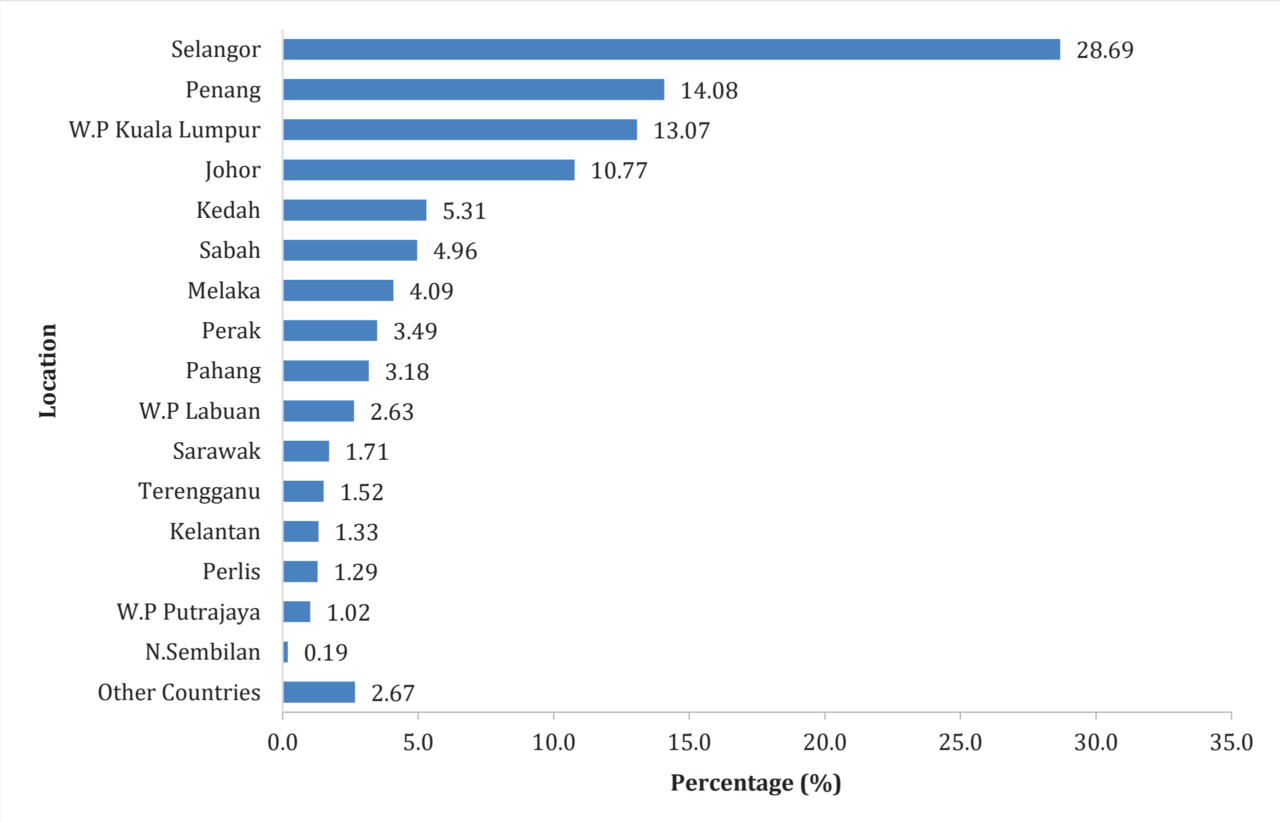
Table 4.5: Number of Products and Revenue Generated in BEs, 2015

	Total number	Revenue (RM Million)
Total number of patents licensing and technology know-how licensing	161	14.68
Total number of commercialised products	48,611	115.50

4.6 Distribution of R&D Projects by Location

The National Survey of R&D 2016 requested information about location for R&D projects. Figure 4.10 shows the distribution of location for R&D projects. Within Malaysia, the highest percentage is in Selangor (28.69%), followed by Penang (14.08%), and Wilayah Persekutuan Kuala Lumpur (13.07%). A few BEs indicated that they also conducted R&D outside Malaysia, such as Germany, India, China, Thailand, Japan and United Kingdom which accounted for 2.67%.

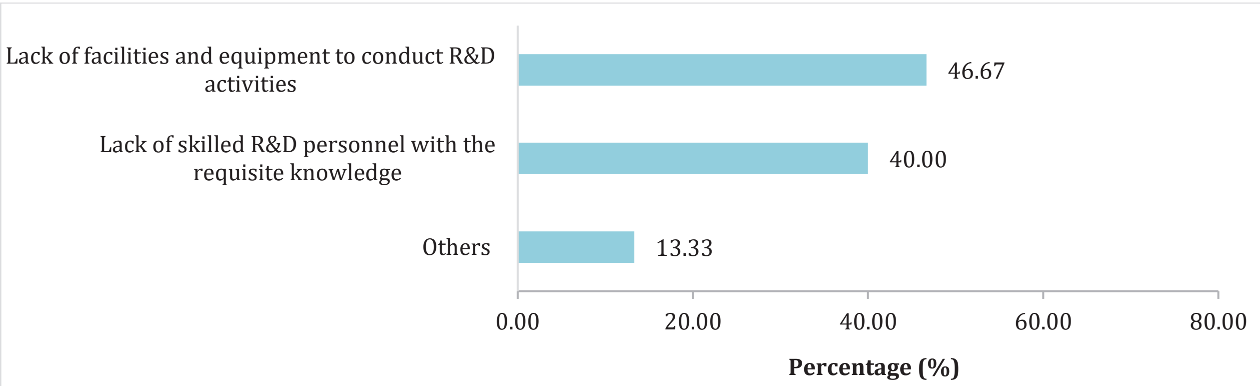
Figure 4.10: Distribution of R&D Projects by Location in BEs, 2015



4.7 Projects Outsourced

Besides conducting their R&D overseas, 22 out of 79 BEs outsourced their R&D projects. The main reason for these companies outsource the R&D projects is lack of facilities and equipment to conduct R&D activities. The second reason is lack of skilled R&D personnel with requisite knowledge.

Figure 4.11: Reasons for Outsourcing R&D Projects in BEs, 2015



4.7.1 Project Being Outsourced to BEs, 2015

The Business Enterprises (BEs) have also conducted some R&D projects for others within Malaysia and outside Malaysia. Some of these projects are being outsourced by other business enterprises and NGO, higher learning institution and Government agency. As shown in Table 4.6, the amount of project being outsourced to BEs from other Malaysian business enterprises is RM13.38 million and from BEs outside Malaysia is RM0.86 million. This makes a total of RM14.24 million. The amount of project being outsourced from higher learning and government agency is RM1.23 million and RM0.53 million respectively.

Table 4.6: Project Being Outsourced to BEs, 2015

Project Being Outsourced	RM Million		
	Within Malaysia	Outside Malaysia	Total amount
From Business Enterprise and NGO	13.38	0.86	14.24
From Higher Learning Institution	0.73	0.50	1.23
From Government Agency and Research Institute	-	0.53	0.53

4.7.2 Number of Project Collaborated with Others, in BEs 2015

Apart from being outsourced, BEs have some collaborations with others within Malaysian and outside Malaysia as well. For 2015, BEs have 544 projects collaborated with others within Malaysia and 75 projects collaborated with others outside Malaysia.

Table 4.7: Number of Project Collaborated with Others, in BEs 2015

Collaborated Projects	Total Number
Within Malaysia	544
Outside Malaysia	75

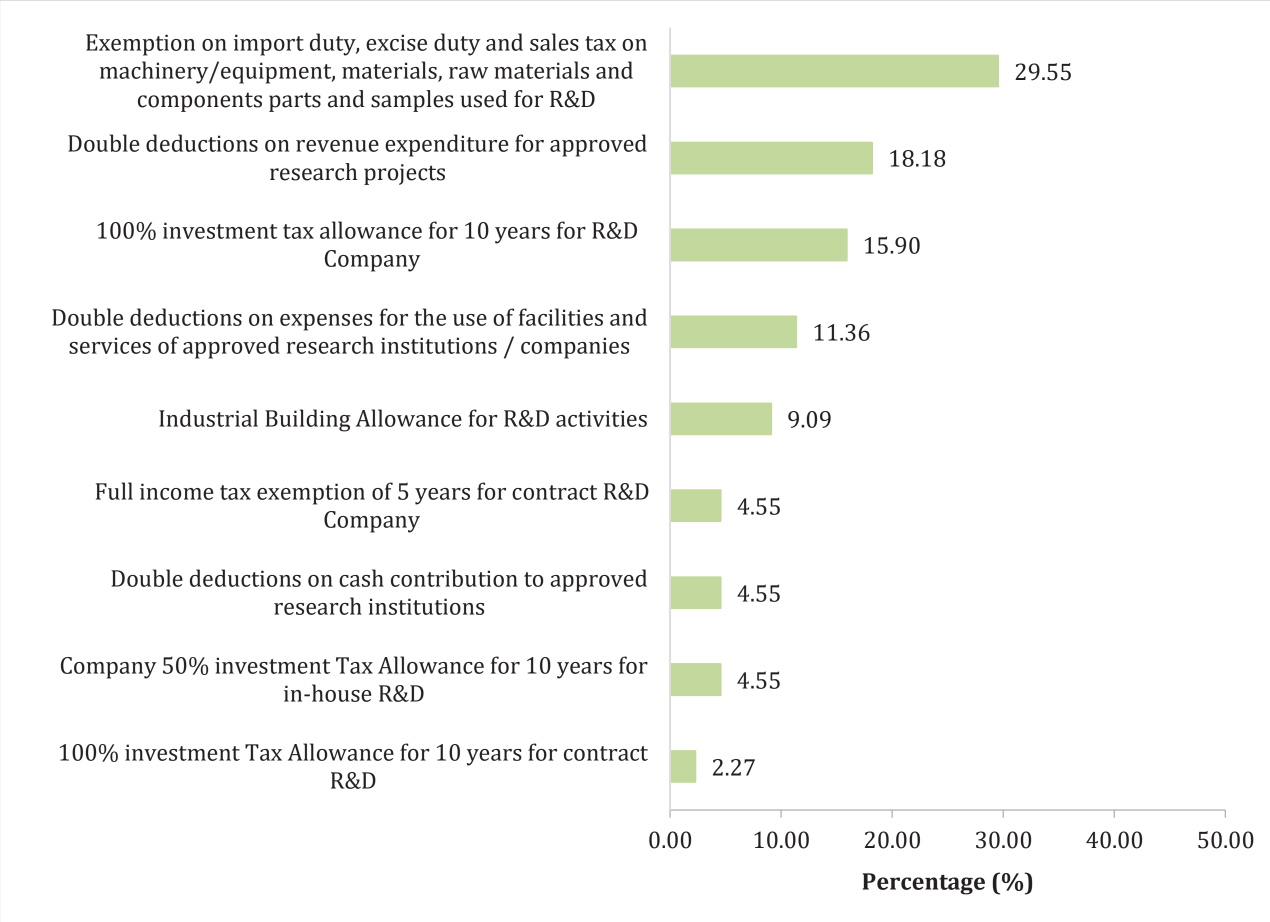
4.8 Research & Development Incentives

To encourage R&D activities in BEs, the government has introduced several types of incentives. Thus, in 2015 survey, the BEs were also asked about the types of R&D incentives received from the government, problems faced with R&D incentives application and reasons why the BEs were not taking advantage of R&D incentives offered by the government. The data was mainly based on the BEs which responded to this particular part of the survey; some BEs did not provide their responses to this part. The BEs can select multiple responses for this part, thus the report will be based on frequency.

4.8.1 Type of R&D Incentives

The first types of R&D incentives given by government to BEs is exemption on import duty, excise duty and sales tax on machinery/equipment, materials, raw materials and components and samples used for R&D (29.55%). The next is, double deductions on revenue expenditure for approved research projects (18.18%). The third one is 100% investment tax allowance for 10 years for R&D company (15.90%). This report was almost the same as in 2014 report. The top three incentives received by the BEs are still the same, except the first was exemption on import duty.

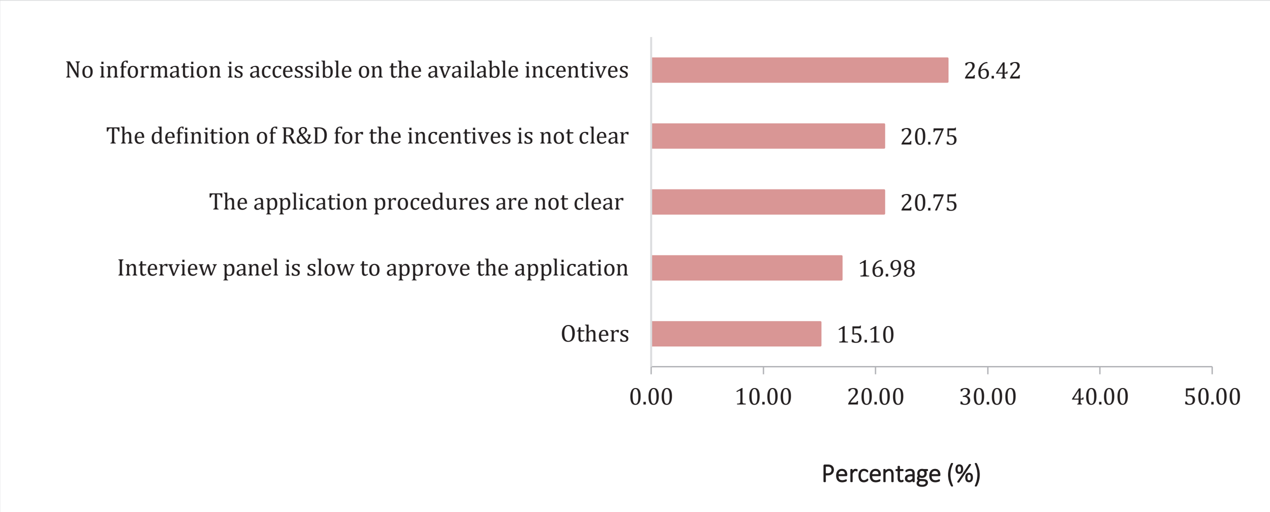
Figure 4.12: Types of Government R&D Incentives Received in BEs, 2015



4.9 Problem Faced with R&D Incentives Application

In Figure 4.13, BEs faced unique problems in applying R&D incentives for their companies as follows; no information is accessible on the available incentives, the definition of the R&D, application procedures are not clear and interview panel is slow to approve the application. The top three reasons suggest that there is a lack of awareness of information about the incentives. Apparently, the BEs are not aware of the government's one stop portal for R&D, 1Dana (http://www.1dana.gov.my/about_1dana.aspx). Therefore in the future, information regarding R&D incentives should be promoted more broadly to make BEs more aware of government support for R&D.

Figure 4.13: Problems Faced with R&D Incentives Application in BEs, 2015



4.9.1 BEs and Government R&D Incentives

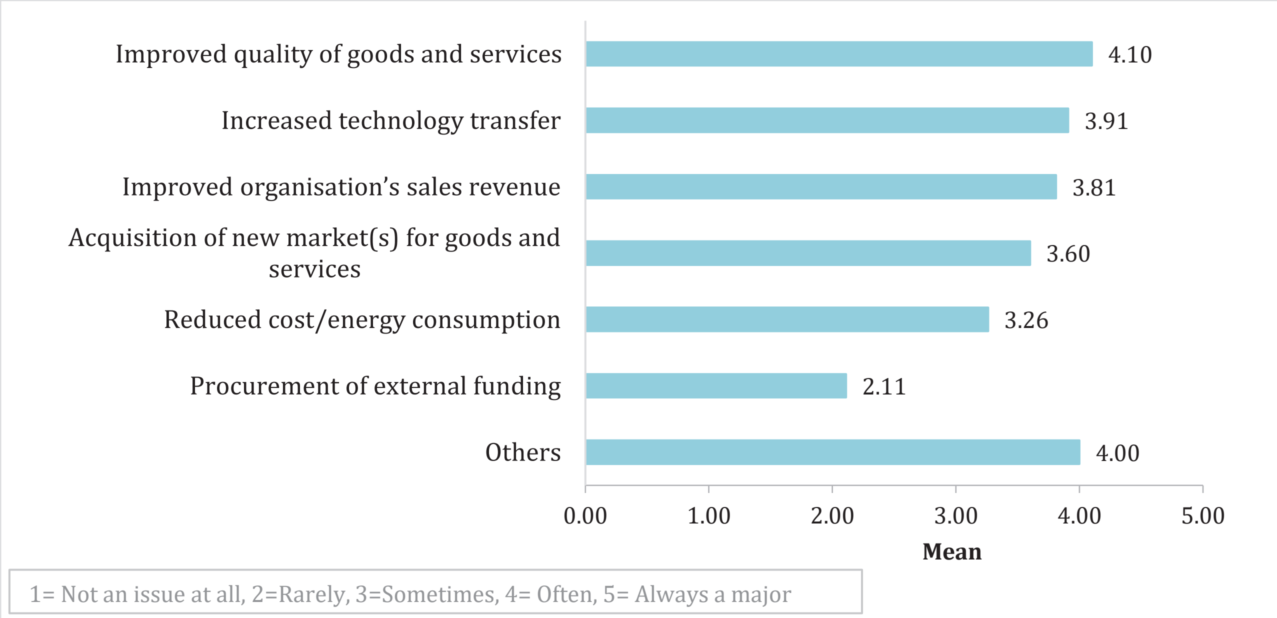
When asked the reasons of BEs not taking advantage of R&D incentives offered by the government, the most common reasons are as shown in Figure 4.14 which include lack of awareness of the availability of the incentives, and no knowledge about incentives application. This can be related to the earlier subsection which suggests lack of information/awareness. Other reasons include the projects and company do not qualify for the incentives and they do not have interest in the incentives offered by Government.

Figure 4.14: Reasons of BEs not taking advantage of Government R&D Incentives, 2015

4.9.2 Benefits Obtained from R&D Activities

Involvement in R&D activities brings a lot of benefits to BEs. As shown in Figure 4.15, the BEs indicated that R&D activities improve the quality of goods and services (Mean=4.10), increased technology transfer (Mean=3.91), improved organisation's sales revenue (Mean=3.81), acquisition of new market for goods and services (Mean=3.60), and reduced cost/energy consumption (mean=3.26).

Figure 4.15: Benefit Obtained from R&D Activities in BEs, 2015



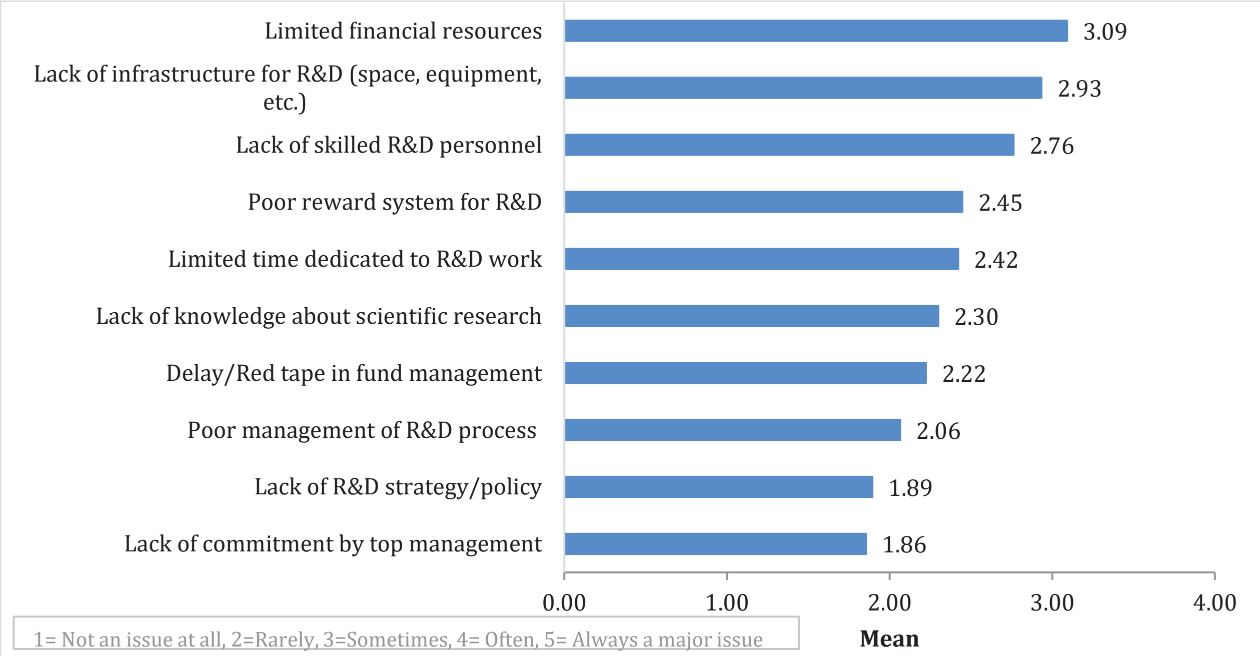
4.10 Limiting Factors of R&D Activities in BEs

In the present R&D national survey, the BEs were also asked to indicate the external and internal factors that limit their R&D activities. The next two subsections will highlight these factors which the BEs responded using a 5-point Likert scale (1 - not an issue at all, 2 – rarely is an issue, 3 - sometimes is an issue, 4 - often is an issue, 5 - always a major issue).

4.10.1 Internal Factors

In general, BEs do not face serious internal factors limiting their R&D activities. The mean scores for all except for limited of financial resources is below 3. As shown in Figure 4.16, the BEs indicated that the most common internal factors they faced are limited financial resources (Mean=3.09), lack of R&D infrastructure (e.g. space, equipment) (Mean=2.93), and lack of skilled R&D personnel (Mean=2.76).

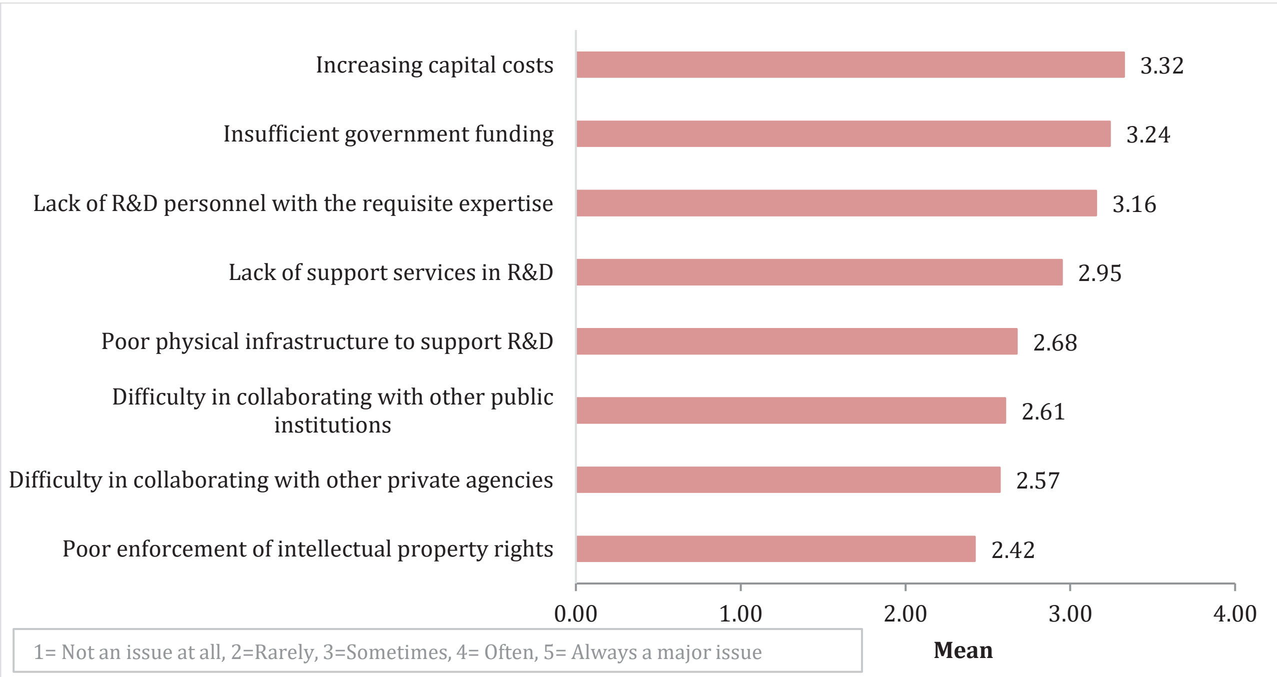
Figure 4.16: Internal Factors Limiting R&D Activities in BEs, 2015



4.10.2 External Factors

As for external factors as shown in Figure 4.17, the BEs highlighted that they faced increased capital costs (Mean=3.32), insufficient government funding (Mean=3.24), lack of R&D personnel with requisite expertise (Mean=3.16), and lack of support services for R&D (Mean=2.95).

Figure 4.17: External Factors Limiting R&D Activities in BEs, 2015



Box 4.1: Innovation to Wealth

As Malaysia seeks to become a high-income country, sustainable long-term growth will depend more and more on the contribution of innovation-driven productivity gains rather than increasing factor inputs. Innovation is central to sustainable growth policies as it drives the competitiveness of industries in international markets and their participation in global value chains (GVCs), generates improvements in the quality of products and processes (including government) and affects real incomes and social welfare through technology-driven enhancements in living standards. Particularly since 1996, Malaysia has utilised an increasing range of policy instruments to encourage additional innovation by public institutions (universities and public research institutions) and businesses (focussing on small and medium-sized enterprises – SMEs).

The Eleventh Malaysia Plan will focus on translating innovation to wealth through strengthening relational capital to foster stronger linkages, collaboration and trust among stakeholders. Stronger relational capital will improve coordination and enable the sharing and testing of ideas across multiple stakeholders and disciplines, thus improving the national innovation ecosystem to enable Malaysia to bring creative outputs to markets and share resources. Strategies are to be undertaken at both the enterprise and societal levels to sustain economic growth and improve wellbeing.

It is targeted the ratio of business and Government expenditure on R&D to be 70:30 in 2020.

(Source: OECD, ECONOMICS DEPARTMENT WORKING PAPERS No. 1370, 2017; Strategy Paper 21, Eleventh Malaysia Plan)

4.11 Conclusion

In conclusion, for Business Enterprise (BE) sector, there was a significant increase of 59.83% of total R&D expenditure for BE from RM4,279.40 in 2008 to RM6,839.67 in 2012. In 2014, the R&D expenditure slightly decreased by 6.73% to RM6,379.09 million as compared in 2012. For 2015 however, total expenditure for BEs increased to RM7,823.54 million. The increment was contributed by an increment in both current expenditure as well as capital expenditure.

Applied research received the highest spending. There was a drop of 24.58% in basic research. Experimental research slightly increased by 29.64% from previous year. As for Socio-Economic Objectives (SEO) R&D expenditure for BEs was predominantly on Sustainable Economic Development (43.07%). The top three highest R&D expenditure with more 95% of the total expenditure, namely Information, Computer And Communication Technology (ICT)(76.60%), Engineering and Technology (17.38%) and Biotechnology (2.92%).

In terms of source of funding, the percentage of funding by BEs increased to 94.05% from 66.50% in 2014. The funding from government decreased from 5.36% in 2014 to 3.85% in 2015. For other sources of funds (specifically foreign funds and others), the percentages have decreased from 28.14% to 2.10% in 2015.

The data on headcount of R&D personnel revealed that the total number of R&D personnel in 2015 was 14,621, the highest for the past 7 years. It increased by 33.50% from 2014. There was an increase in all categories of personnel, namely, 49.65% in researcher, 5.33% in technician and 16.28% in support staff.

An analysis of researchers by gender shows that female participation in BEs R&D has steadily increased from 2008 to 2015. The number of female researchers increased from 1,093 in 2008 to 3,315 in 2015. The male researcher participation also increased by 43.82%.

The total FTE increased from 2008 to 2012 but slightly decreased in 2014 (9,793.25), and increased by 12.48% in 2015. Although, the total FTE increased in 2015, the increment was only for researcher. There was a decrease of technician and support staff.

In 2015, the Intellectual Property shows some increases in the number of patent applied, patent awarded and trademark. However, there were some decreases in the number of copyright and industrial design. The number of copyright has dropped to 159 as compared 186. For industrial design, the number has dropped from 93 to 86.

In terms of location for R&D projects, the highest percentage is in Selangor (28.69%), followed by Penang (14.08%), and Wilayah Persekutuan Kuala Lumpur (13.07%). A few BEs indicated that they also conducted R&D outside Malaysia, such as Germany, India, China, Thailand, Japan and United Kingdom.

Some BEs outsourced their R&D due to lack of facilities and equipment to conduct R&D activities and not having sufficient skilled R&D personnel with requisite knowledge.

In general, BEs do not face serious internal factors limiting their R&D activities. Some of the external factor limiting the R&D activities are an increased capital costs, insufficient government funding, lack of R&D personnel with requisite expertise, and lack of support services for R&D.

Box 4.2: Innovation in SMEs

SMEs plays a big role in the Malaysian economy with its establishment of 98.5%. Out of 1,407 BEs participated in the 2015 survey, 1,072 are SMEs. It represents 76.19% of the BEs sector.

Total number of Business Enterprise (BEs)	**1,407**
Total number of SMEs	1,072

As reported earlier the total expenditures of BEs was RM7,823.54 million. Out of which, RM2,754.17 million is from SMEs. The total expenditures of SMEs is 35.20% of the total expenditures of the BEs. The SMEs' BERD per GDP is 0.24%. The BERD per GDP for BEs as a whole is 51.95%. This is based GDP 2015 (Current Price) = RM1,157,139M. This indicates that the business enterprises R&D expenditures in Malaysia is contributed mostly by large companies. With 23.81% representing the total number of BEs participated in the survey, large enterprises contributed to 64.80% of the total expenditures.

The Eleventh Malaysia Plan (2015), addresses the productivity and innovation as the most important pillars to drive the economy towards the desired stage. In doing so, the Malaysian government is determined in apportioning supporting resources to assist in the development of Malaysian SMEs. In order to unlock the innovation potentials and boost the domestic, regional, and global competitive advantage among Malaysian SMEs, the Malaysian government, in its Eleventh Malaysian Plan, embark a "game-changing" strategies to stimulate the economic growth by strengthening the innovation activities, developing competitive cities and building regional economic corridors to create vibrant hubs for investment platforms and providing an ecosystem that supports the creation of new talent and knowledge. Through the same plan, the economic growth will be underpinned by a strong policies; high-skilled talent in line with a stronger investment and productivity (EPU, 2015).

The Eleventh Malaysian Plan (EPU, 2015), underlines important agendas that will focus on improving collaboration among all stakeholders to reinforce the relationship capital among major stakeholders of the nation. At the enterprise level, the focus are to upgrade the demand-driven research, improve collaboration between researchers and industries to mould research outputs that is more relevant to business context, contribute ideas, infrastructure, tools, and expertise, as well as encourage private investment in research, development, commercialization and innovation (R&D&C&I).

(Source: EPU (2015). ELEVENTH MALAYSIA PLAN 2016-2020 ANCHORING GROWTH ON PEOPLE. (Economic Planning Unit, Ed.) Malaysia: Prime Minister's Department)

RESEARCH AND DEVELOPMENT IN HIGHER LEARNING INSTITUTIONS (HLIs)

CHAPTER 5: RESEARCH AND DEVELOPMENT IN HIGHER LEARNING INSTITUTIONS (HLIs)

5.1 Introduction

The measurement of research and development (R&D) in higher education sector is particularly important due to its contribution to the economic growth and prosperity of a nation. The knowledge generated by the R&D activities can be leveraged to fulfill the national aspirations to face global challenges as well as to enhance the societal well-being.

Higher education sector comprises of Higher Learning Institutions (HLIs) which is defined as universities or colleges of technology or other institutions providing formal tertiary education programs, whatever their source of finance or legal status, and all research institutes, centers, experimental stations and clinics that have their R&D activities under the direct control of, or administered by, tertiary education institutions (Frascati Manual, 2015).

HLIs in Malaysia have seen significant progress especially in R&D activities from the past decades as reflected in the rate of growth of research output which was amongst the highest in the world (Malaysia Education Blueprint, 2015-2025). It is imperative that continuous support from the government and private sectors in R&D activities to HLIs to be sustained in ensuring Malaysia's level of competitiveness in the global economic environment to thrive.

The focus of R&D activities in HLIs has been aligned to the many policies stated in Malaysia Education Blueprint. The following are the summary of the policies or called shifts written in the blueprint to further spur the excellence in R&D activities in the HLI sector.

Under the second shift in the blueprint, the focus is on the talent excellence, the goals are to improve and retain the qualified researchers as well as to attract excellent researchers. In this regards, the government, through Ministry of Higher Education, has laid down few initiatives including;

- Positioning HLIs according to their niche areas of institutional excellence,
- Enabling HLIs to develop multi-track career pathways,
- Providing best practice guidelines.

Under the fifth shift that focuses on financial sustainability, the goal is to move the system from fully dependent on the government resources to the one that is outcome centric and supported by the stakeholders. Amongst the R&D initiatives that is relevant to this shift is the incentivising creation of endowment and *waqf* funds to sponsor the R&D activities.

The sixth shift focuses on empowering the governance of HLIs. The objective is to ensure efficient functioning of the institutions. This is particularly important for private HLIs where the strengthening of quality assurance system could help the institutions to gain access to government research funding.

Under the seventh shift relating to innovation ecosystem the objective is summarised into quadruple helix concept where the academics, industries, government and local communities coming together in partnership for the incubation, development and commercialisation of research ideas. Amongst the initiatives involved are;

- Focusing on creating scale and growth,
- Playing a catalytic role in securing investments,

- Incentivising HLIs to establish supporting system for the commercialisation of ideas.

Under the eighth shift hovering on global prominence, the objective is to enable the academics and research experts to be recognised, referred to and respected as part of the initiative to rebranding the HLIs to the higher level of competitiveness. The shift is particularly important to attract excellent foreign researchers and students to serve and study in the local HLIs, hence the initiatives that has been strategized are;

- Collaborating with other ministries and agencies to streamline the immigration procedure,
- Increasing the proportion of postgraduate foreign students,
- Strengthening the promotion and marketing strategies.

The implementation of the shifts is divided into few round of waves under the blueprint roadmap as follows;

- Wave 1 (2015) – building momentum and lay foundation,
- Wave 2 (2016-2020) – accelerate system improvement,
- Wave 3 (2021-2025) – move towards excellence with increased operational flexibility,

where these initiatives are planned to take place over the span of 11 years.

This chapter presents a report on R&D performance and activities in Higher Learning Institutions (HLIs) sector in Malaysia for the financial year 2015. The performance is compared against the data recorded from the previous National R&D surveys (2008-2015) for the purpose of trend analysis of the data. For the National R&D survey 2016, a total of 109 HLIs has been identified and invited to participate in the survey. The survey started from 22 September 2016 and received 100% response rate in which 74 institutions reported the involvement in R&D activities as shown in Table 5.1.

Table 5.1: Number of Respondents for Higher Learning Institution Sector

Total sample	Respondent response with R&D conducted	Respondent response without R&D conducted
109	74	35

The focus of the analysis and discussion are based on the outlined R&D indicators specified in Frascati Manual 2015 especially on the R&D expenditure, source of funds and research personnel.

Box 5.1: R&D Initiatives in Malaysia Higher Education Blueprint 2015

The Ministry of Education has published a comprehensive document for the planning and development of growth of the higher education sector on 7 April 2015. The Malaysia Education Blueprint 2015-2025 (Higher Education) lays down the strategies to achieve five key aspirations and eight key targets that are "to create a higher education system that ranks among the world's leading higher education systems and enables Malaysia to compete globally."

The blueprint has drawn upon inputs from Malaysian and international education experts as well as global institutions such as UNESCO and, OECD and speaks of a need for "a fundamental transformation of how the higher education system and higher learning institutions (HLIs) currently operate" in order for the sector to stay ahead in global competition.

The five key aspirations are:

1. Instil an entrepreneurial mindset throughout Malaysia's higher education system and create a system that produces graduates with a drive to create jobs, rather than to only seek jobs;
2. Construct a system that is less focused on traditional, academic pathways and that places an equal value on much-needed technical and vocational training;
3. Focus on outcomes over inputs and to actively pursue technologies and innovations that address students' needs and enable greater personalisation of the learning experience;
4. Harmonise how private and public institutions are regulated, and to transition from the current, highly-centralised governance system for HLIs to a model based on earned autonomy within the regulatory framework; and
5. Ensure the financial sustainability of the higher education system by reducing HLIs reliance on government resources and asking all stakeholders that directly benefit from it to contribute as well.

The eight key targets are:

1. Increase number of international students from 108,000 today to 250,000 by 2025
2. Increase overall tertiary enrolment from 36% in 2012 to 53% in 2025 (1.4M to 2.5M)
3. Increase graduate employability to more than 80% by 2025
4. Improve league table performance by placing one university in Asia's Top 25, two in the Global Top 100 and four in the Global Top 200 by 2025.
5. Increase its U21 research output from 26th out of 50 countries to the top 25
6. Improve enrolment and completion rates for students from socio-economically disadvantaged backgrounds
7. Increase ethnic diversity and provide students with shared values
8. Maximise return on investment in higher education and maintain levels of Government expenditure per student

The vision for implementing the blueprint is framed around ten shifts that represent both the challenges and opportunities for the sector. The first four shifts focus on outcomes for key stakeholders, while the remaining six focus on broader "enablers" for the sector as a whole.

The vision will be implemented over the next decade in three waves. The first wave will establish the building blocks for transformation, the second will accelerate the pace of change by introducing more structural improvements and the third wave will aim to strengthen the prominence of Malaysia's higher education system.

Source: The Malaysia Education Blueprint 2015-2025 (Higher Education)

5.2 Gross Expenditure on Research and Development

This section presents the analysis of research expenditure involved to support R&D activities in HLIs for the year 2015 as well as benchmarked analysis from the data of 2008 to 2014 surveys.

5.2.1 Expenditure by Type of Cost

In 2015, the total amount spent on R&D activities by HLIs sector was estimated at RM4,288.84 million. Figure 5.1 breaks the figure down to current and capital expenditures respectively. Current expenditure which included labour cost and operating cost stood at RM3,483.35 million which constituted 81.22% of the total expenditure. The remaining balance of RM805.49 million which was 18.78% of the total expenditure was spent on capital expenditure to purchase fixed assets.

Figure 5.1: Expenditure by Type of Costs in HLIs, 2015 (in million)

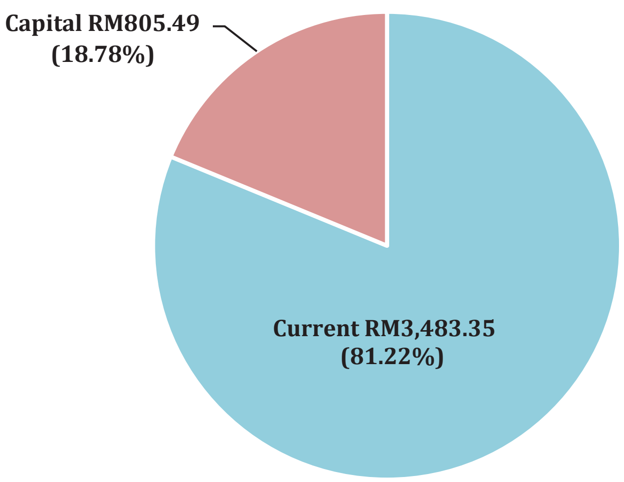
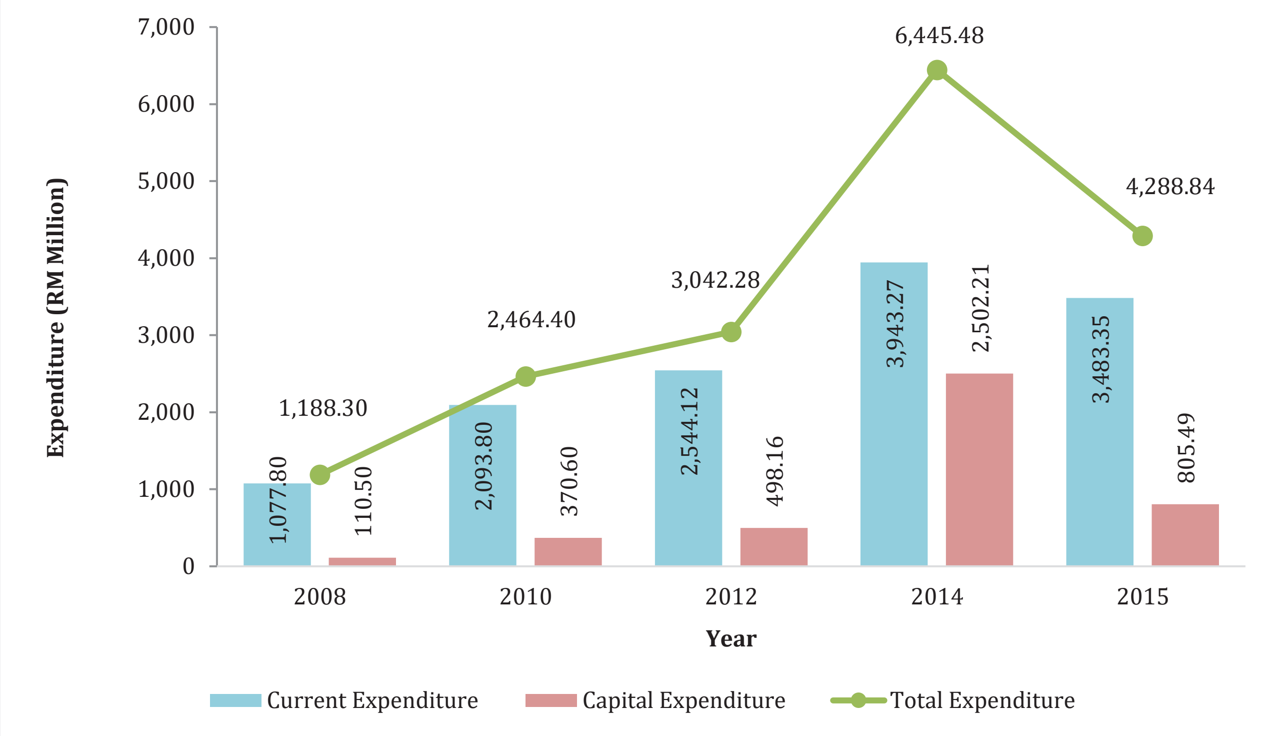


Figure 5.2 shows that the total expenditure in 2015 was considered favorably high eventhough the total amount dropped almost 33.5% from 2014. This was parallel to the economic climate in Malaysia in particular which see a drop in economic growth from 6% (GDP-annual variation) 2014 to 5% (GDP-annual variation) and as a result affecting the government spending on the HLIs especially of public type. The bigger drop can also be seen in the capital cost that represented lesser spending by the institutions to purchase fix assets in 2015 as compared to 2014. It is worth to be noted that there was a significant spending on land purchase for R&D activities in 2014 and that was not happening in 2015. Nevertheless the government was highly committed to support R&D activities by looking at the data trend from 2008 to 2012 which placed the 2015 data on the linear projection in term of R&D expenditure.

Figure 5.2: Expenditure by Type of Costs in HLIs, 2008-2015



5.2.2 Expenditure by Type of Research

The pie chart in Figure 5.3 shows that the biggest chunk of the expenditure representing 53.20% of the expenditure is to conduct basic research with the amount totaling up to RM2,281.68 million. Basic research was an experimental or theoretical work undertaken primarily to acquire new knowledge without a specific application in view (Frascati Manual 2015). The applied research took RM1,648.56 million out from the total expenditure which was equivalent to 38.44% of the total figure. Meanwhile, experimental research formed 8.36% from the total figure recording the amount of RM358.60 million. Based on the Frascati Manual, applied research involved original work in acquiring new knowledge with specific application in view and experimental research involves systematic work using existing knowledge gain from other research respectively.

Figure 5.4 shows the trend from 2008 to 2015 on the research expenditure based on the research types. It was interesting to note that despite the drop of total expenditure in 2015 as compared to 2014 figure, the amount spent on basic research maintained its positive trend from 2008 with the increase of almost 19.46% as compared to 2014 figure. The applied research suffered the biggest setback with the drop of almost 59.12% of the total expenditure from the year 2014 and the experimental research dropped 28.64%. The focus on basic research has reflected the initiative by HLIs in general to strengthen the fundamental issues in R&D on which the applied and experimental research would be built.

Figure 5.3: Expenditure by Type of Research in HLIs, 2015 (in million)

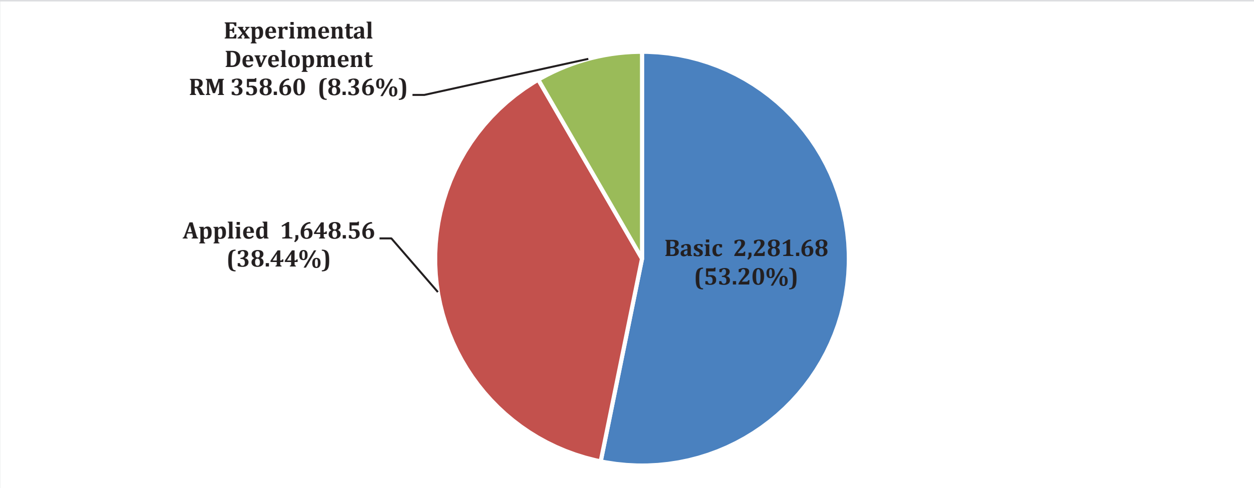
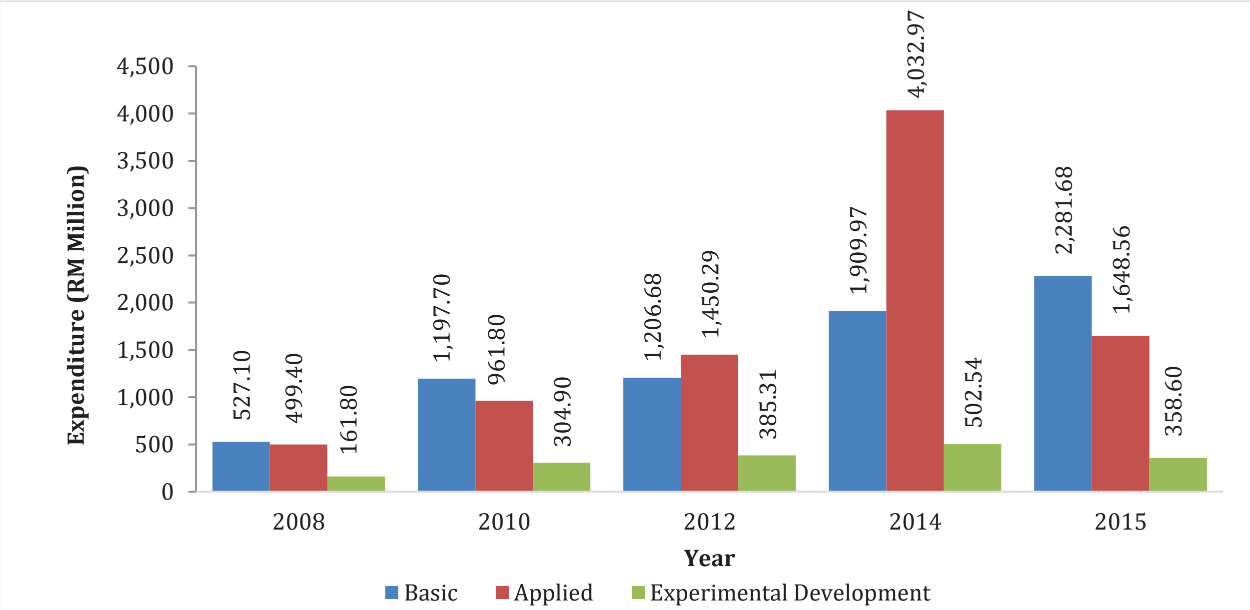


Figure 5.4: Expenditure by Type of Research in HLIs, 2008-2015



5.2.3 Expenditure by Field of Research and Socio-Economic Objectives

The identification of FOR is important as it could help the government to strategise its policy on generating sustainable economic growth. It is closely related to the societal needs in a way it could impact the socio-economic requirements of the society. FOR represents R&D activities classified according to the scientific and academic disciplines which tend to be universal and SEO allows R&D activities to be categorised according to the purposes or presumed sectorial benefits (MRDCS V6).

Figure 5.5 depicts the amount of expenditure on R&D activities based on the FOR for year 2015. The biggest amount spent was in Engineering and Technology field which accorded almost 29.72% of the total expenditure. This was followed by Natural Science (17.35%), Medical and Health Science (13.90%), Social Sciences (13.82%), Agriculture and Forestry (7.60%), ICT (7.05%), Economics, Business and Management (5.08%), Biotechnology (2.98%) and

Humanities (2.50%). As usual, the amount spent on Science and Technology (S&T) related fields remained dominating as almost 75% of total expenditure was spent on these fields.

Figure 5.5: Expenditure by Field of Research in HLIs, 2015 (in million)

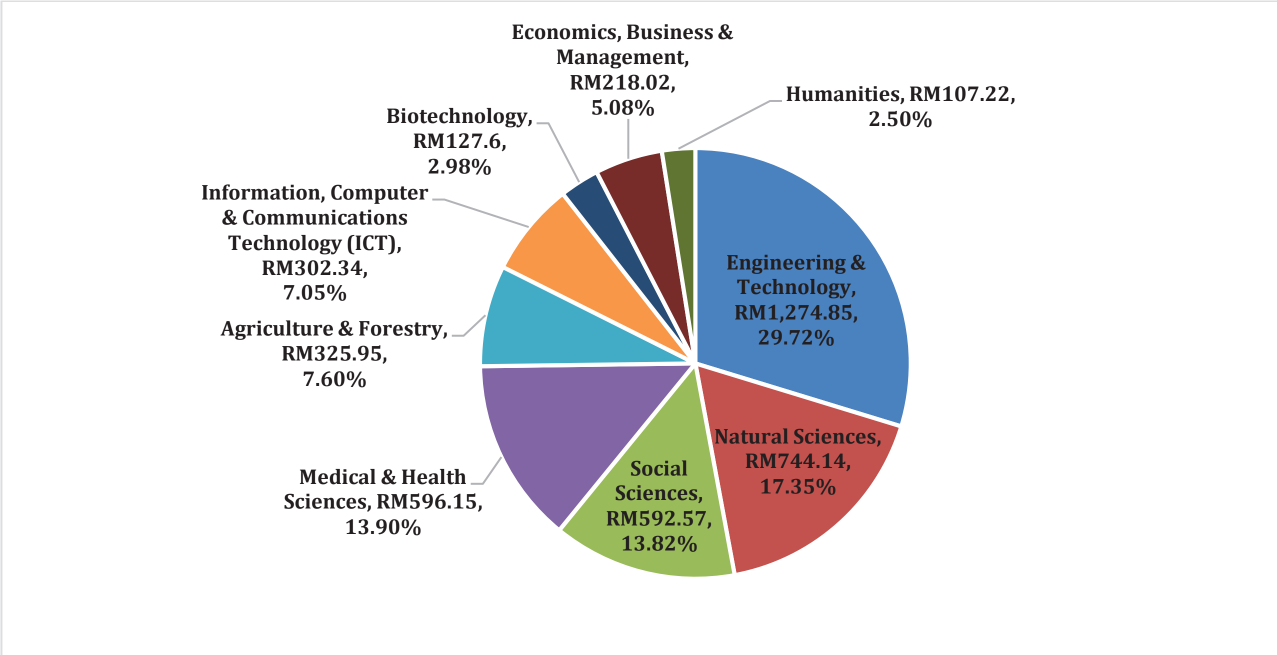
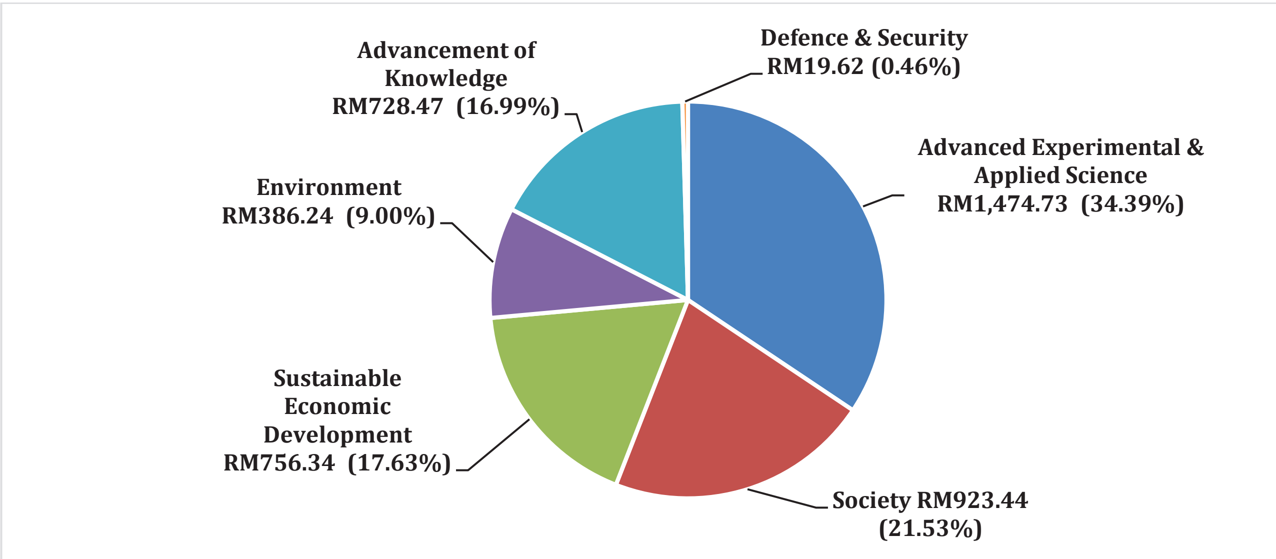


Figure 5.6 depicts the percent of expenditure on the respective SEOs. The highest expenditure of R&D activities was spent towards achieving Advanced Experimental and Applied Science objective with 34.39% of total expenditure. This was followed by Society (21.53%), Sustainable Economic Development (17.63%), Advancement of Knowledge (16.99%), Environment (9.00%) and, Defense and Security (0.46%).

Figure 5.6: Expenditure by Socio-Economic Objectives in HLIs, 2015 (in million)



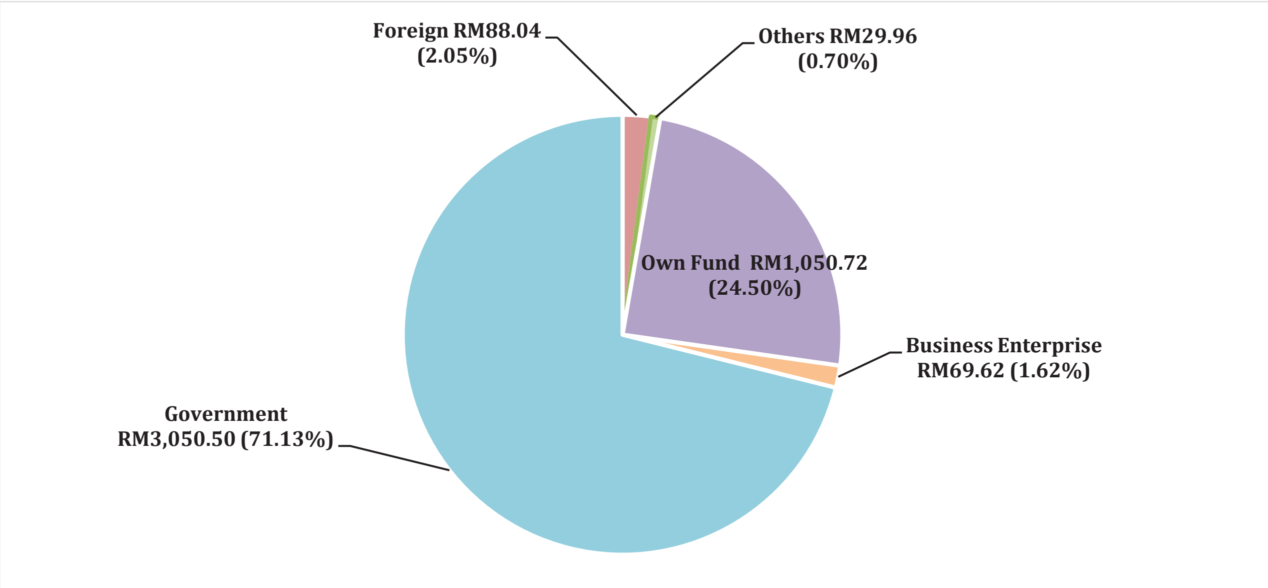
5.3 Sources of R&D Funds in HLIs

This section presents the analysis of source of funds to support R&D activities in HLIs for the year 2015 surveyed and benchmarked analysis based on the data from 2008 to 2014 surveys.

5.3.1 Sources of R&D Funds

Figure 5.7 shows the source of funds to support R&D activities in HLIs for year 2015. The biggest contributor was the Government which contributed 71.13% of the total fund. This was followed by the Institution itself (24.50%), Foreign Agencies (2.05%) and Business Enterprise (1.62%).

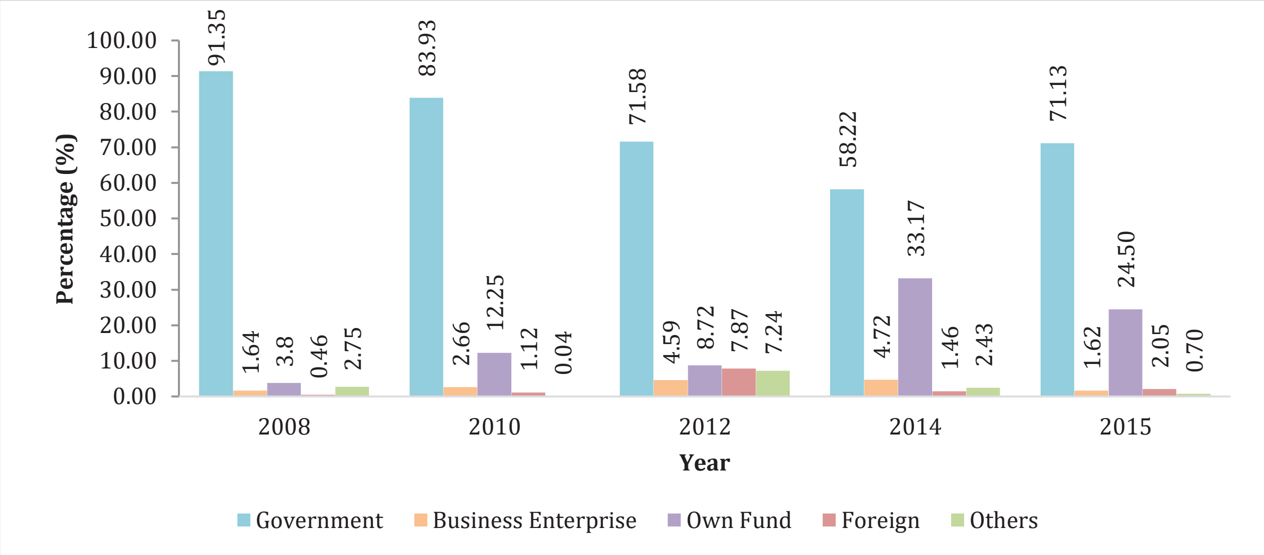
Figure 5.7: Sources of R&D Funds in HLIs, 2015 (in million)



Throughout 2008 to 2015 the government has been the major contributor to fund R&D activities in HLIs. This was apparent from the data shown in Figure 5.8. Though the downward trend from 2008 to 2014 was shown in the figure, it spiked up again in 2015 in term of percent of total fund. The reason might be due to the difficulties faced by the HLIs to generate their own funds due to the economic climate at that time. It was supported by the fund contributed by the Business Enterprise which seemed to be invisible as opposed to the past surveyed data.

However the trend was expected to be reversed in the near future as initiatives have been taken by the government under the seventh shift of Malaysia Education Blueprint 2015-2025 (Higher Education) to spur partnership between the academics, industries, government and local communities to incubate, develop and commercialise research ideas from R&D activities.

Figure 5.8: Sources of R&D Funds in HLIs, 2008-2015



5.4 Human Resource Development

This section presents the analysis of human resource development to support R&D activities in HLIs for the year 2015 surveyed and benchmarked analysis based on the data from 2008 to 2014 surveys.

5.4.1 Headcount of R&D Personnel

Research personnel are persons who have been employed to conduct R&D activities as well as those who provide direct services for R&D. Figure 5.9 depicts the proportion and number of research personnel involved in R&D activities in the HLIs for the year 2015. 73,291 person has been employed as researchers who comprised of academic staff and graduate research students in the HLIs. This was 71.13% from the total 103,045 persons employed. The remaining personnel was consisted of support staff who represented 22.07% or 22,739 personnel out of the total and technician who formed 6.80% of the workforce that was translated to 7,015 personnel.

Figure 5.9: Headcount and Proportion of R&D Personnel in HLIs, 2015

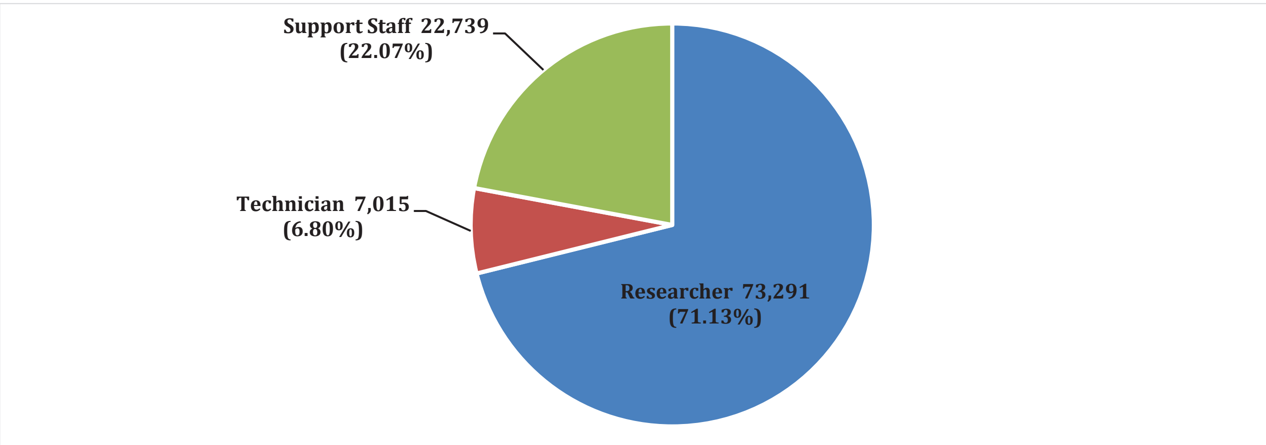


Figure 5.10: Headcount of R&D Personnel in HLIs, 2008-2015

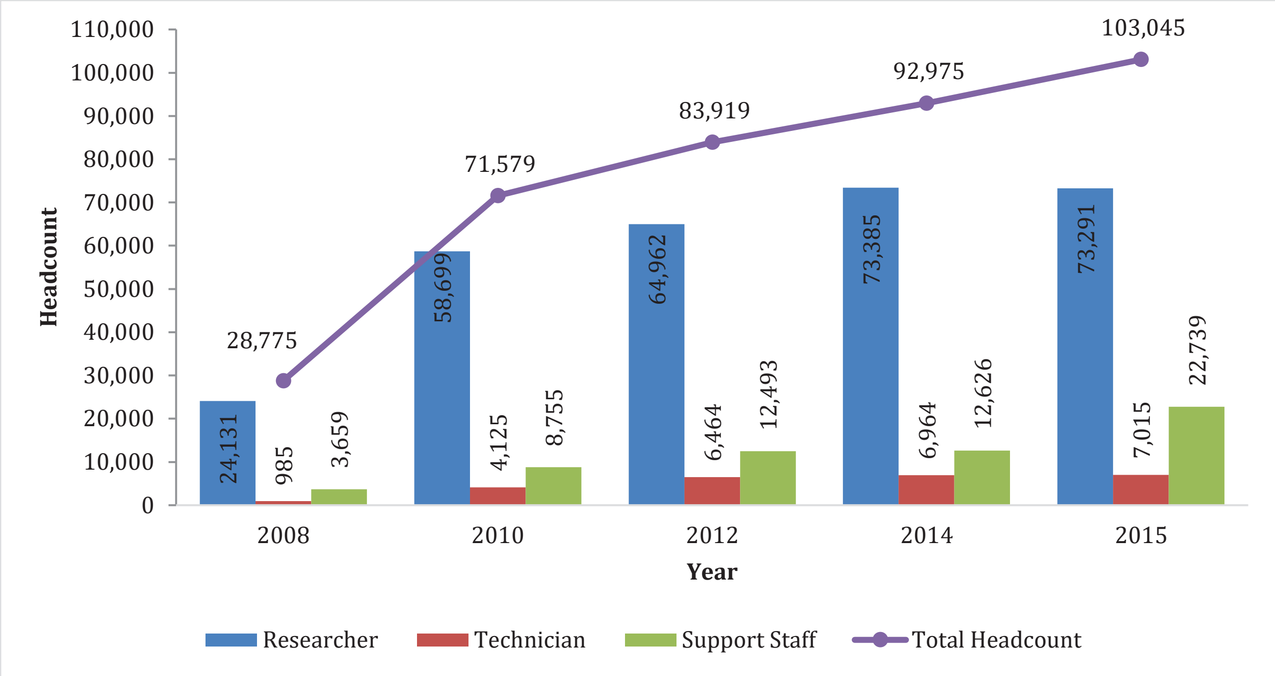


Figure 5.10 shows the data from 2008 to 2015 on the number of research personnel which recorded a steady increase in the number. It was also noted that there was a big increase in the number of support staff from the year 2014 to 2015 whereas the number of researchers and technician seemed stable during the same period of time.

5.4.2 Headcount and Proportion of Researchers by Gender

In 2015, the proportion of female to male researchers seems balanced as shown in Figure 5.11 with a very small difference of 49 persons from the total 73,291 researchers. Similar trend has been recorded since 2010 as shown in Figure 5.12.

Figure 5.11: Researchers by Gender and Its Proportion in HLIs, 2015

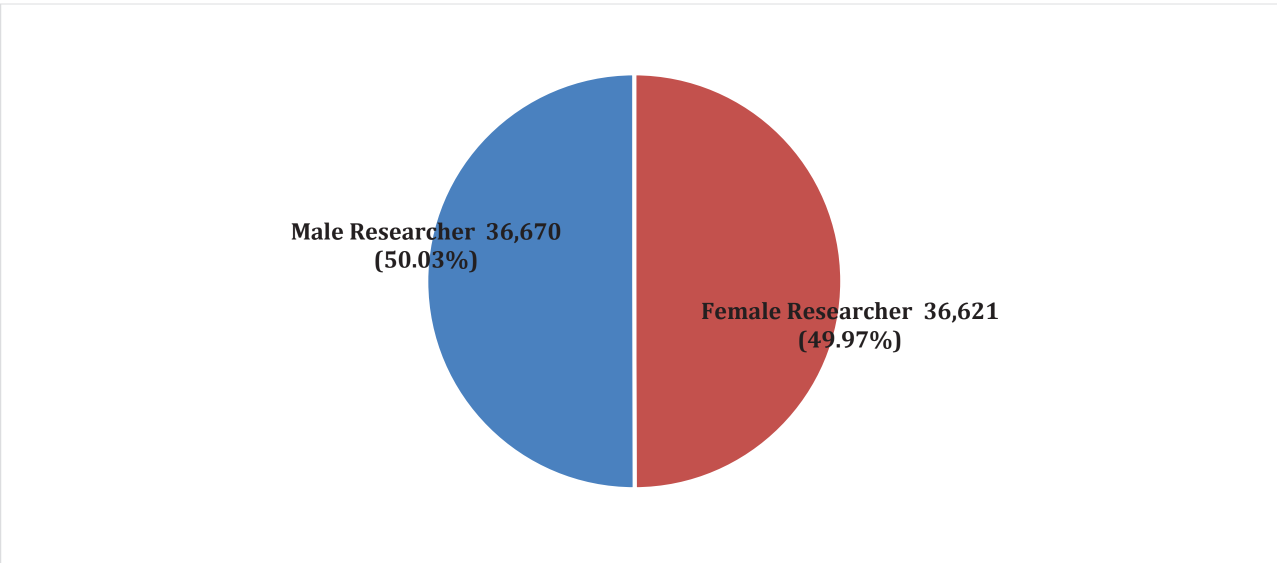
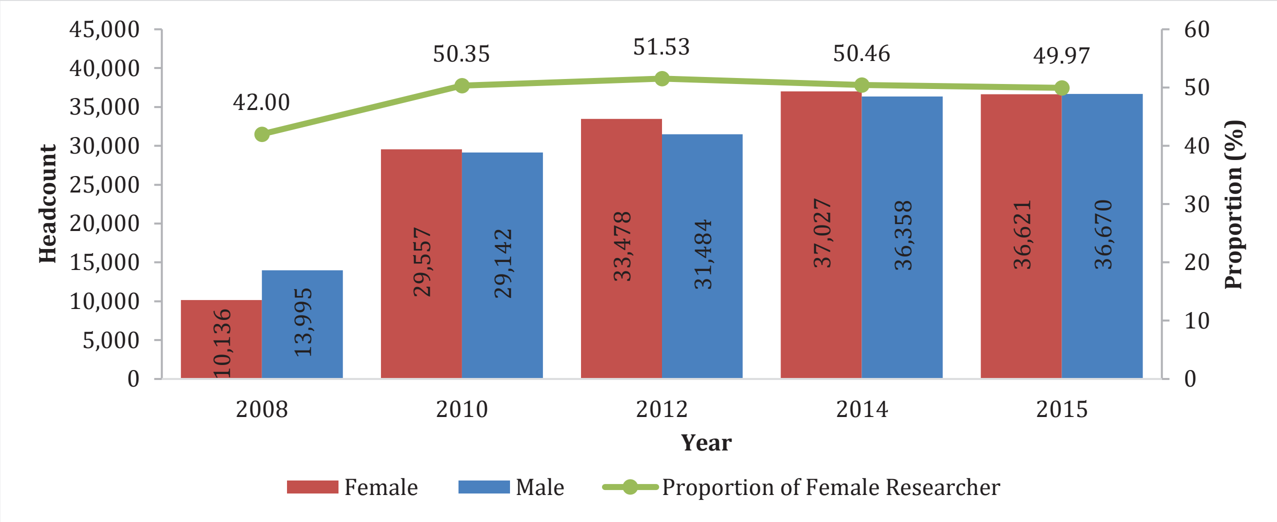


Figure 5.12: Headcount of Researchers by Gender in HLIs, 2008-2015



5.4.3 Proportion of Researchers (Internal) by Age Group

Headcount by age group of researchers was a new indicator introduced in the National Survey of R&D 2016. Table 5.2 records the age group data tabulation and it showed the highest percentage of age group of researchers was between 35 to 44 years old which constituted 37.16% of total researchers. Out of this figure the female researchers formed the bulk of the number as much as 20.58%. As expected the researcher under the age of 25 was the least age group number recorded as for this age group in HLIs, the researchers were the students who were still studying at bachelor degree level.

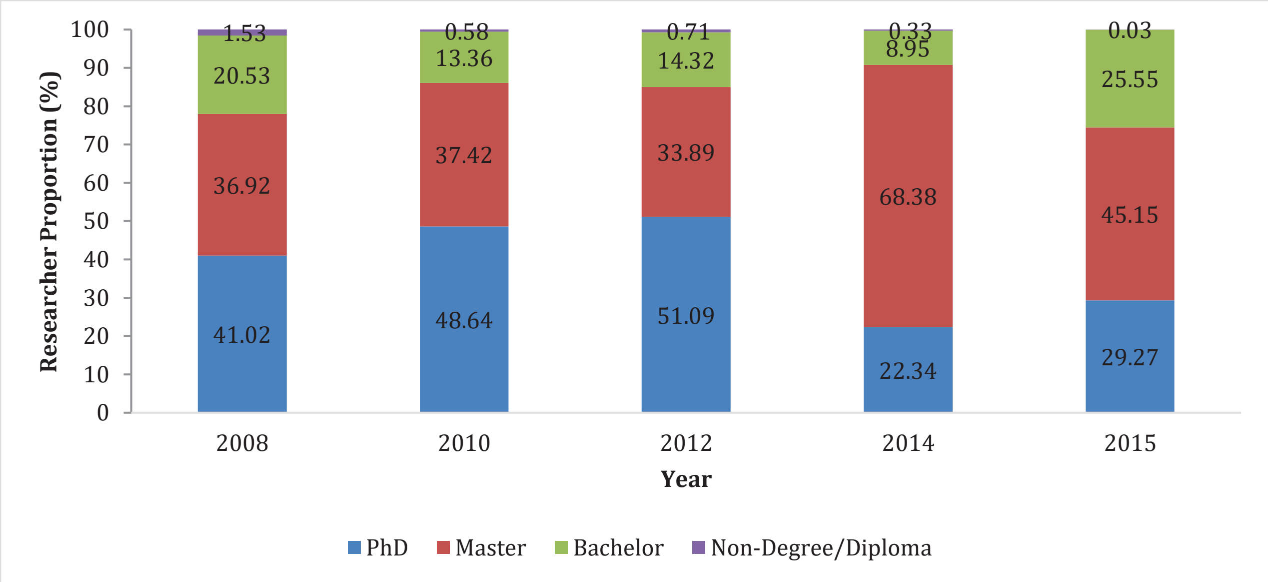
Table 5.2: Proportion of Researchers (Internal) by Age Group

	Under 25	25-34	35-44	45-54	55 and more
Male (%)	0.67	9.66	16.58	11.97	7.56
Female (%)	0.57	16.55	20.58	11.37	4.49
Total (%)	1.24	26.21	37.16	23.34	12.05

5.4.4 Proportion of Researchers by Qualifications

Figure 5.13 shows the distribution of researchers based on qualification from the surveyed data of 2008 to 2015. It has to be clarified here that in the 2008-2012 data, the graduate student at PhD level was considered to have PhD qualification, whereas in the 2014 & 2015 data they were considered to have Master qualification. For year 2015, the researcher with PhD qualification is recorded to be 29.27% which marked an increase of 6.93% from the data in 2014. For the researcher with Master qualification, there is a drop as much as 23.23% over the 2014 data.

Figure 5.13: Proportion of Researchers by Qualification in HLIs, 2008-2015



5.4.5 Internal R&D Personnel Flow

Internal R&D Personnel Flow was also a new indicator introduced in the National Survey of R&D 2016. It can be seen from Table 5.3 that the number of researchers recruited in 2015 was higher than the one retiring with a ratio of 2 to 1. For technician, 87.86% out of total technicians involved in the flow process were the new recruits and the balance 12.14% are the retirees. The same trend was recorded for support staff where the number of new recruits form 62.93% of total support staff and the remaining formed the percent of those retiring in 2015 as much as 37.07%.

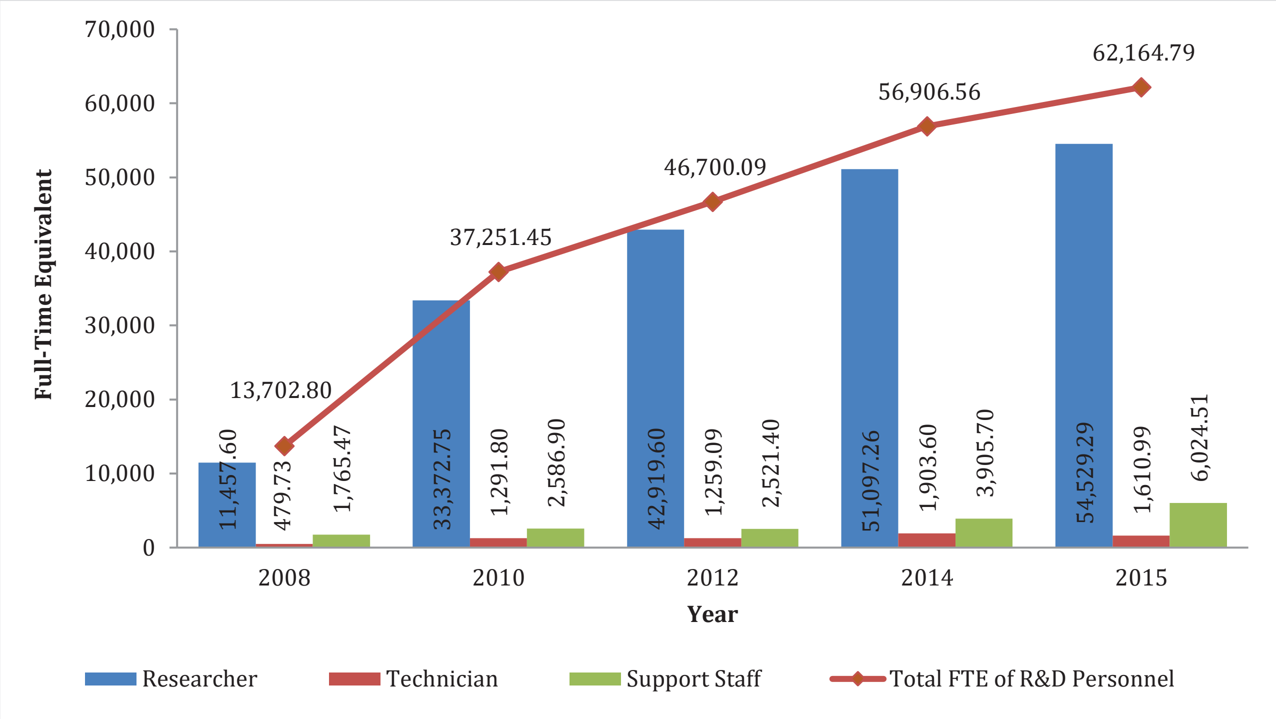
Table 5.3: Internal R&D Personnel Flow in term of New Recruitment and Retirement in HLIs, 2015

	Researcher	Technician	Supporting staff
Recruited in 2015	2,287 (66.29%)	876 (87.86%)	1,195 (62.93%)
Retiring in 2015	1,163 (33.71%)	121 (12.14%)	704 (37.07%)

5.4.6 Full-Time Equivalent of Research Personnel in HLIs

The increasing number of research personnel in 2015 was reflected in the calculation of full time equivalent (FTE) of the research personnel in 2015 as shown in Figure 5.14. FTE was the unit measurement for R&D personnel and it showed one's effort in conducting R&D related activities per year. As such, the increasing trend can be seen in the FTE profile for researchers and support staff from 2008 to 2015. The FTE for technician seemed balanced throughout 2010 to 2015.

Figure 5.14: Full Time Equivalence of R&D Personnel in HLIs, 2008-2015



5.5 Research Output

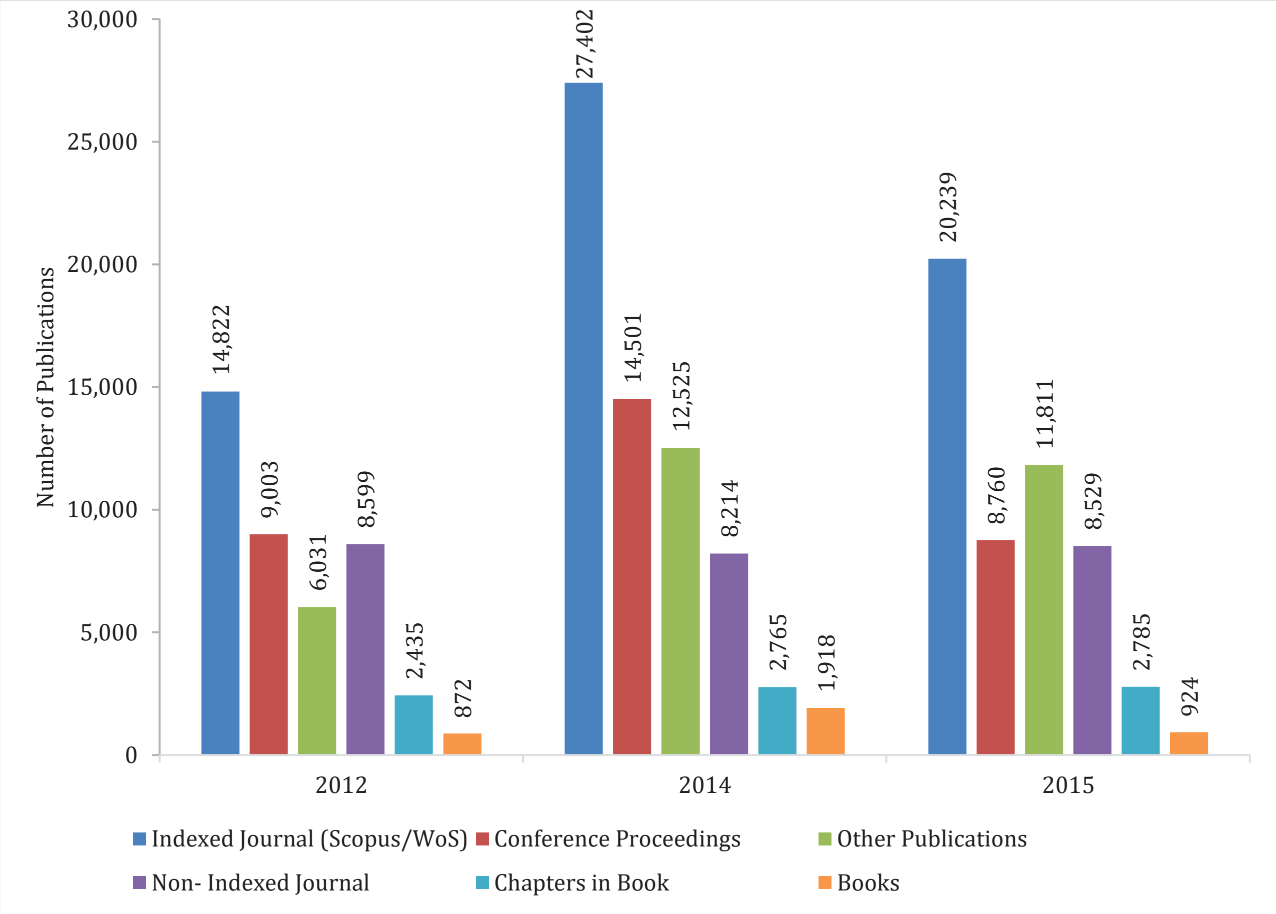
This section presents the analysis of research output from R&D activities in HLIs for the year 2015 surveyed and benchmarked analysis based on the data from the 2012 to 2014 surveys.

5.5.1 Publication

Research output by publications was relatively new indicator to the National R&D survey introduced in 2013 survey. In general for all type of publications, the numbers recorded in 2015 survey showed drops as compared to 2014 data but still higher that what was captured in 2012 as shown in Figure 5.15. The data for chapters in books and non-indexed journals from 2012 to 2015 seemed consistent. However, index journal and conference proceeding suffered the biggest drop from 2014 data sample as much as 26.14% and 39.59% respectively.

This trend might be due to incomplete estimated data derived from the survey and partly related to the drop of total expenditure in R&D activities recorded in 2015 against 2014 expenditure.

Figure 5.15: Number of Publications in HLIs, 2012-2015



Box 5.2: Statistics from Secondary Sources on Publications, Patents and International Collaborations

Total number of publications has shown a drop of 3.34% from 25,445 in 2014 to 24,595 in 2015 based on the data extracted from Scopus database. However, there were mixed trends observed, when looking from different type of publications perspective. For every 100 researchers, the number of indexed journals produced has shown an increase of 10.42% in 2015 against 2014 figure. Increasing trend has also be seen in the non-indexed journal type where it accorded 26.16% increase over the same period of time. However, for conference proceeding, it marked a significant drop as for every 100 researchers, only 6.92 papers were produced in 2015 as compared to 10.50 papers in 2014. That resulted in 34.10% drop. It was also interesting to note that in term of international collaboration, there was an increase of 1.70% in joint authorship of the total publications.

Publications	2014	2015
Indexed Journal Article	16,268	17,940
*Non indexed Journal Article	5,558	7,001
Conference Proceeding	7,709	5,070
Book	30	50
Chapter in Book	382	394
Other publications (ie Review , letter, editorial material)	1,056	1,141
Total (excluding non-indexed journal)	25,445	24,595
International Collaboration	2014	2015
HLI	34.10%	35.80%

International Collaboration	2014	2015
HLI	34.10%	35.80%

Statistics on Publications	2014	2015
Indexed Journal Article per 100 researchers	22.17	24.48
*Non-indexed Journal Article per 100 researchers	7.57	9.55
Conference Proceeding per 100 researchers	10.50	6.92

Based on the data obtained from MyIPO database on the number of patent applied, for every 100 researchers, the figure stood at 0.79 applications in 2014 and dropped to 0.71 in 2015. This accounted to a total of 10.13% drop over the period of time. Meanwhile, from the analysis on the patent granted, for every 100 researchers, there were 0.25 patent granted in 2014 and 0.20 in 2015. These figures reflected a drop in patent granted as much as 20%.

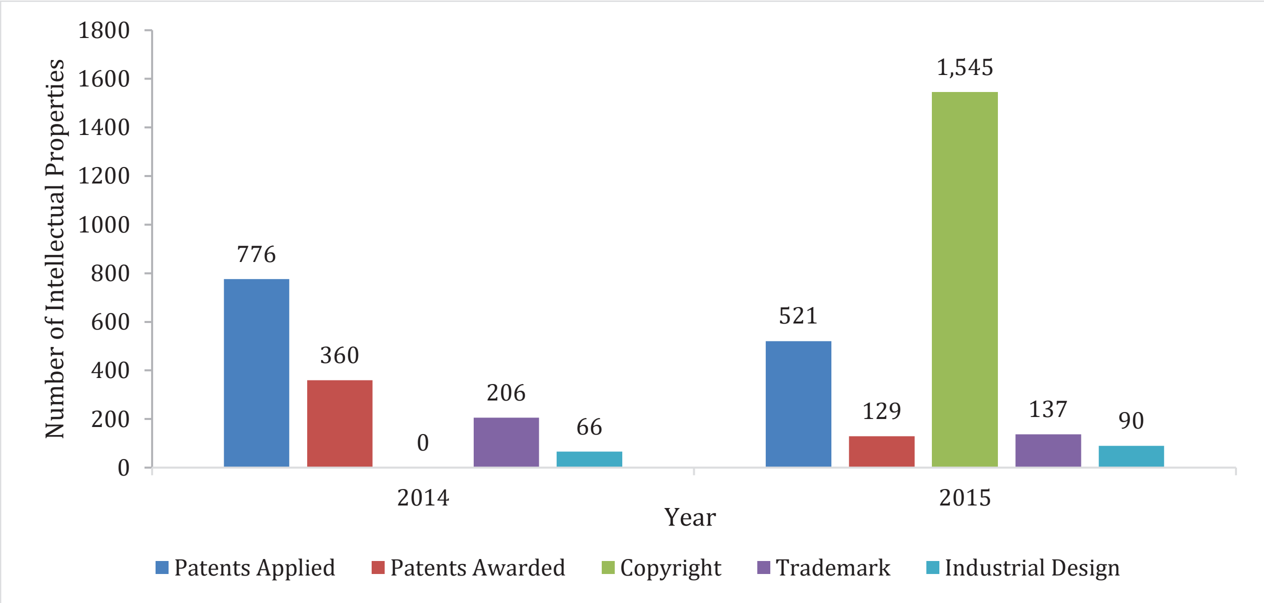
Statistics on Patents	2014	2015
Number of Patent Applied	583	569
Patent Applied per 100 researchers	0.79	0.71
Number of Patent Granted	187	143
Patent Granted per 100 researchers	0.25	0.20

(Source: MyIPO database, Scopus database, *MyJurnal database)

5.5.2 Intellectual Property and Revenue Generated

In the survey conducted to study the 2015 R&D activities in term of research outputs, the type of intellectual properties (IPs) was extended to include copyright. From Figure 5.16, this new indicator has accumulated a total number of 1,545 copyrights. It can also be seen in the figure that the number of patents awarded and trademarks has dropped from the previous surveyed data as much as 64.17% (2014) and 33.50% (2014) respectively. The trend on patent in particular, was also corroborated by the statistics provided by MyIPO database. The high cost of filing and maintaining patents on top of the drop on R&D expenditure contributed to the trend.

Figure 5.16: Number of Intellectual Properties in HLIs, 2014-2015



Revenue generated from the R&D product was a new indicator introduced in the National Survey of R&D 2016. The data was tabulated in Table 5.4 which showed that the number of products that has been licensed through patent and technology know-how to be 76 with total revenue generated to be RM41.56 million. Meanwhile RM10.74 million worth of revenue has been gained from 70 commercialised products.

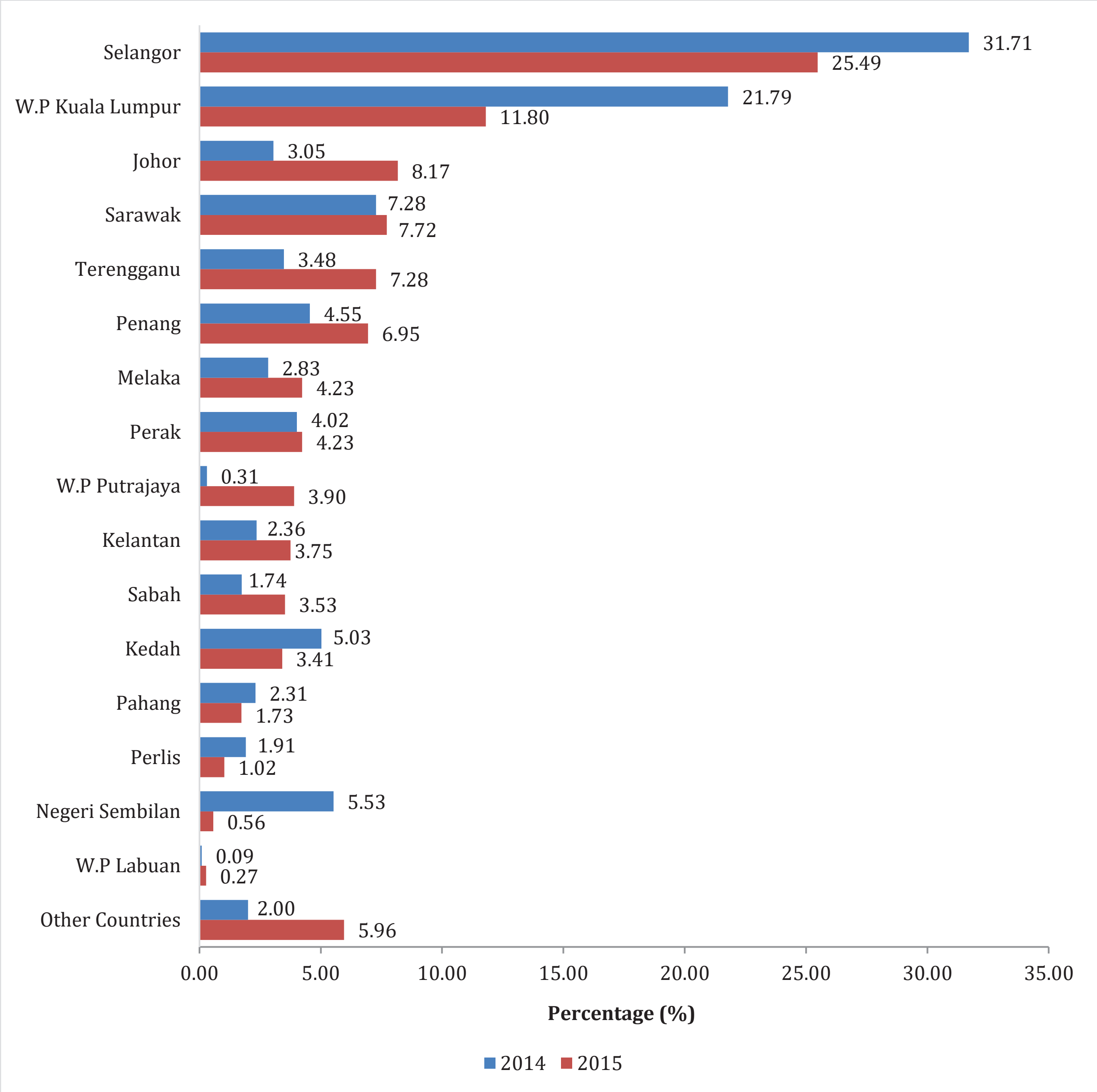
Table 5.4: Number of Products and Revenue Generated in HLIs, 2015

	Total number	Revenue (RM Million)
Patents licensing and technology know-how licensing	76	41.56
Commercialised product	70	10.74

5.6 Distribution of R&D Projects by Location

Location where the research was being conducted by the R&D personnel was introduced in National Survey of R&D 2016 to study the trend of 2014 R&D activities. Figure 5.17 shows the location data in term of percentage for year 2014 and 2015 surveyed. It was noted that the states that recorded an increase in R&D activities for more than 50% as compared to 2014 data were W.P. Putrajaya, W.P Labuan, Sabah, Terengganu and Johor. Meanwhile, Negeri Sembilan was the only state that recorded the decrease for more than 50% of R&D activities.

Figure 5.17: Distribution of R&D Projects by Location in HLIs, 2014 and 2015



5.7 Projects Outsourced

5.7.1 Project Being Outsourced to HLIs

The R&D indicators under this section were introduced in the National Survey of R&D 2016. It reported on the R&D projects being outsourced to the HLIs and R&D projects outsourced by the HLIs for year 2015. The data on the outsourced project by the HLIs to other institutions was omitted in this report as the data obtained from the survey was only from a single institution and thus, not relevant to HLI sector in general.

Table 5.5: Projects Being Outsourced to HLIs, 2015

Projects Being Outsourced	RM Million		
	Within Malaysia	Outside Malaysia	Total amount
From Business Enterprise	9.40	6.56	15.96
From Government Agency and Research Institute	70.59	3.35	73.94

From Table 5.5, it was clear that Government and Research Institute within Malaysia has been outsourcing many R&D projects to HLIs amounting to RM70.6 million. This was followed by the BEs within Malaysia that contributed RM9.4 million worth of projects to HLIs. Though the potential for the local HLIs to receive outsourced project was huge, the major contributors remains within local sectors. Hence, it was vital for the HLIs to promote R&D expertise, skills and facilities to a higher level, as reflected in the government initiatives (Malaysia Education Blueprint) that was to bring up the HLIs to global prominence.

5.7.2 Projects Collaborated with Others in HLIs, 2015

Number of collaboration in R&D projects was another new indicator introduced in National Survey of R&D 2016. Table 5.6 shows the number of research collaborations in HLIs for year 2015. It was noted that 3,221 collaborated R&D projects have been conducted within Malaysia and 495 projects outside Malaysia.

Table 5.6: Number of Projects Collaborated with Others in HLIs, 2015

Collaborated Projects	Total Number
Within Malaysia	3,221
Outside Malaysia	495

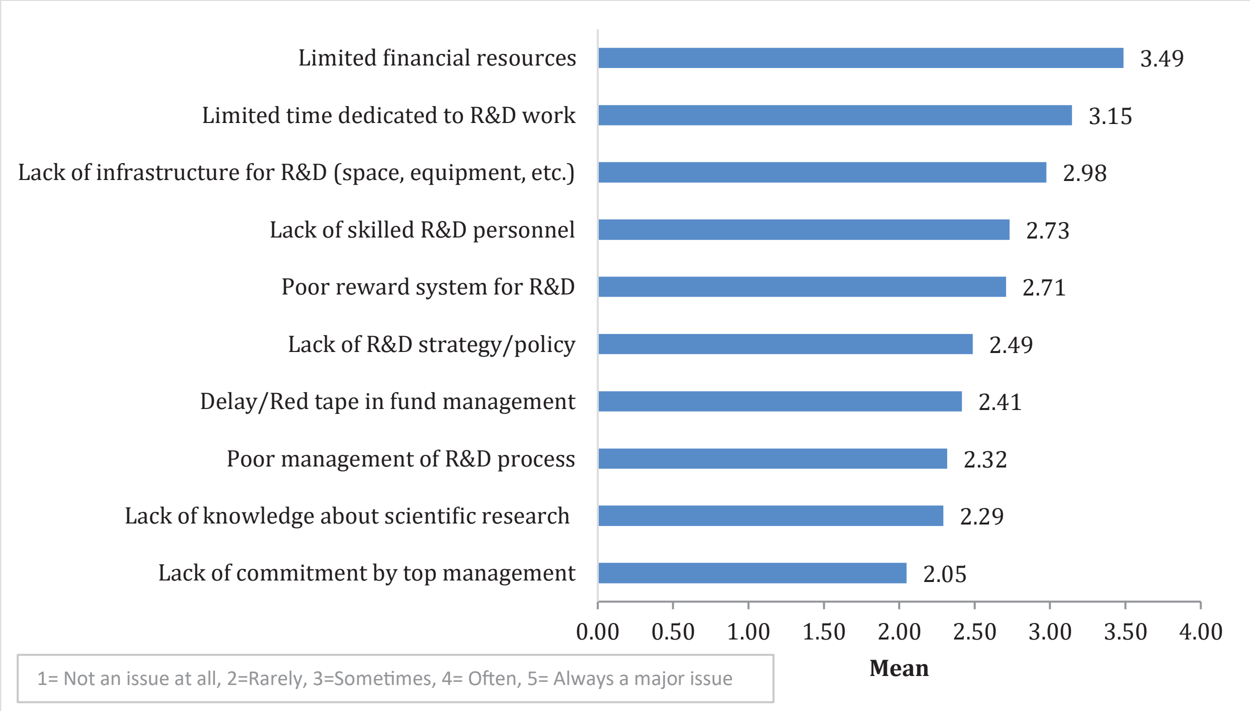
5.8 Limiting Factors of R&D Activities in HLIs

Other information included in the National Survey of R&D 2016 were the internal and external factors that limiting R&D activities. This information were measured based on Likert scale where,1 – not an issue at all, 2 – rarely an issue, 3 – sometimes an issue, 4 – often is an issue, 5 – always a major issue.

5.8.1 Internal Factors

As can be seen in Figure 5.18, the top three internal factors limiting R&D activities were limited financial resource, limited time to dedicate to R&D work, and lack of infrastructure for R&D. It was interesting to note that time factor was still a limiting factor for the researchers to conduct R&D activities. Despite of having the total researcher FTE increased as compared to the previous survey, the total number of researchers seemed stable during the same period of time. This might suggest the researchers' perception towards the annual key performance index (KPI) imposed on them which was ever increasing especially in term of the need to produce more of research outputs. At the same time the KPI required them to fulfill other responsibilities in teaching, consultation and administration.

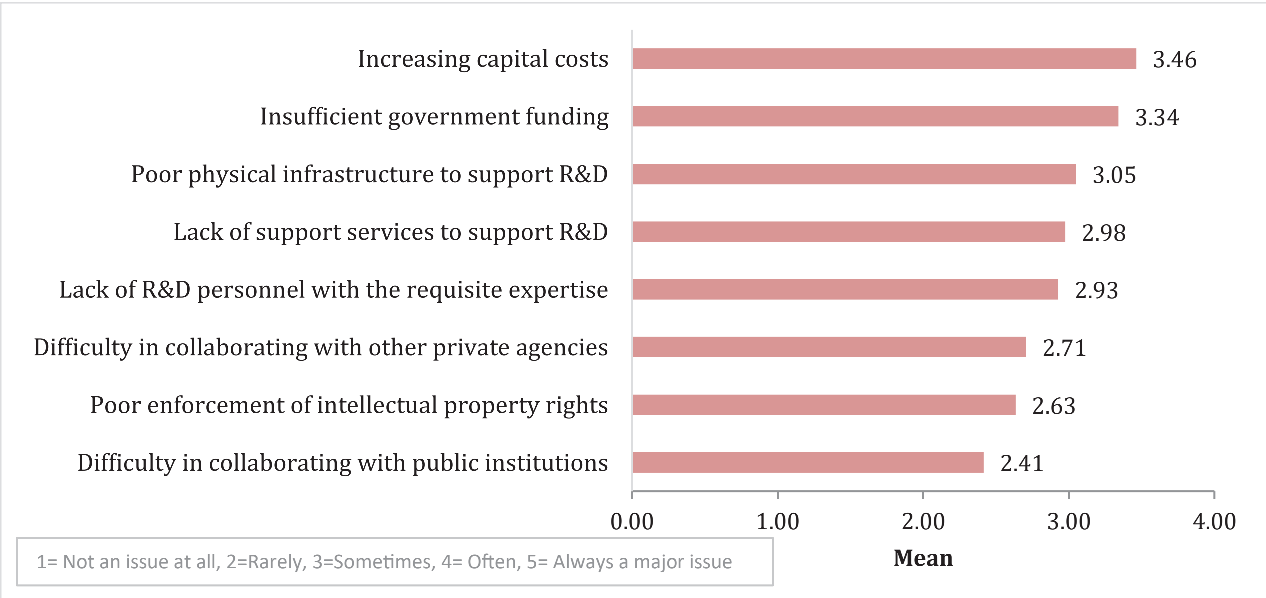
Figure 5.18: Internal Factors Limiting R&D Activities in HLIs, 2015



5.8.2 External Factors

From Figure 5.19, the top three external factors that limit the R&D activities are increasing capital cost, insufficient government funding and poor physical infrastructure to support R&D.

Figure 5.19: External Factors Limiting R&D Activities in HLIs, 2015



5.9 Conclusion

The total expenditure for R&D activities in Malaysia relied on the economic growth of the nation. From 2008 to 2012 the total expenditure increased at almost an averaged constant rate of 35.40% and jumped to around 52.80% in 2014. In 2015 somehow the country has recorded a drop in GDP from 6% (2014) to 5% (2015). It was reflected in the total expenditure of R&D in 2015 which recorded a drop of almost 33.40%. Nevertheless, by projecting the 2008-2012 data to 2015 the total expenditure recorded can still be considered very high. This proved the degree of government commitment towards R&D activities in HLIs in Malaysia. The claim was substantiated from the amount of source of fund the government has contributed which account for 71% of the total source of funds to support R&D activities in 2015.

Out from the total expenditure, the highest expenditure was on the basic research which also showed a steady increase from 2008 to 2015. This was the initiative taken by the government and the HLIs in general to strengthen the fundamental issues in R&D on which the applied and experimental research will be built. On top of that, engineering and technology field remained the biggest field of research the expenditure was spent on.

The number of R&D personnel continuously increased in 2015 from 2010 on an average rate of 11.40% with a balanced proportion of male and female researchers. In addition, for researcher in HLIs, though the figure seemed stagnant as compared to 2014 figure, they formed the majority of 71.13% from the total R&D research personnel. 74.42% of them were composed of lecturers and PhD level students. They were mostly in the age group of 35-44 years old. FTE was the unit measurement for R&D personnel and it showed one’s effort in conducting R&D related activities per year. As such, the increasing trend at a constant rate can also be seen in the FTE profile for researcher from year 2010 to 2015 surveyed.

In term of research outputs, the survey on 2015 R&D activities for HLIs has recorded drops across most type of publications except non-indexed journals and chapter in books as compared to 2014 data but still higher than that of 2012 data. Mixed trends were recorded for the production of different types of IPs where number of patents awarded recorded a drop of 64.17% and trademarks for 33.50% from 2014 data. Meanwhile industrial design has recorded an increase of 36.36% within the same period of time. The small drop in the number of total researchers may also contribute to this mixed trends. Although the total FTE for researchers in particular has increased, it failed to be translated into the increase of research outputs. In this regards, the expenditure on R&D activities can be seen to play an important role to increase the number of research outputs.

Nevertheless revenue generated from the licensing through patent and technology know-how was valued at RM41.56 million derived from a total of 76 products. Meanwhile 70 products have been successfully commercialised, generating revenue of RM10.74 million worth.

RESEARCH AND DEVELOPMENT IN GOVERNMENT AGENCIES AND RESEARCH INSTITUTES (GRIs)

CHAPTER 6: RESEARCH AND DEVELOPMENT IN GOVERNMENT AGENCIES AND RESEARCH INSTITUTES (GRIs)

6.1 Introduction

Government Agencies and Research Institutes (GRIs) play a prominent role in a country's national development through research and development (R&D) activities. Malaysian GRIs have always been at the frontier in the R&D activities at the national level. Over the years, these institutions have received numerous accolades for the products and cutting-edge technologies developed by them.

In Malaysia, various government agencies and research institutes have been contributing to R&D activities of the country under respective ministries that responded the survey questionnaires as shown in Table 6.1. These GRIs are responsible for generating new knowledge through research activities in a wide range of disciplines, namely natural sciences, biotechnology, engineering and technology, information, computer and communication technology, medical and health sciences, agriculture and forestry, social sciences, humanities, economics, business and management (MRDCS, 2011), while, Table 6.2 provides the account of the number of respondents in the present survey.

Table 6.1 Organisations that Responded the Survey Questionnaires

Ministries	Government Agencies	Government Research Institutes
Ministry of Science, Technology and Innovation	9	6
Ministry of Natural Resources and Environment	5	3
Ministry of Agriculture & Agro-Based Industry	1	4
Ministry of Health	5	7
Ministry of Works	1	1
Ministry of Rural and Regional Development	1	1
Ministry of Urban Wellbeing, Housing & Local Government	3	0
Ministry of Finance	1	1
Ministry of Transport	0	1
Ministry of Tourism and Culture	3	0
Ministry of Plantation Industries & Commodities	6	0
Ministry of Human Resources	0	3
Ministry of Energy, Green Technology & Water	1	0
Ministry of Education	1	3
Prime Minister's Department	4	2
Ministry of Home Affairs	1	0
State Government (Sarawak)	2	0
Ministry of Youth and Sports	0	1
State Government (Sabah)	1	0
Total	45	33
	78	

Table 6.2: Number of Respondents for GRIs

Total sample	Respondent Response with R&D	Respondent Response without R&D Conducted
269	78	191*

* The GRIs which responded without R&D in 2015 are departments under various ministries.

In order to achieve 2.00% GERD per GDP by 2020, Malaysia needs to strengthen the public services and governance to ensure an eco-system that is conducive for the development and uptake of S&T (Science Outlook, 2015). Therefore, it is critical for GRIs under various ministries to harmonise efforts, collaboration of resources and exchange ideas between various agencies and research institutes as they are one of the key drivers of R&D in Malaysia. Rasiah et al. (2015) highlighted that Malaysia lacks critical mass of R&D human capital and infrastructure such as laboratories at government-owned research institutions especially in frontier R&D. Even with the presence of R&D in multinational corporations, the R&D spill-over in Malaysia has not been significant. Therefore, GRIs should be at the forefront of R&D and play a more catalytic role to encourage and provide knowledge transfer through consulting, services and collaboration with HLIs and BEs (SMEs and MNCs).

This chapter presents an overview of the R&D activities in the Government Agencies and Research Institutes from 2008 to 2015 which contributed to the national R&D performance discussed in Chapter 3. The overview highlights the development of R&D in GRIs sector over the years with respect to Gross Expenditure, Field of Research, Socio-Economic Objectives, Sources of Funds, Human Resource Development and Research Output.

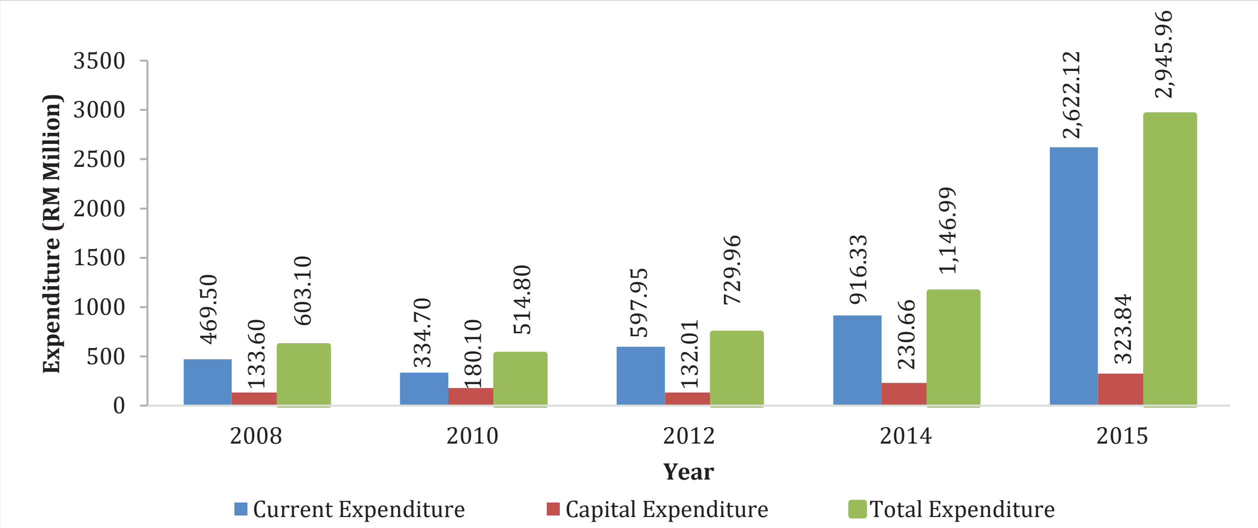
6.2 Gross Expenditure on Research and Development

In the following sections, various results are presented based on analysis of the 78 GRIs that responded the survey questionnaires.

6.2.1 Expenditure by Type of Cost

R&D expenditure for GRIs in 2008 was RM603.10 million, but decreased to RM514.80 million in 2010, and gradually increased to RM729.96 million in 2012, RM1,146.99 million in 2014 and to RM2,945.96 million in 2015 as shown in Figure 6.1. It is to be noted that there has been 156.84% increase in R&D expenditure in 2015 compared to the year 2014. One plausible reason for this upward trend could partly be due to the increasing number of GRIs reporting, from 34 organisations in 2010 to 44 in 2012 to 62 in 2014 and 78 in 2015. Also, some of the participating organisations where previously classified as BEs but now those are regarded as GRIs. Government's contribution towards GRIs has also increased from 60.40% of total expenditure in 2014 to 70.40% of total expenditure in 2015. This increase is also consistent with increased number of research personnel in GRIs in 2015 (see figure 6.1).

Figure 6.1: Expenditure by Type of Cost in GRIs, 2008-2015

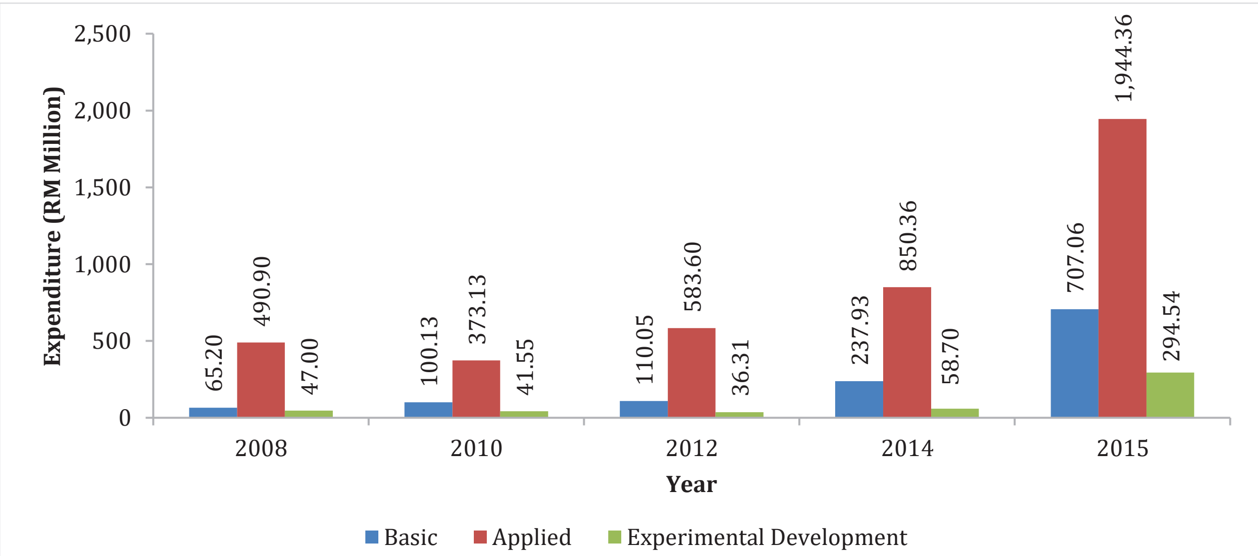


6.2.2 Expenditure by Type of Research

GRIs in Malaysia are involved in basic research, applied research and experimental research. As shown in Figure 6.2, applied research is the biggest contributor to GRIs expenditure in R&D since 2008. The trend has been increasing since 2010 from RM373.13 million in 2010 to double with RM850.36 million in 2014. Surprisingly, in 2015, the amount jumped more than twice with RM1,944.36 million. Figure 6.2 also illustrates the relative distribution of the three types of research from 2008 to 2015.

The GRIs also conducted basic research but on a smaller scale. The expenditure since 2008 has shown gradual increase from RM65.20 million to RM110.05 million in 2012 to RM237.93 million in 2014 and more than double with RM707.06 million in 2015. For experimental research, there is a downward trend from RM47 million in 2008 to RM36.31 million in 2012 and increased to RM58.70 million in 2014. However, in 2015, the amount has been increased to RM294.54 million which is five times higher than previous year.

Figure 6.2: Expenditure by Type of Research in GRIs, 2008-2015



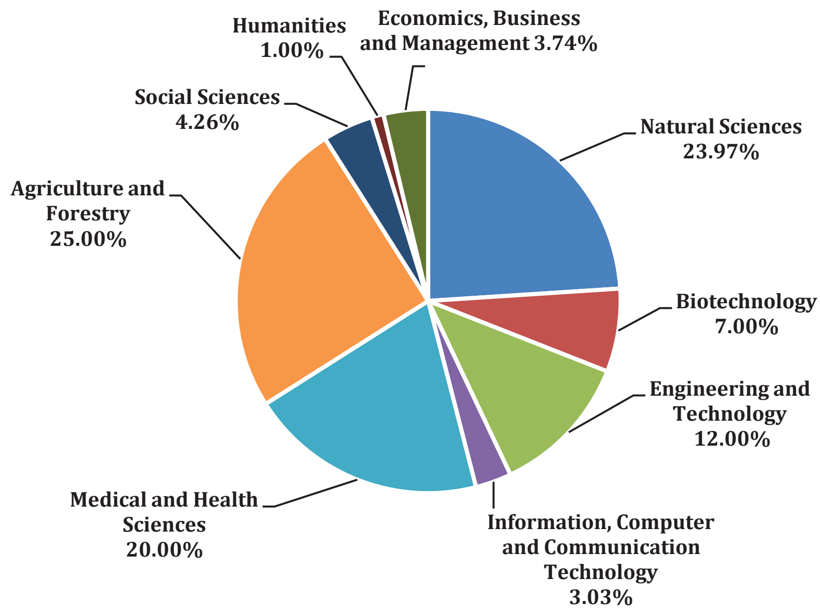
In terms of total expenditure for R&D, there is a downward trend for applied research from 81.40% in 2008 to 66.00% in 2015 whereas basic research has increased from 10.81% in 2008 to 24.00% in 2015.

6.2.3 Expenditure by Field of Research and Socio-Economic Objectives

According to MRDCS (2011), there are nine divisions for Field of Research (FOR) and six divisions of Socio-Economic Objectives (SEO). In this survey, the GRIs were asked to identify their FOR and SEO with best estimation. Due to the diversity of field of research, 20 subdivisions of FOR were provided in the survey questionnaires.

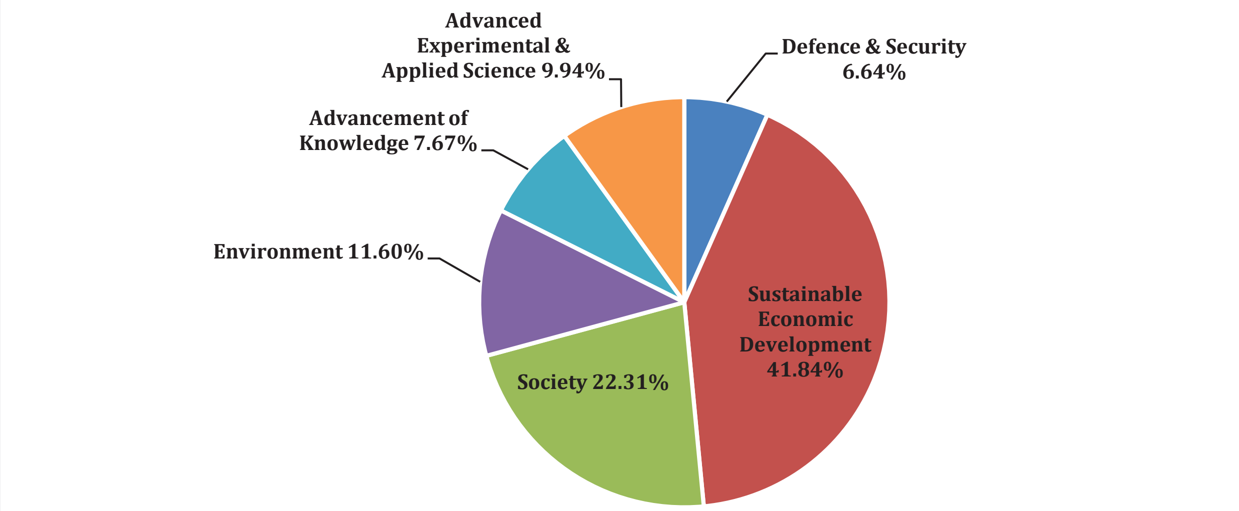
Figure 6.3 shows the expenditure of three out of nine main FOR divisions comprising 68.97% of the total expenditure, namely Agriculture Science and Forestry (25.00%); Natural Sciences (23.97%), as well as Medical and Health Sciences (20.00%), while Engineering and Technology contributed 12.00% of the total R&D expenditure of GRIs, Biotechnology contributed 7.00% only. Social Sciences, Economics Business and Management, Information, Computer and Communication Technology and Humanities contributed less than 5.00% R&D expenditure of the GRIs.

Figure 6.3: Expenditure by Field of Research in GRIs, 2015



As for Socio-economic Objectives, 75% of the R&D expenditure of GRIs were predominantly on Sustainable Economic Development (41.84%); Society (22.31%), as well as Environment (11.60%). In addition, Advanced Experimental & Applied Science (9.94%), Advancement of Knowledge (7.67%) and Defence and Security (6.64%) contributed about 25.00% of R&D expenditure of the GRIs. Table 6.3 and Figure 6.4 illustrate the breakdown by the six divisions of SEO.

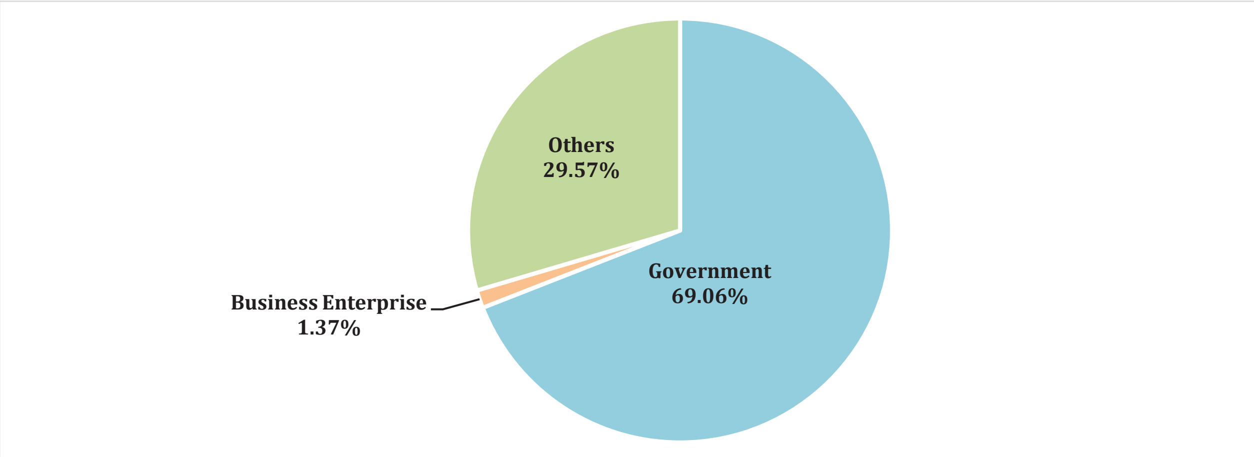
Figure 6.4: Expenditure by Socio-Economic Objectives in GRIs, 2015



6.3 Sources of R&D Funds in GRIs

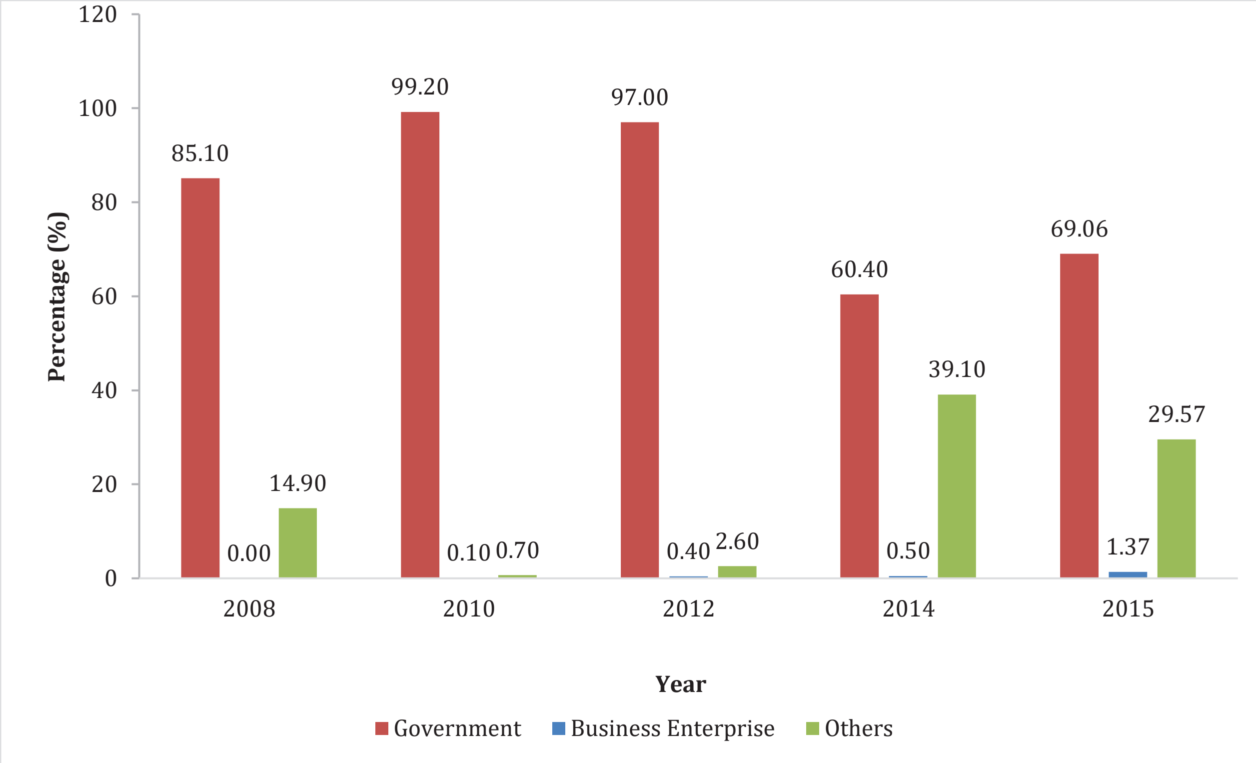
Figure 6.5 shows the source of funds to support R&D activities in GRIs for the year 2015. The biggest contributor is the Government which contributes 69.06% of the total fund. This is followed by the other sources of funds (foreign funds and other) which contributes 29.57%. Business Enterprise contributes only 1.37%.

Figure 6.5: Source of R&D Funds in GRIs, 2015



Throughout 2008 to 2015 the government has been the major contributor to fund R&D activities in GRIs. This is apparent from the data shown in Figure 6.6. Despite the downward trend from 2010 to 2014 as shown in the figure, it spikes up again in 2015. The reason might be due to the difficulties faced by the GRIs to generate their own funds due to the volatile economic climate at that time. It is supported by the fund contributed by the Business Enterprises which seems to be invisible due to its small amount as opposed to the previous years data.

Figure 6.6: Sources of R&D Funds in GRIs, 2008-2015



Despite significant progress made since the 1970s, Malaysia is not yet in the same league as dynamic Asian economies such as the Republic of South Korea, with which it is often compared. Governance issues and weak institutional capabilities in STI top the list of current shortcomings. In addition, budget deficits have recently started putting pressure on public investment levels, especially on research and development (R&D). In particular, recurrent crises have pushed the government to shift expenditure towards addressing socio-economic problems (Rasiah and Yap, 2015).

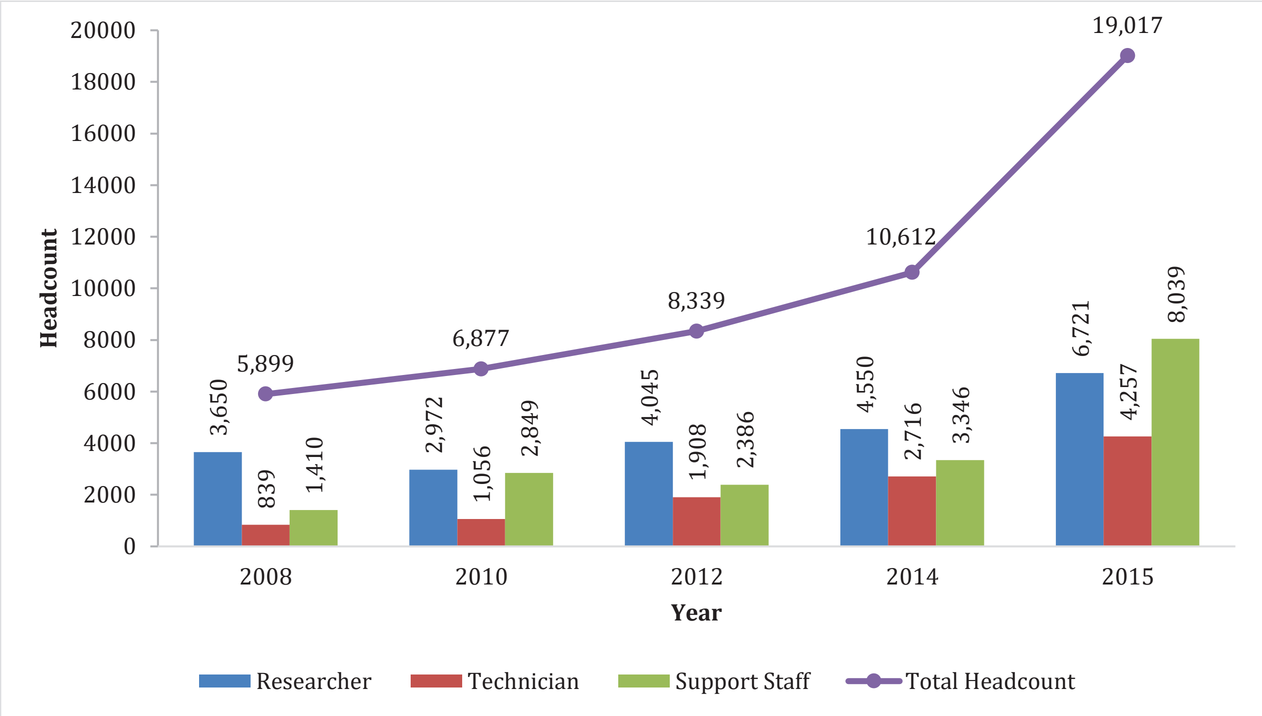
6.4 Human Resource Development

This section presents the analysis of human resource development to support R&D activities in GRIs for the year 2015 and benchmarked analysis from year 2008 to 2015.

6.4.1 Headcount of R&D Personnel

Since 2008, there is an appreciable increase in the total headcount for R&D personnel in GRIs particularly in the number of researchers. Assuming 2008 as a base, there has been 222.38% increase of total headcount in 2015, whereas, the increase of researchers in 2015 is 84.14% compared to 2008. This shows that the growth of headcounts in technician and support staff is significantly more than the number of researchers. Possible reason for this increase is an increased number of respondent GRIs in 2015 compared to 2014. Figure 6.7 illustrates the overall picture of headcount of R&D personnel in GRIs from 2008 to 2015.

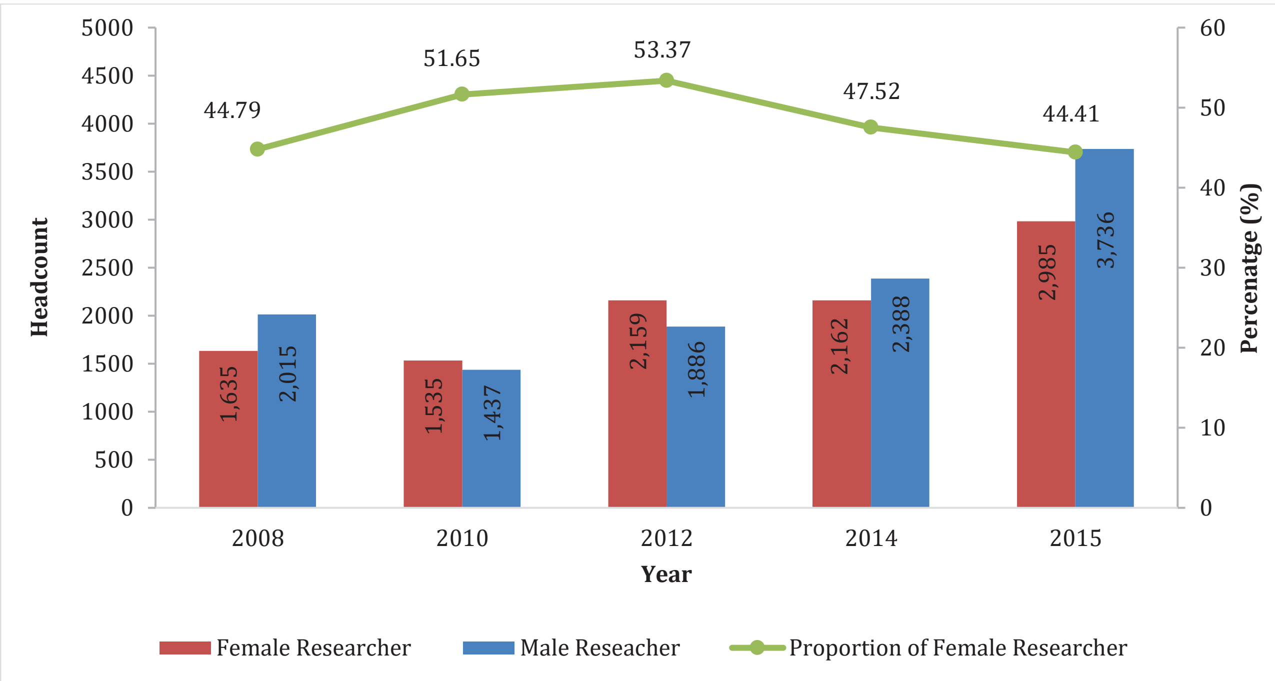
Figure 6.7: Headcount of R&D Personnel in GRIs, 2008-2015



6.4.2 Headcount of Researchers by Gender

Figure 6.8 shows that female researchers' participation in GRIs has steadily increased from 2008 to 2012 which recorded the highest participation of 53.37% but dropped slightly to 47.52% in 2014 and further dropped to 44.41% in 2015.

Figure 6.8: Headcount of Researchers by Gender in GRIs, 2008-2015



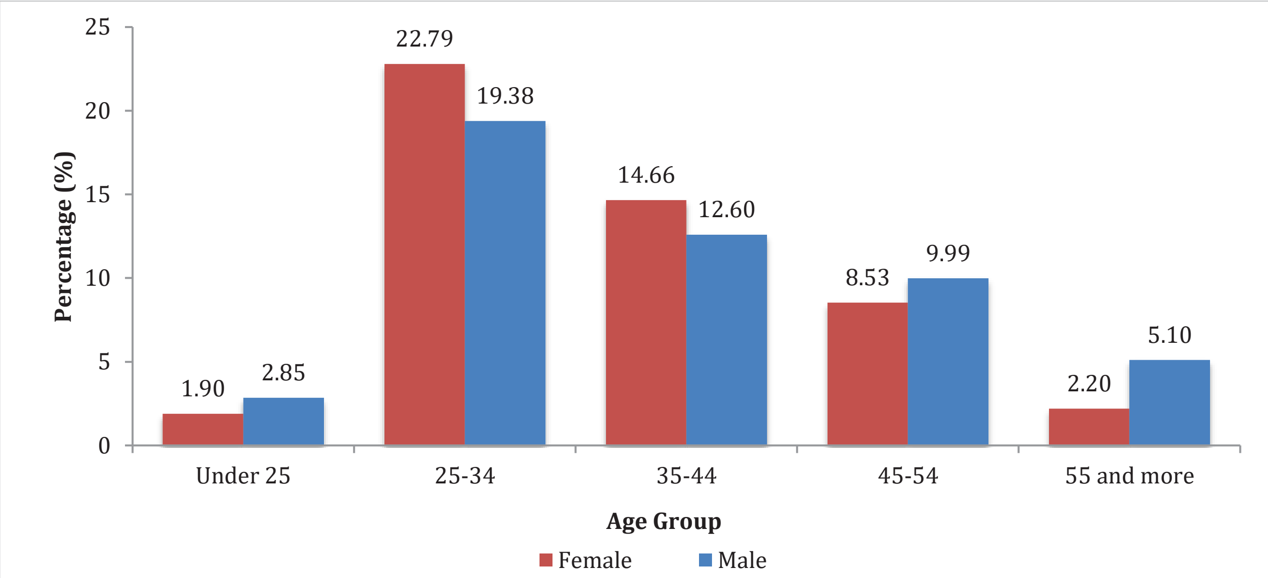
6.4.3 Proportion of Researcher (Internal) by Age Group

Headcount by age group of researchers is a new indicator introduced in the National Survey of R&D 2015. Table 6.3 and Figure 6.9 records the age group data tabulation and it shows the highest percentage of age group of researchers is between 25-34 years old which constitutes 42.17% of total researchers. Out of this figure the male researchers constitute as much as 19.38%. The researchers under the age of 25 is the least age group number recorded.

Table 6.3: Proportion of Researchers (Internal) by Age Group in GRIs, 2015

Age group	Under 25	25-34	35-44	45-54	55 and more
Male (%)	2.85	19.38	12.60	9.99	5.10
Female (%)	1.90	22.79	14.66	8.53	2.20
Total (%)	4.75	42.17	27.26	18.52	7.30

Figure 6.9: Proportion of Researchers (Internal) by Age Group in GRIs, 2015



6.4.4 Headcount and Proportion of Researcher by Qualification

Altogether, 6,721 researchers are involved in various kinds of R&D activities in 2015. Among them, Bachelor and Master degree holders constitute almost equal percentage, namely 35.49% and 36.36%, respectively. In terms of number and percentage, they are followed by PhD degree holders (14.77%). The rest of the researchers have either Diploma or the researchers are having others qualifications (other than doctoral, master, and bachelor) (Table 6.4).

Table 6.4: Headcount of Researcher by Qualification in GRIs, 2015

Qualifications	Headcount	Percentage
PhD	993	14.77
Master	2,444	36.36
Bachelor	2,385	35.49
Non-Degree/Diploma	782	11.64
Others/Not Specified	117	1.74

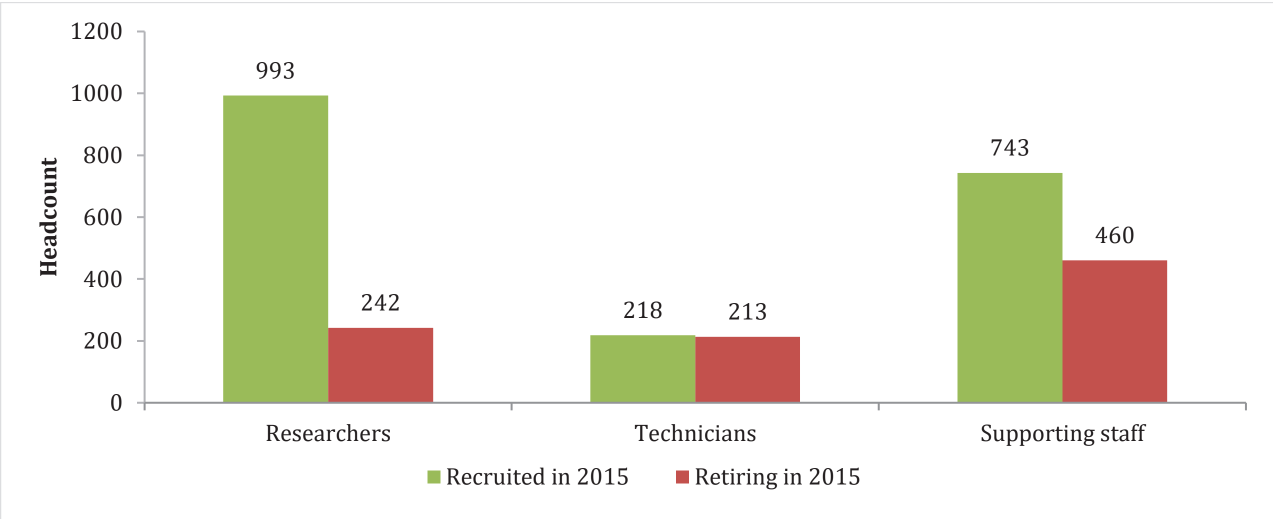
6.4.5 Internal R&D Personnel Flow

The internal R&D personnel flow is measured by the number of staff recruited over the number of staff retiring. The total number of staff recruited in 2015, altogether was 1,954. Specifically, there were 993 researchers, 218 technicians and 743 supporting staff recruited in 2015. In terms of retiring in 2015, the total number of personnel retiring was 915 personnel. Category wise, personnel retired were 242 researchers, 213 technicians and 460 supporting staff. These numbers were compared with JPA provided statistics and found that the numbers of retirees reported in the following Table 6.5 are less than the JPA provided statistics. The reason for discrepancy is that JPA's GRIs list included various ministries, however, those ministries data were not included in the present report as they didn't have R&D in 2015.

Table 6.5: Internal R&D Personnel Flow in term of New Recruitment and Retirement in GRIs, 2015

	Researcher	Technician	Supporting staff
Recruited in 2015	993 (80.40%)	218 (50.58%)	743 (61.76%)
Retiring in 2015	242 (19.60%)	213 (49.42%)	460 (38.24%)

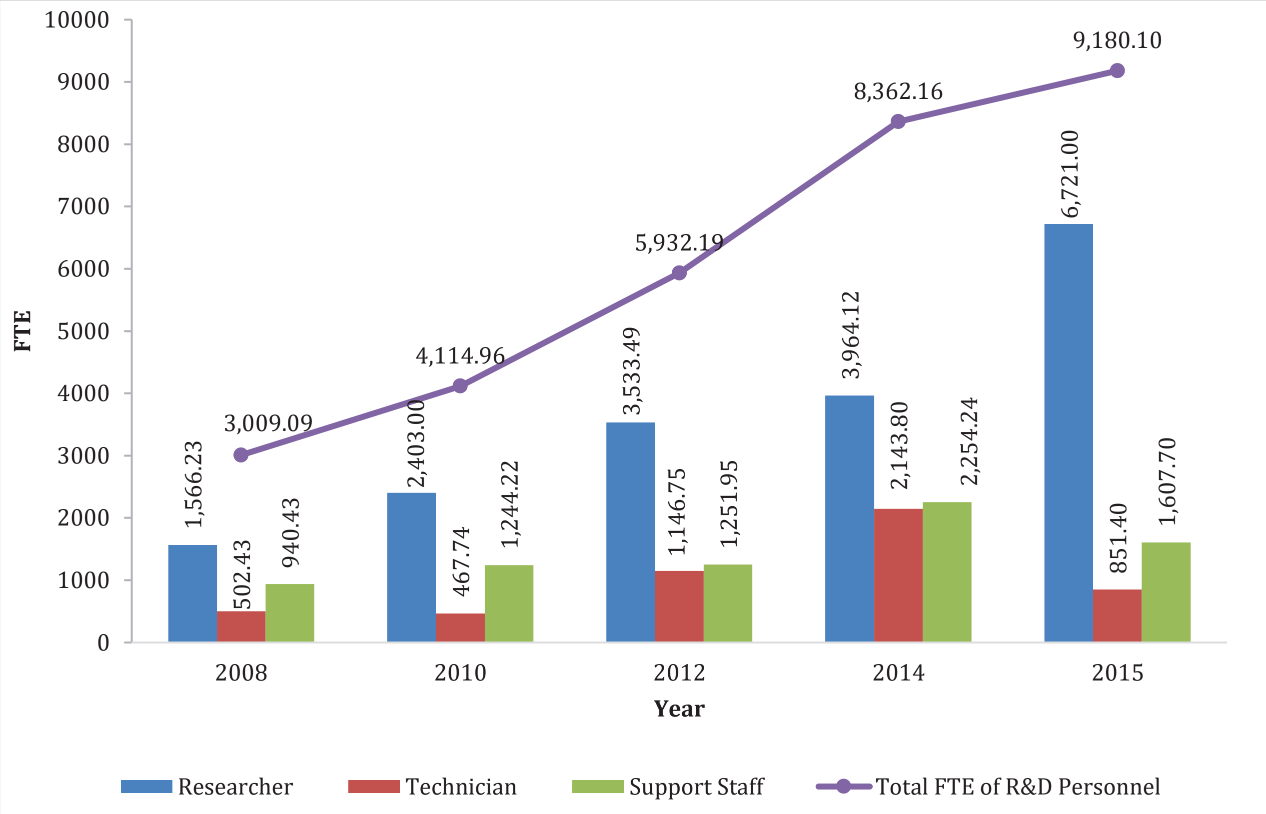
Figure 6.10: Number of Internal R&D Personnel Flow in term of New Recruitement and Retirement in GRIs, 2015



6.4.6 Full-Time Equivalent of R&D Personnel

The increase in the number of research personnel in 2015 is not reflected in the calculation of full time equivalent (FTE) of the research personnel in 2015 as proven in Figure 6.11. FTE is the unit measurement for R&D personnel and it shows one effort in conducting R&D related activities per year. As such the function of support staff in 2015, though bigger in number is less contributing in term of FTE unit. However, the increasing trend can be seen in the FTE profile for researchers from 2008 to 2015.

Figure 6.11: Full-Time Equivalent of R&D Personnel in GRIs, 2008-2015



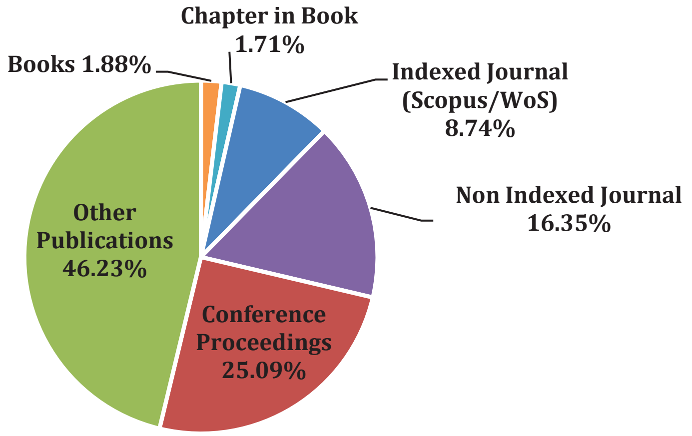
6.5 Research Output

This section presents the analysis of research output from R&D activities in GRIs for the year 2015 and benchmarked analysis from year 2008 to 2015.

6.5.1 Publication

Publication refers to an act of producing printed materials through the effort of an agency or institution in order to spread newly-acquired knowledge. Figure 6.12 demonstrates that the GRIs share their R&D information through Conference Proceedings (25.09%) and Journal articles indexed in other citation (16.35%) besides WoS and Scopus. However, majority of GRI's publications are in Other Publications (46.23%) that have created an impact to government/society/policy such as abstracts, articles in magazines, newsletters, et cetera, not including unpublished reports. The balance includes journals or articles indexed in WoS, Scopus, chapters in book, and books.

Figure 6.12: Number of Publication in GRIs, 2015

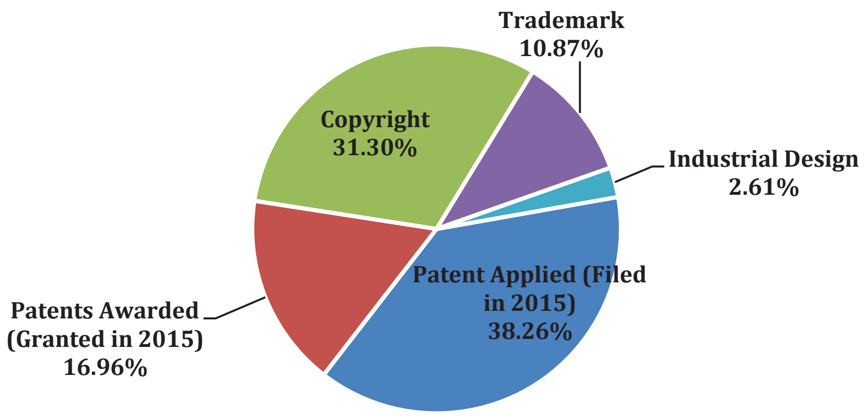


6.5.2 Intellectual Property and Revenue Generated

For 2015, the intellectual property data sought was in terms of patent applied (filed), patent awarded (granted), copyright, trademark and industrial design. The present survey also asked additional information about the number of patents licensing, number of commercialised product and their revenue. This additional information was not covered in 2014 report.

As shown in Figure 6.13, in 2015 the GRIs reported that 38.26% of their intellectual property (IP) comprised patent applied (filed in 2015), 31.30% copyright as well as 16.96% patents awarded (granted in 2015). Trademark and industrial design covered are 10.87% and 2.61% respectively.

Figure 6.13: Number of Intellectual Property in GRIs, 2015



There was a mixed trend in three types of intellectual property (patents awarded, trademark and industrial design) when compared to 2012 and 2014 report as shown in Table 6.6. In addition, the survey did not solicit information on the number of copyrights in 2012 and 2014. In 2015 GRIs reported 230 total number of intellectual property, whereas, in 2012 and 2014 the total number of intellectual property for GRIs was 142 and 352, respectively. Specifically, the achievements for GRIs in 2015 include 88 patent applied, 39 patent awarded, 72 copyright, 25 trademark, and 6 industrial design.

GRIs also reported that they obtained 16 patents licensing and 6 of commercialised products which generated RM7.82 million and RM0.59 million revenue respectively in 2015 (Table 6.7).

Table 6.6: Number of Intellectual Property in GRIs, 2012-2015

Intellectual Property	2012	2014	2015
Patent Applied	52	204	88
Patent Awarded	39	82	39
Copyright	-	-	72
Trademark	47	42	25
Industrial Design	4	24	6

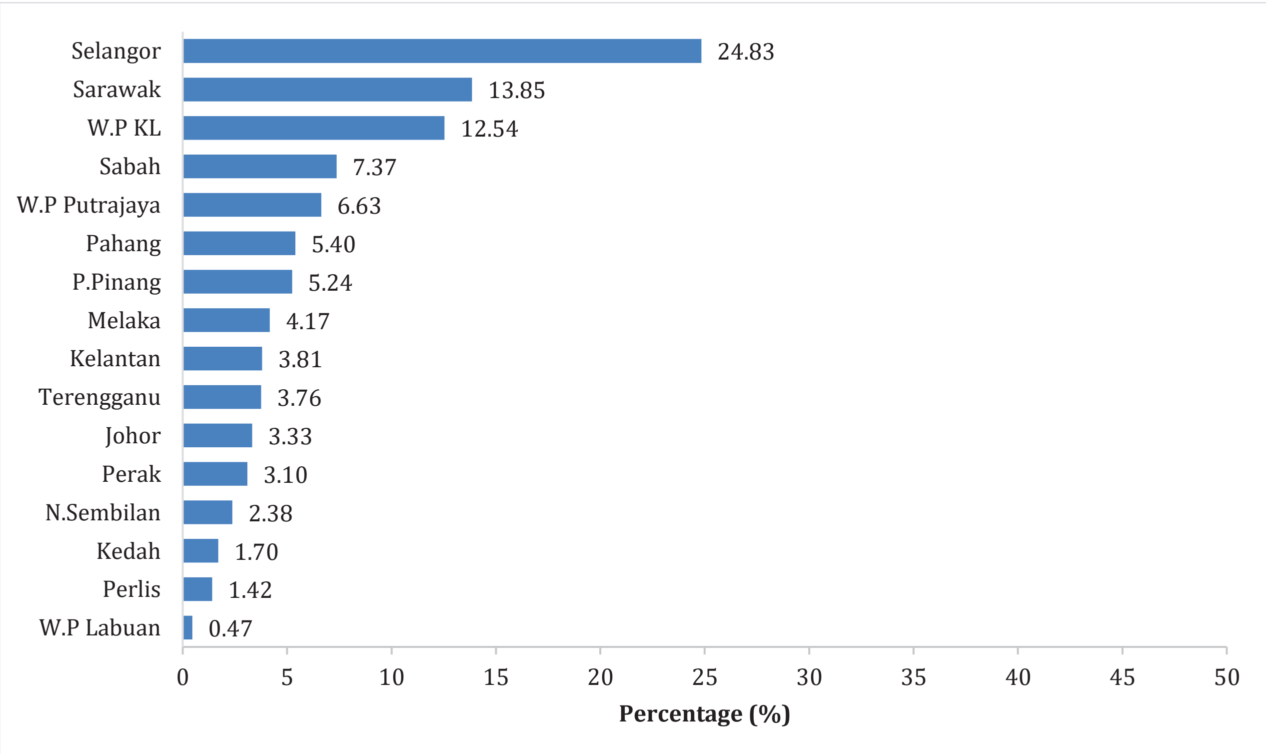
Table 6.7: Number of Products and Revenue Generated in GRIs, 2015

	Total number	Revenue (RM Million)
Total number of patents licensing and technology know-how licensing	16	7.82
Total number of commercialised product	6	0.59

6.6 Distribution of R&D Projects by Location

The survey requested additional information about location for R&D projects. Figure 6.14 shows the distribution of location for R&D activity projects and the highest percentage (24.83%) was in Selangor, followed by Sarawak (13.85%) and Wilayah Persekutuan Kuala Lumpur (12.54%). Three GRIs indicated that they also conducted R&D outside Malaysia, namely China and Singapore.

Figure 6.14: Distribution of R&D Projects by Location in GRIs, 2015



Box 6.1: Agricultural and Biodiversity Research in Malaysia

Safeguarding the rich natural resources is an important issue for strengthening Malaysia's flourishing economy. It is essential for the country to continue the research in the areas of agriculture and biodiversity. This type of research activities will support Malaysian peoples' livelihoods, improve productivity and resilience of agricultural and forest ecosystems. The investment in agricultural and biodiversity will result in improved diets, adapt to climate change, control pests and diseases and help reverse forest and land degradation. Since the mid-1980s, Bioversity International has been collaborating with the Malaysian Agricultural Research and Development Institute (MARDI) on the conservation and use of Malaysia's rich plethora of tropical fruits.

Bioversity International assists MARDI with Malaysia's national genebank programme and provides financial support to what will become the country's first rice genebank. Moreover, it collaborates on palm oil collection and setting up a germplasm collection of other fruit crop species. In 2000, the Malaysian Government, primarily through MARDI, collaborates with the International Coconut Genetic Resources Network (COGENT, established by Bioversity International) to undertake research and development activities on coconut genetic resource conservation. In 2002, MARDI joins the Banana Research Network for Asia-Pacific (BAPNET), an international network coordinated by Bioversity International. In 2003, Bioversity International joins the Asia Pacific Forest Genetic Resources Programme (APFORGEN). Together with the Forest Research Institute Malaysia (FRIM), Bioversity International starts studying genetic variation of tree species, in 2006.

In 2009, Bioversity International leads a United Nations Environment Programme / Global Environment Facility (UNEP/GEF) funded project on tropical fruit trees in four Asian countries, including Malaysia. In 2012, together with the Malaysian Agricultural Research and Development Institute (MARDI), Bioversity International publishes recommendations on implementing the Multilateral System of Access and Benefit Sharing in Malaysia. In 2015, Bioversity International initiates research collaboration to develop approaches and practices for restoring productivity and resilience of degraded forests. Together with Malaysian research partners, Bioversity International plans to capitalize on building national and regional capacity in cryopreservation and on-farm conservation of key agricultural and tree diversity for future use.

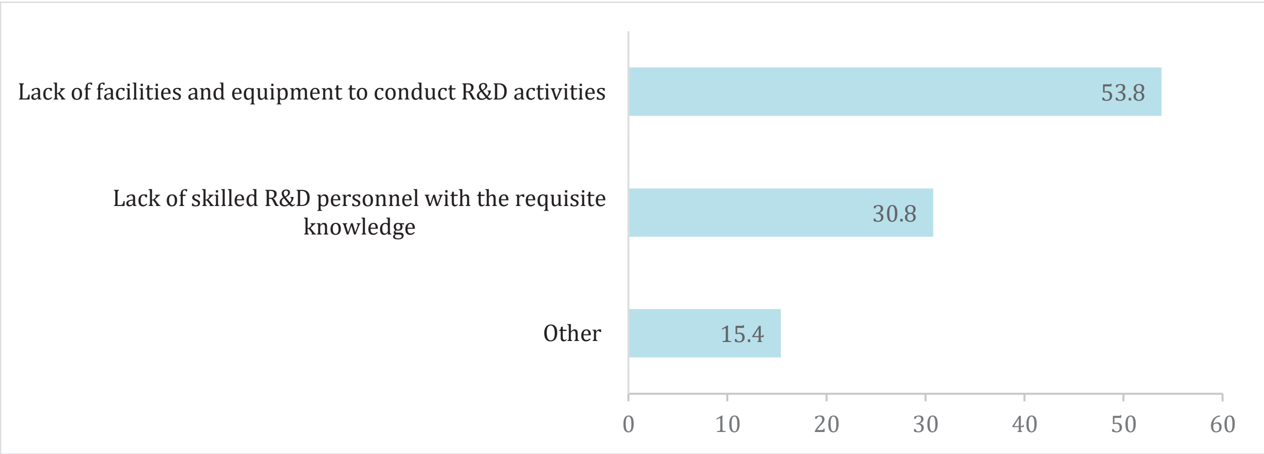
Source : www.bioversityinternational.org

6.7 Projects Outsourced

6.7.1 Reasons for Outsourcing R&D Projects

From the results of the present national survey of R&D, it is observed that, 26 out of 78 GRIs outsourced their R&D projects due to various reasons. Figure 6.15 shows that lack of facilities and equipment to conduct R&D activities is the main reason for projects outsourcing. It is also noted that GRIs have outsorced their projects because of limited number of skilled R&D personnel with requisite knowledge in their institutions.

Figure 6.15: Reasons for outsourcing R&D in GRIs, 2015



6.7.2 Projects Being Outsourced to GRIs, 2015

From Table 6.8, it is clear that GRIs within Malaysia have been outsourcing many R&D projects to HLIs amounting to RM7.85 million. This is followed by the HLIs' contribution of RM0.84 million worth of projects came from outside Malaysia. Finally, BEs contribute RM0.45 million by means of outsourcing projects to GRIs.

Table 6.8: Projects Being Outsourced to GRIs, 2015

Projects Being Outsourced	RM Million		
	Within Malaysia	Outside Malaysia	Total amount
From Business Enterprise	0.45	-	0.45
From Higher Learning Institution	7.85	0.84	8.69

6.7.3 Projects Collaboration with Others in GRIs, 2015

Number of collaboration in R&D projects is another new indicator introduced in National R&D Survey 2016. Table 6.9 shows the number of research collaborations in GRIs for year 2015. It is noted that 546 collaborated R&D projects have been conducted within Malaysia and 402 projects outside Malaysia.

Table 6.9: Number of Projects Collaborated with Other in GRIs, 2015

Collaborated Projects	Total Number
Within Malaysia	546
Ouside Malaysia	402

6.8 Limiting Factors of R&D Activities in GRIs

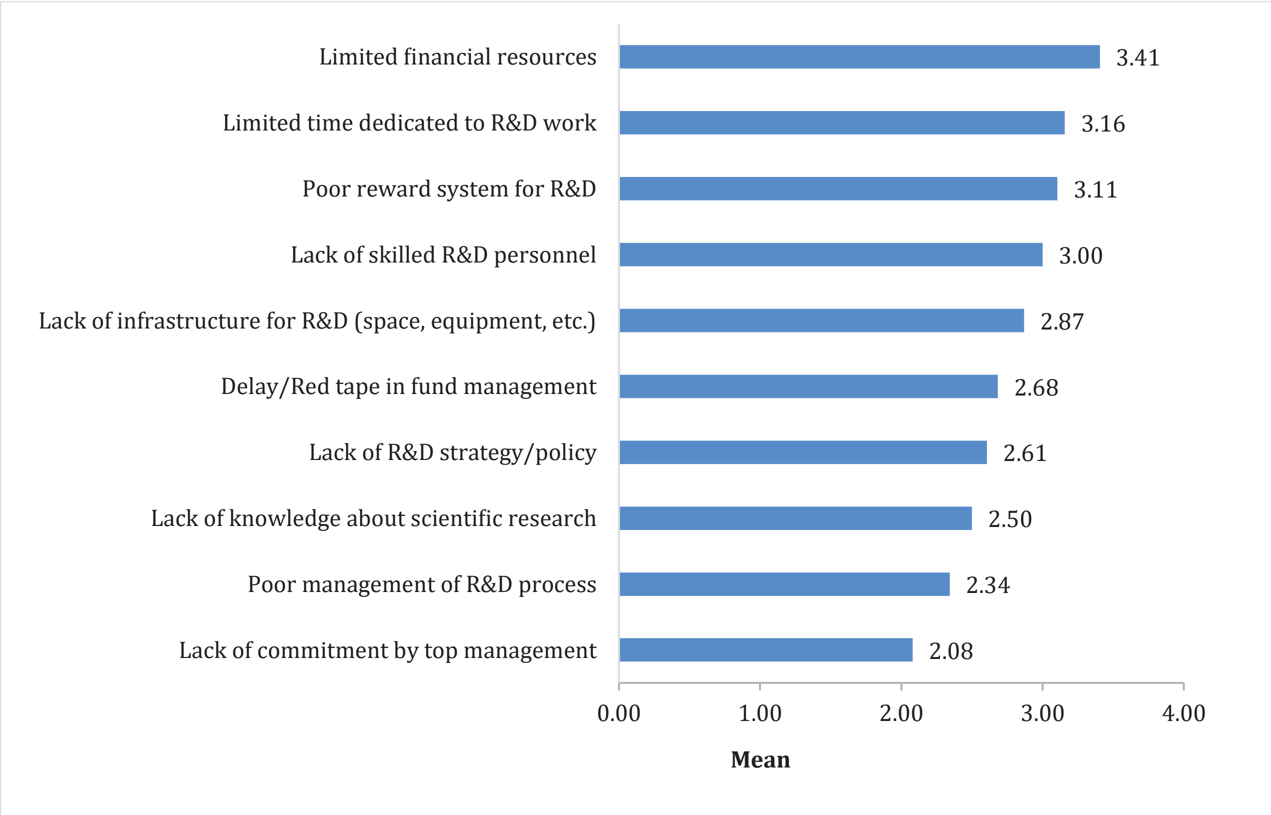
6.8.1 Internal Factors

Other additional information included in the National R&D Survey 2016 were the internal and external factors which limited R&D activities. This information were measured based on Likert scale where, 1 – not an issue at all, 2 – rarely an issue, 3 – sometimes an issue, 4 – often is an issue, 5 – always a major issue.

As can be seen in Figure 6.16, the top three internal factors limiting R&D activities are limited financial resource, limited time to dedicate to R&D work, and poor reward system for R&D.

It is interesting to note that the researchers in GRIs perceive that they have limited time of carrying out R&D activities, despite the fact that total FTE has increased. This could be due to ever increasing KPIs for the researchers set by the organisations. Furthermore, the researchers could be also entrusted by some other activities such as administration.

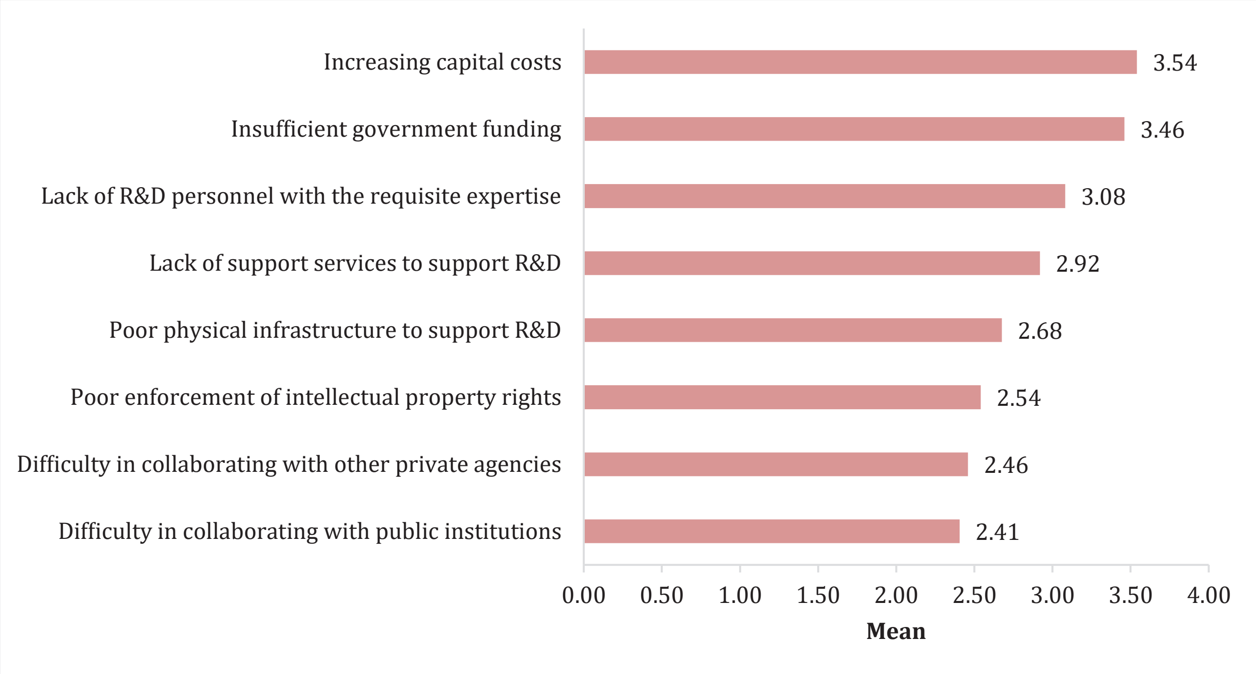
Figure 6.16: Internal Factors Limiting R&D Activities in GRIs, 2015



6.8.2 External Factors

As for external factors as shown in Figure 6.17, the GRIs highlighted increasing capital costs (Mean=3.54), insufficient government funding (Mean=3.46) and lack of R&D personnel with the requisite expertise (Mean=3.08) as top three external factors that limit the R&D activities.

Figure 6.17: External Factors Limiting R&D Activities in GRIs, 2015



6.9 Conclusion

In conclusion, compared to 2014, R&D expenditure for GRIs increased from RM1,146.99 million to RM2,945.97 million in 2015 with the majority dedicated to applied research. the GRIs also reported an increase in basic research and experimental research in 2015.

The GRIs expenditure by FOR subdivisions is mostly in Agriculture Science and Forestry (25.00%), Natural Sciences (23.97%) and Medical and Health Sciences (20.00%). As for SEO, R&D expenditure of GRIs is predominantly on Sustainable Economic Development (41.84%), Society (22.31%), and Environment (11.60%). In terms of funding, the government has always been the highest contributor of R&D funds for GRIs.

There has been significant increase in the total headcount for R&D personnel (19,017) in GRIs, predominantly in the number of researchers from 2008 to 2015. Assuming 2008 as a base, there has been 222.38% increase of total headcount in 2015, whereas, the increase of researchers in 2015 is 84.14% compared to 2008.

The total FTE in GRIs progressively increased and became three times more from 2008 to 2015. However, as a percentage, total FTE of researcher, technicians and support staff has mixed trends.

The R&D outputs of GRIs are obtained predominantly through Conference Proceedings (25.09%) and Journal articles indexed in other citation (16.35%), besides WoS and Scopus. The majority of GRIs' publications are in Other Publications (46.23%). Compared to 2014, increase is observed in all types of publications in 2015. Further, Patents Applied, Patents Awarded, Trademarks and Industrial Design have decreased in 2015.

INTERNATIONAL COMPARISONS

CHAPTER 7: INTERNATIONAL COMPARISONS

7.1 Introduction

This chapter presents Malaysia's R&D performance as compared to selected countries including OECD countries, Asia's Newly Industrialized Countries (NIC) as well as ASEAN countries. Data from 2012 and 2014 were mainly obtained from the IMD World Competitiveness Online for GERD and BERD whereas data from United Nations Educational, Scientific and Cultural Organization's (UNESCO) Institute for Statistics were used for comparison on human capital. The data for Malaysia were derived from this survey. It is imperative that Malaysia compare its R&D performance in order to benchmark its position in the global R&D arena. Data on R&D expenditures by country and region provide a broad picture of the changing distribution of R&D capabilities and activities around the world.

7.2 Gross Expenditure on Research and Development (GERD) Across Countries

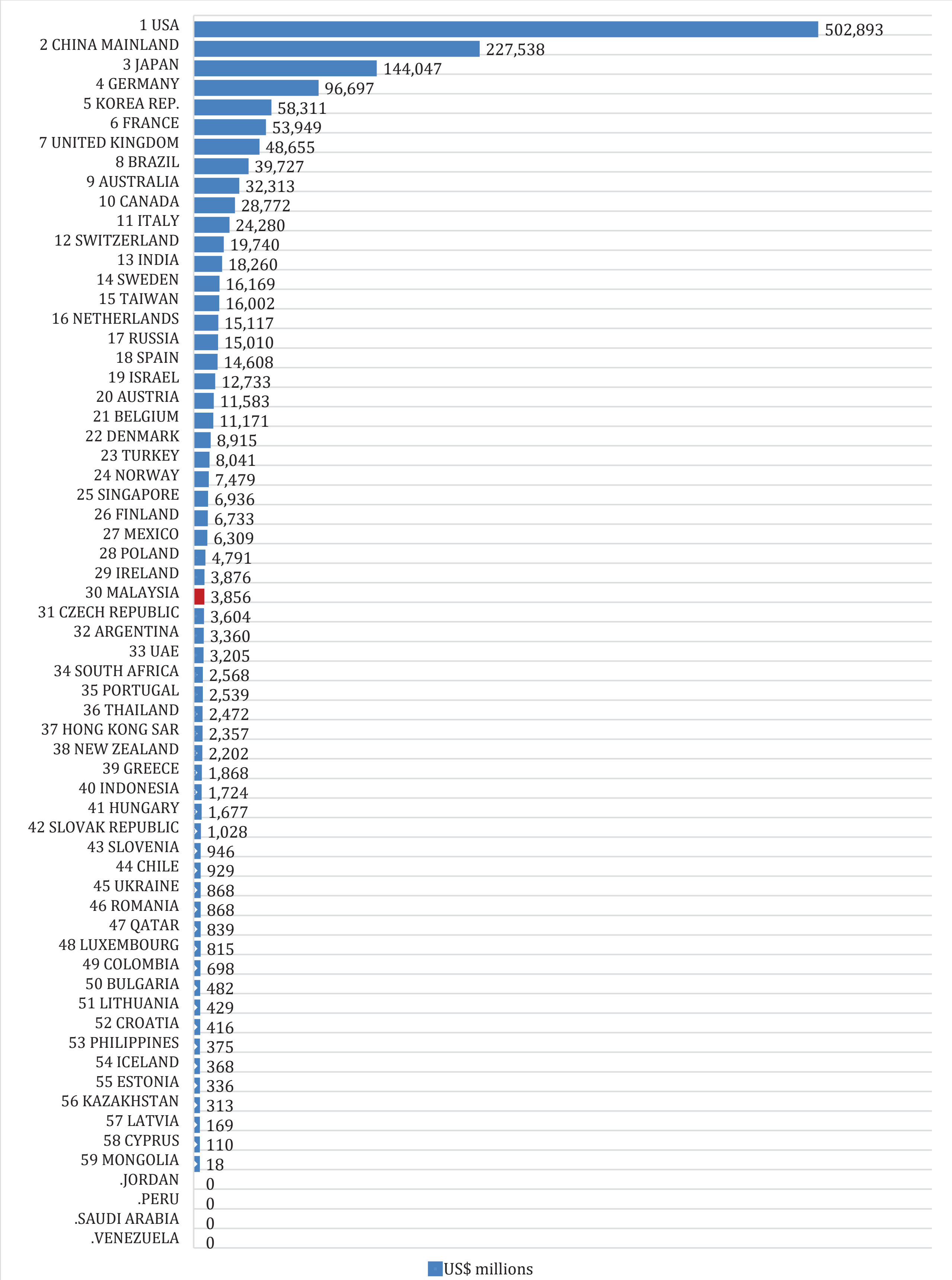
Research and development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge (including knowledge of man, culture and society) and the use of this knowledge to devise new applications. R&D covers three activities: basic research, applied research, and experimental development. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. Applied research is also original investigation undertaken in order to acquire new knowledge; it is, however, directed primarily towards a specific practical aim or objective. Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to install new processes, systems and services, or to improve substantially those already produced or installed. Research and development (R&D) activities allow scientists and researchers to develop new knowledge, techniques, and technologies. New research continues to show that investment in R&D spurs economic growth; where a one per cent increase in R&D spending develops the economy by 0.61%. This means that as countries invest more in R&D, their economy will grow faster (John Wu, 2015).

The main aggregate used for international comparisons is gross domestic expenditure on R&D (GERD). This consists of the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc. It includes R&D funded from abroad but excludes domestic funds for R&D performed outside the domestic economy.

Gross expenditure on R&D (GERD) was used as an indicator to compare R&D activities across various countries. It is expected that a country's R&D expenditure will reflect its R&D activities; for example, the higher the expenditure, the greater the R&D activities. In 2014, Malaysia's GERD for 2014 was USD3,219.00 million. This was based on the 2014 average annual exchange rate of RM1.00 = USD0.23. It is observed that if the RM was pegged to USD1.00 = RM3.80 (or RM1.00 = USD0.26) as in September 1998 until 2005, the GERD value for Malaysia may be higher at USD3,676.73 million. This may bear implication to fiscal policies of Malaysia if GERD value is to be increased but may have ramification on the country's economy and export-import.

As shown in Figure 7.1, in 2015, Malaysia's GERD of USD3,856 million placed it at the 30th out of 63 countries in the IMD world ranking. USA ranked first with GERD of USD502,893 million, followed by China Mainland (USD227,538 million), Japan (USD144,047 million), Germany (USD96,697 million) and Republic of Korea (USD58,311 million). Malaysia was ranked at 30th in comparison to Czech Republic, Argentina, UAE, South Africa, Portugal, Thailand and Hong Kong whose GERD were USD3,604 million, USD3,360 million, USD3,205 million, USD2,568, USD2,539 million, USD2,472 million and USD2,357 million respectively.

Figure 7.1: Gross Expenditure on R&D in Selected Countries, 2015



Source: IMD World Competitiveness Online 1995-2017

Box 7.1: Lessons from Korea

In Korea, R&D expenditure grew by 6% over 2012-13 and by 66% in real terms over 2007-2013, primarily boosted by the business sector. Over the past 20 years, Korean R&D spending as a share of GDP has doubled to reach 4.1% in 2013, the second highest R&D intensity in the OECD, only slightly below Israel.

Similarly in 2015, The Republic of Korea, is ranked 2nd highest GERD per GDP for 2015. The general features of the STI system of Korea is that it is committed to technology-based economic development and enjoys a national consensus on the importance of STI. It has high levels of R&D expenditure, a highly educated labour force, good and improving innovation framework conditions, large knowledge-intensive and internationally competitive firms, and a strong ICT infrastructure.

Almost three-quarters of Korean R&D is performed by business, with 88% in manufacturing in 2010, second only to Germany; 48% was carried out in a single sector, radio, television and communication equipment, by far the largest share among OECD countries.

63% of all R&D is directly targeted at developing specific new or improved applications (i.e. experimental development). Spending on basic research represented about 20% of total R&D spending in 2013, a share similar to other countries such as the United States or the United Kingdom. However, while most basic research in other economies (between 50% and 75%) is performed in the higher education sector, in Korea about 60% of all basic research is done in companies and only 20% in universities and higher education institutions.

Recent changes in STI expenditures: Korea's GERD was 3.74% of GDP in 2010 and has grown by a robust 9.3% a year over the past decade, and by 10% a year over the five years to 2010. In 2010, 72% of GERD was funded by industry, 27% by government and only 0.2% from abroad. Overall STI strategy: Korea's 577 Initiative aims to increase GERD to 5% of GDP by 2012, nurture seven strategic technology areas, and become the world's seventh "S&T power".

To meet these targets, the government has increased government expenditure on R&D and has used various tax incentives to encourage more private investment in R&D. In line with a decade-long trend, government support has continued to shift away from large firms towards SMEs. STI policy governance: In 2011, the National Science and Technology Commission (NSTC) was reconstituted as a co-ordinating agency with considerable responsibility for national STI policies and allocation of public R&D funding.

(Source: OECD, 2016. Available at https://www.oecd.org/sti/Korea-CN-EN-Scoreboard.pdf)

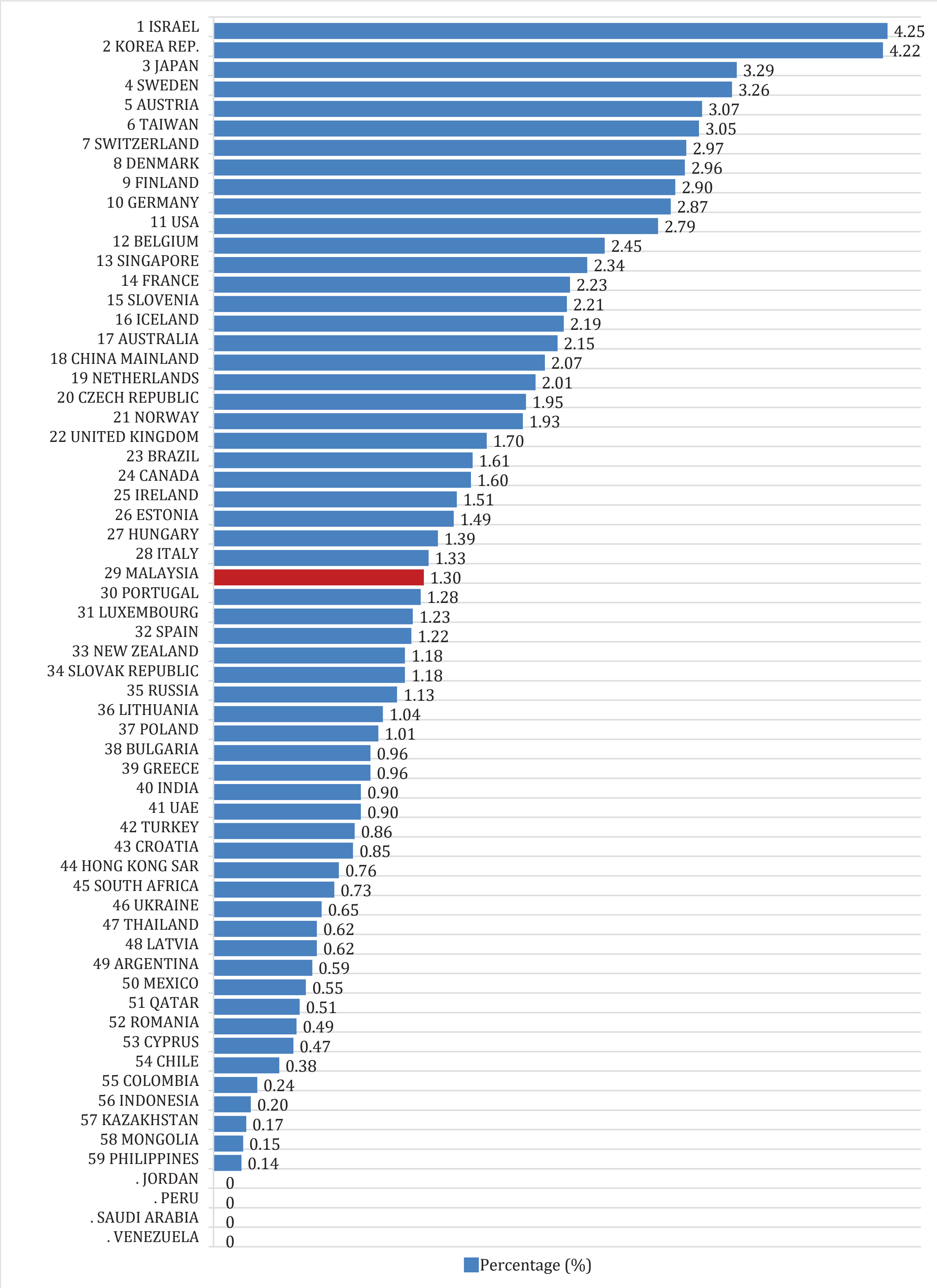
7.3 Gross Expenditure on Research and Development per Gross Domestic Product

R&D expenditure as a percentage of GDP, also known as "R&D intensity," gives a better gauge of the importance a country has placed on innovation and future growth (John Wu, 2015). R&D intensity compares GERD figures across numerous countries based on GERD per GDP and this approach adjusted the differences in the size of national economies.

As shown in Figure 7.2, Malaysia's GERD per GDP for 2015 was ranked 29th with 1.30%. The highest GERD per GDP was charted by Israel with 4.25%, and followed by the Republic of Korea with 4.22%. Other countries that recorded relatively high GERD per GDP above 3.00% were Japan (3.29%), Sweden (3.26%), Austria (3.07%), and Taiwan (3.05%). Other developed countries with GERD per GDP ratios above 2.00% include Netherlands, China Mainland, Iceland, Slovenia, France, Singapore, Belgium, USA, Germany, Finland, and Denmark. Among the NIEs, Taiwan ranked 6th place with GERD per GDP of 3.05% and Singapore in 13th place with 2.34%.

Malaysia has relatively low R&D investment as reflected in GERD per GDP of 1.30% in 2015 as compared to G20 countries, however Malaysia GERD has increased from 1.26% in 2014 to 1.30% in 2015. There is an opportunity for Malaysia to seek private sector funding to support the R&D initiatives and increase the percentage of her GERD per GDP as reflected in the NIEs countries, if not the OECD countries by 2020.

Figure 7.2: Gross Expenditure on R&D per Gross Domestic Product (%), 2015



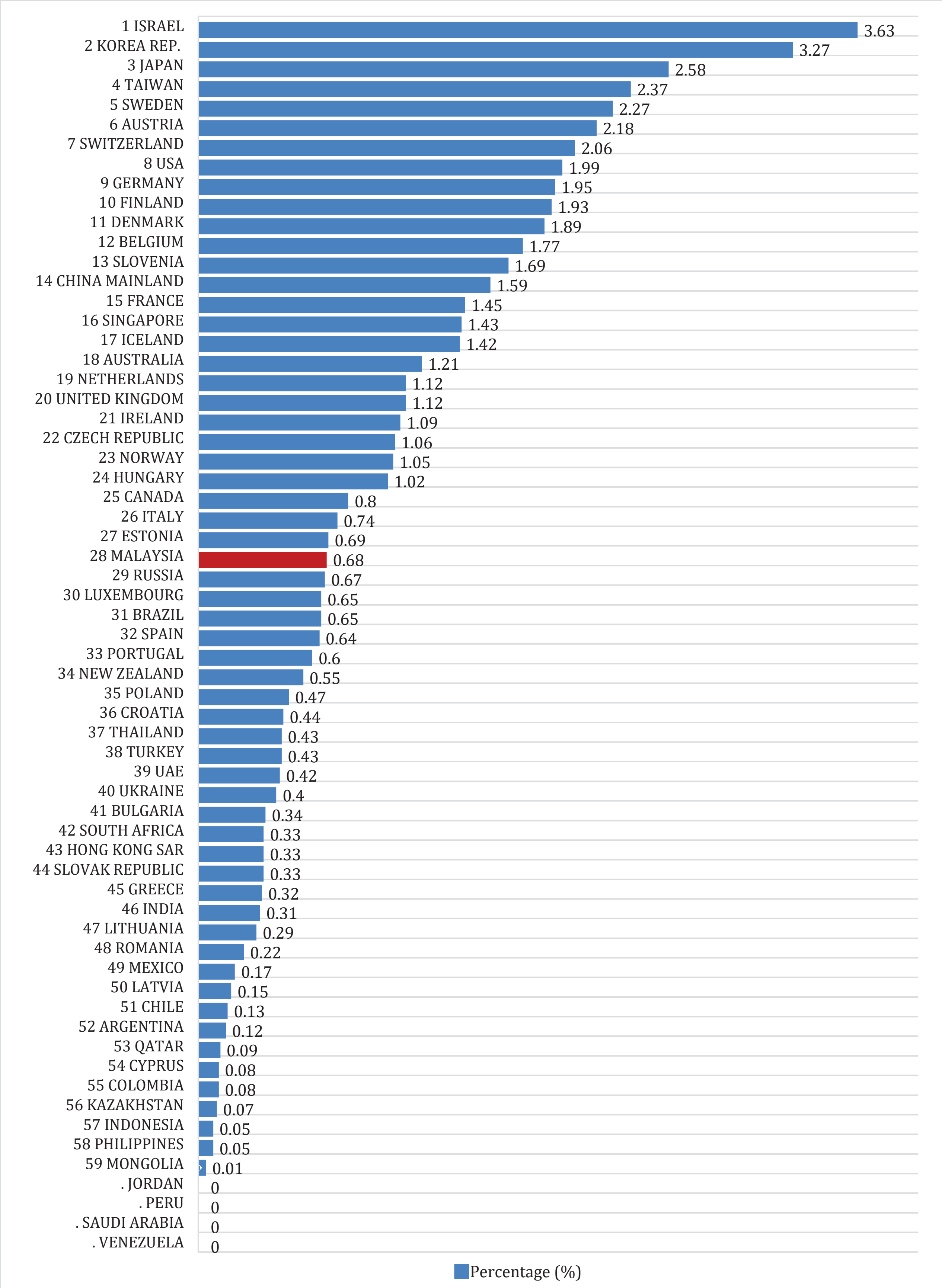
Source: IMD World Competitiveness Online 1995-2017

7.4 Business Expenditure on Research and Development (BERD)

Business enterprise expenditure on research and development (BERD) is considered important for innovation and economic growth. The importance of the business sector's involvement in R&D is reflected in the BERD per GERD. This shows the share of R&D in relation to the total R&D expenditure in the business sector of the advanced economies. In the National Survey of R&D in Malaysia 2015, it was reported for 2012, Malaysia was ranked 18th in the world ranking of BERD per GERD at 64.45%, Israel's BERD per GERD was the highest at 89.02%. Among the NIEs, Korea's ranked 2nd with BERD per GERD amounting to 77.95% and closely followed by China in 4th (76.15%) and Taiwan in 6th place with 74.17%. It was also reported for 2014, Malaysia recorded BERD per GERD of 45.66% while India recorded BERD per GERD of 35%.

In 2015, Malaysia ranked 28th at 0.68% BERD per GDP. The top five are Israel, Republic of Korea, Japan, Taiwan and Sweden (Figure 7.3).

Figure 7.3: Business Expenditure on R&D per GDP (%), 2015



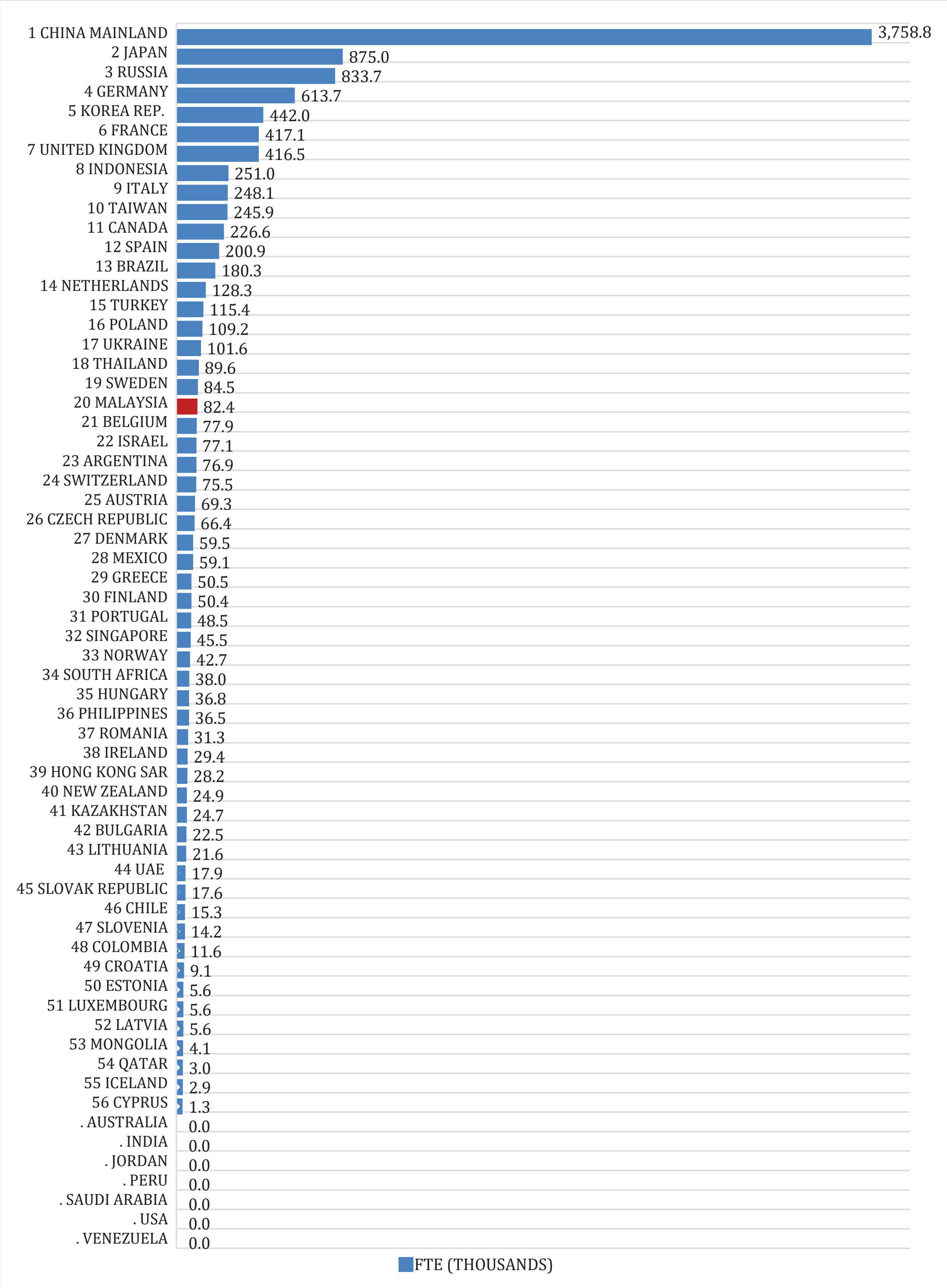
Source: IMD World Competitiveness Online 1995-2017

7.5 Human Resource Development in Research and Development

Having qualified staff is key to a country's ability to develop and implement innovations and thus to enhance its competitiveness. The quality of human resources defines the quality of research performed and is the prerequisite for the development of new knowledge and new technologies. Limited-skilled human resources in the field of science and technology posed significant barriers in order to develop a country's R&D capabilities (which in this context, Malaysia's R&D capabilities). As reported in the 2012 survey report, this could be due to the possibility of lesser focus on the basic sciences, technology and engineering for most courses in tertiary education offered by Malaysian universities.

In 2015, Malaysia was ranked 20th with FTE R&D personnel of 82.4. The 1st in the list is China Mainland with 3,758.8 FTE (Figure 7.4).

Figure 7.4: Full-Time Equivalent of R&D Personnel, 2015



Source: IMD World Competitiveness Online 1995-2017

7.5.1 Headcount of Researchers

The headcount of researchers is the function size of the economy, as well as, the population. Generally, countries with larger population size tend to have more researchers. However as shown in Table 7.1. Japan (926,671) was ranked 1st followed by Republic of Korea (437,447), Russian Federation (373,905), Turkey (181,544) and Egypt (124,976) researchers in 2014. These are the top five countries with highest total headcount of researchers. The Republic of Korea population size is less than Russian Federation, yet Republic of Korea was ranked higher than Russian Federation.

In 2012 report, among the developed countries in OECD, Malaysia ranked on the 15th place with higher headcount of researchers than Eastern Europe and the Scandinavian countries. However, in 2014, Malaysia was ranked on the 8th place, and total headcount of researcher increased from 75,257 to 84,516. It increased by 12.3%. In 2015, Malaysia total headcount of researchers increased to 89,861.

Table 7.1: Total Headcount of Researchers, 2014

Rank	Countries	Headcount	Rank	Countries	Headcount
1	Japan	926,671	21	Serbia	15,163
2	Republic of Korea	437,447	22	Chile	12,320
3	Russian Federation	373,905	23	Slovenia	12,155
4	Turkey	181,544	24	Peru	5,737
5	Egypt	124,976	25	Iraq	4,765
6	Poland	115,375	26	Cuba	4,355
7	Thailand	101,356	27	Armenia	4,144
8	*Malaysia	84,516	28	The former Yugoslav Republic of Macedonia	3,793
9	Argentina	83,837	29	Republic of Moldova	3,315
10	Ukraine	58,695	30	Kyrgyzstan	3,013
11	Finland	55,515	31	Georgia	2,893
12	Czech Republic	54,493	32	Uruguay	2,288
13	Norway	50,025	33	Mongolia	1,903
14	Singapore	40,730	34	Bosnia and Herzegovina	1,831
15	Hungary	39,190	35	Madagascar	1,828
16	Tunisia	33,996	36	Bahrain	1,560
17	Uzbekistan	30,785	37	China, Macao Special Administrative Region	1,379
18	Romania	27,535	38	Trinidad and Tobago	1,228
19	Slovakia	25,080	39	El Salvador	792
20	Azerbaijan	16,337	40	Togo	729

Source: UNESCO Institute for Statistics, *National Survey of R&D 2015
Note: Malaysia's Total Headcount of Researchers in 2015 = 89,861

7.5.2 Researchers per 10,000 Labour Force

Table 7.2 compared the proportion of researchers per 10,000 labour force as an indicator of researcher intensity across countries. In 2012, Finland ranked first with the largest number of researchers per 10,000 labour force (208.00), followed by Denmark (200.50) and Norway (174.40) per 10,000 labour force. Among the NIEs, the Republic of Korea ranked on the 4th place with 157.20, Singapore ranked on the 9th place with 127.70, Hong Kong at 22nd with 67.30. Malaysia ranked 25th with 57.45 researchers per 10,000 labour force in 2012 and improved to ranked 13th with 60.66 in 2014. There has been steady increment for Malaysia. In 2015, Malaysia's headcount of researchers per 10,000 labour force was 61.88.

Table 7.2: Headcount of Researchers per 10,000 Labour Force, 2014

Rank	Countries	Headcount	Rank	Countries	Headcount
1	Finland	205.85	21	Romania	29.61
2	Norway	182.70	22	Armenia	26.89
3	Republic of Korea	167.77	23	Ukraine	25.91
4	Japan	141.01	24	Thailand	25.51
5	Singapore	130.49	25	Uzbekistan	23.72
6	Slovenia	119.29	26	Republic of Moldova	23.23
7	Czech Republic	102.14	27	Bahrain	21.01
8	Slovakia	91.42	28	Trinidad and Tobago	18.18
9	Hungary	86.04	29	Mongolia	14.58
10	Tunisia	83.59	30	Chile	14.00
11	Turkey	62.88	31	Uruguay	13.07
12	Poland	61.65	32	Georgia	12.96
13	*Malaysia	60.66	33	Kyrgyzstan	11.93
14	Russian Federation	49.12	34	Cuba	8.22
15	Argentina	42.90	35	Iraq	5.42
16	Egypt	42.26	36	Peru	3.49
17	Serbia	39.64	37	El Salvador	2.86
18	The former Yugoslav Republic of Macedonia	39.46	38	Togo	2.20
19	China, Macao Special Administrative Region	38.48	39	Madagascar	1.55
20	Azerbaijan	33.63			

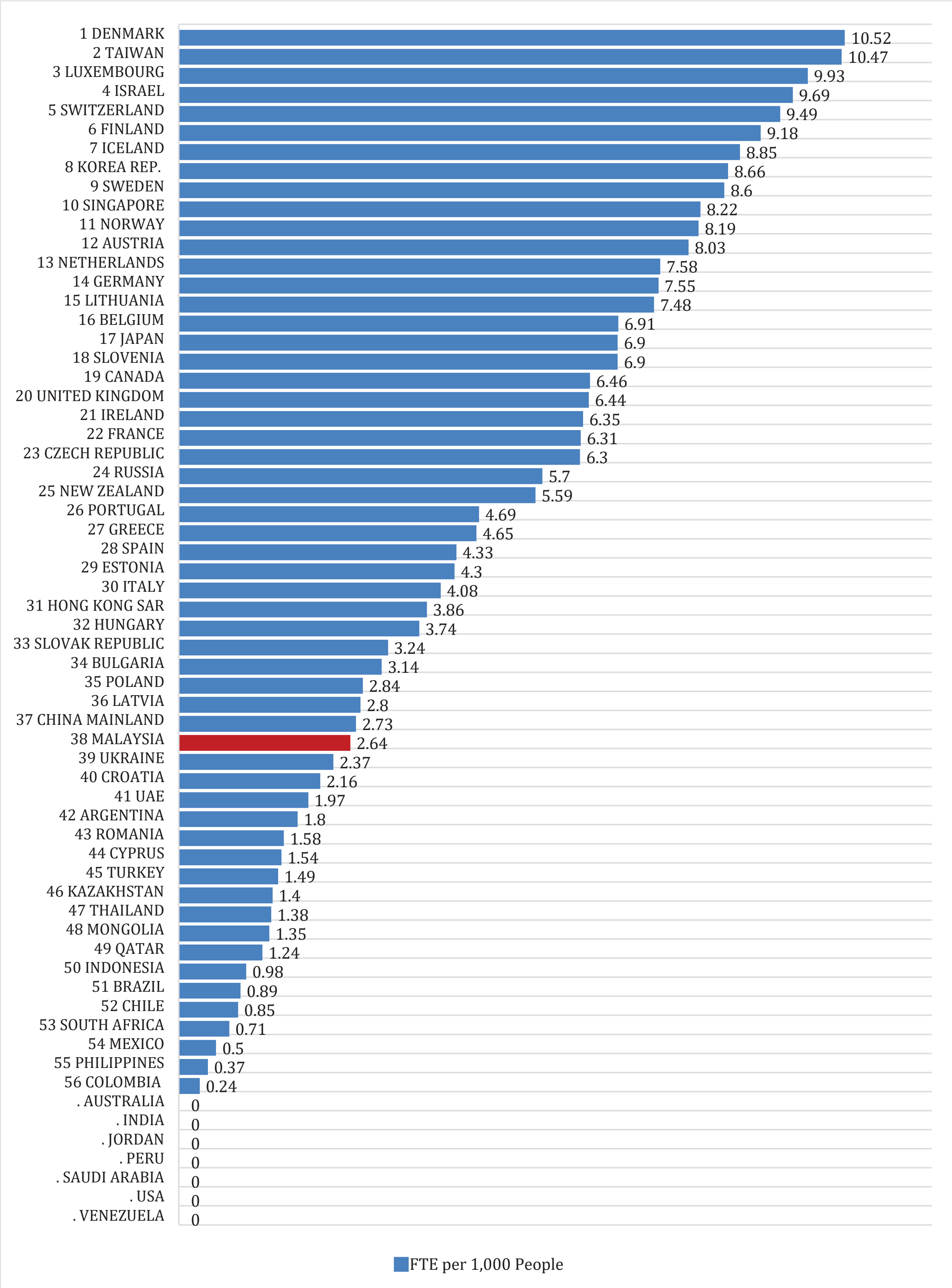
Source: UNESCO Institute for Statistics, *National Survey of R&D 2015
Note: Malaysia's Headcount of Researchers per 10,000 Labour Force in 2015 = 61.88

7.5.3 Full-Time Equivalent of Research Personnel

In 2012, the report for the number of R&D personnel in FTE shows Israel was ranked first with FTE of 21.76 per 1,000 labour force followed by OECD countries in Europe (Denmark, Finland, Luxembourg, Switzerland, Sweden and Austria). Among the NIEs, the Republic of Korea, Singapore, and Hong Kong have more FTE per 1,000 labour force compared to Malaysia (4.93) in 2012. In 2014, Malaysia’s FTE showed an encouraging improvement (5.39) compared to 2012.

In 2015, Malaysia's FTE R&D personnel per 1,000 people was 2.64 and ranked 38th, just right below China Mainland which has FTE R&D personnel per 1,000 people of 2.73 (Figure 7.5).

Figure 7.5: Full-Time Equivalent of R&D Personnel per 1,000 People, 2015



Source: IMD World Competitiveness Online 1995-2017

7.5.4 Female Researchers

The following Table 7.3 exhibits the percentage of female researchers in selected countries. In 2014, Malaysia ranked on the 11th place (48.78%) in the percentage of Malaysian female researchers as compared to three Latin American countries (Venezuela, Argentina, Paraguay) and two Eastern European countries (Latvia and Lithuania) and Azerbaijan. Among the NIEs, Malaysia was higher than Macao (32.63%) and Singapore (30.08%). In 2015, Malaysia reported 47.76% of female researcher.

Table 7.3: Headcount of Female Researchers in 2014 (%)

Rank	Countries	%	Rank	Countries	%
1	Trinidad and Tobago	54.64	21	Uzbekistan	40.65
2	Azerbaijan	54.27	22	Russian Federation	40.52
3	Tunisia	53.90	23	Bahrain	38.97
4	Armenia	53.74	24	El Salvador	37.88
5	Thailand	53.28	25	Iraq	37.50
6	Argentina	52.96	26	Norway	37.43
7	Georgia	51.19	27	Poland	37.23
8	Serbia	49.15	28	Turkey	36.89
9	The former Yugoslav Republic of Macedonia	49.14	29	Slovenia	36.09
10	Mongolia	48.92	30	Bermuda	35.48
11	*Malaysia	48.78	31	China, Macao Special Administrative Region	32.63
12	Uruguay	48.47	32	Madagascar	32.11
13	Cuba	48.17	33	Finland	32.10
14	Kyrgyzstan	47.99	34	Chile	31.54
15	Republic of Moldova	47.84	35	Hungary	30.36
16	Romania	46.01	36	Singapore	30.08
17	Ukraine	45.81	37	Czech Republic	27.19
18	Bosnia and Herzegovina	44.29	38	Republic of Korea	18.49
19	Slovakia	42.49	39	Japan	14.70
20	Egypt	42.22	40	Togo	9.47

Source: UNESCO Institute for Statistics, *National Survey of R&D 2015
Note: Malaysia's Headcount of Female Researchers in 2015 = 47.76%

7.6 Conclusion

In conclusion, the R&D survey of financial year 2015 has shown that Malaysia's performance in global R&D has improved slightly than previous years. Although there was an improvement, further efforts are needed especially in GERD and BERD. In 2015, Malaysia has improved it GERD. Malaysia's GERD of USD3,856 million placed it at the 30th out of 63 countries in the IMD world ranking in comparison to USA which was ranked first with GERD of USD502,893 million.

Malaysia's GERD per GDP for 2015 was ranked 29th with 1.30%. The highest GERD per GDP was charted by Israel with 4.25%, and followed by the Republic of Korea with 4.22%. Other countries that recorded relatively high GERD per GDP above 3.00% were Japan (3.29%), Sweden (3.26%), Austria (3.07%), and Taiwan (3.05%). Other developed countries with GERD per GDP ratios above 2.00% include Netherlands, China Mainland, Iceland, Slovenia, France, Singapore, Belgium, USA, Germany, Finland, and Denmark. Among the NIEs, Taiwan ranked on the 6th place with GERD per GDP of 2.94% and Singapore in 12th place with 2.00%.

Malaysia has relatively low R&D investment as reflected in GERD per GDP of 1.30% in 2015 as compared to G20 countries, however Malaysia GERD has increased from 1.26% in 2014 to 1.30% in 2015.

In terms of BERD, for 2015, Malaysia ranked on the 26th place with 51.95% BERD per GERD. The top five are Israel, Japan, Taiwan, Republic of Korea and China Mainland. Malaysia ranked 28th at 0.68% BERD per GDP.

Malaysia has experienced steady increment in terms of headcount of researchers. Specifically, in 2012, Malaysia ranked on the 15th place with higher headcount of researchers than Eastern Europe and the Scandinavian countries. However, in 2014, Malaysia was ranked on the 8th place, and total headcount of researcher increased from 75,257 to 84,516. It increased by 12.3%. In 2015, Malaysia total headcount of researchers further increased to 89,861.

For researcher intensity, in 2015, Malaysia's headcount of researchers per 10,000 labour force was 61.88. There has been steady increment for Malaysia. In 2012 and 2014, Malaysia's headcount was 57.45 and 60.66 respectively.

In 2015, the Malaysia's FTE R&D personnel per 1,000 people was 2.64 and the female researchers headcount was 47.76%.

Box 7.2: Lessons from Germany

Germany offers cash grants for eligible R&D projects, but does not offer tax incentives.

R&D incentives, mainly in the form of non-repayable cash grants, are awarded on a “per project” basis, usually for collaborative projects. There is no legal claim for R&D funding. Grant rates average at 50% of eligible project costs, although higher rates may be possible for SMEs.

The selection criteria for eligible projects include: • Extent of innovation; • Extent of technical risk; and • Extent of economic risk.

R&D loans are an alternative to R&D grants. R&D loans are not contingent on conducting R&D activities in a specific technology field and there are no application deadlines. R&D loans are provided under different governmental programs (e.g., the ERP Innovation Program offers 100% financing of eligible R&D project costs up to EUR 5M). R&D tax incentives are not yet offered, but the introduction of such incentives is on the political agenda.

Eligibility is not limited to particular industries. Companies in the following industries typically seek cash grants: • Biotech and life sciences • Information and Communication Technology (ICT) • Manufacturing, including automotive • Energy and utilities

Qualifying expenditure includes: personnel costs, materials, overhead, subcontracts, amortization, and travel costs. Cash grants generally are disbursed to the business after costs have been incurred. Qualifying activities include the following: • Fundamental research—experimental or theoretical work aimed at gaining new knowledge; • Industrial research—research with a specific practical objective aimed at developing new products, processes, or services, or at improving existing ones; and • Experimental research—research aimed at producing draft, plans, and prototypes.

(Source: Deloitte, 2015 Global Survey of R&D Tax Incentives)

CONCLUSION AND RECOMMENDATIONS

CHAPTER 8: CONCLUSION AND RECOMMENDATIONS

8.1 Trends and Performance of Research and Development

The following trends are observed from the 2016 R&D survey:

1. Malaysia's Gross Expenditures on Research and Development (GERD) has increased from RM13.97 billion in 2014 to RM15.06 billion in 2015. BEs (7.82 billion) is the major contributor to GERD followed by HLIs (4.29 billion) and GRIs (2.95 billion).

2. Malaysia's GERD per GDP has increased from 1.26% in 2014 to 1.30% in 2015.

3. Business Expenditure on R&D has increased from RM6,379 million in 2014 to RM7,823 million in 2015.

4. BERD per GERD has increased from 45.66% in 2014 to 51.95% in 2015.

5. GRIs contribute 28.48% of R&D expenditure which is less than BEs (51.95%) contribution to GERD in 2015.

6. The government has remained the main source of R&D funds for HLIs 71.13% and GRIs (69.06%) in Malaysia as like previous years. BEs generated R&D funds mainly from their own, which has increased to 94.05% in 2015 from 66.50% in 2014.

7. In 2015, the two sectors that mostly contributed to applied research are BEs (RM7,020.59 million) and GRIs (RM1,944.36 million). The HLIs focuses less on applied research (RM1,648.56 million) compared to basic research. The basic research in Malaysia is mostly conducted by HLIs (RM2,281.68 million) followed by GRIs (RM707.06 million) and BEs (RM163.67 million). On the other hand, experimental research is contributed mostly by BEs (RM639.28 million) followed by HLIs (358.60 million) and GRIs (294.54 million).

8. In the case of FOR, the contribution of information, computer and communication technology to GERD has increased from 39.04% in 2014 to 42.40% in 2015 and remains at the first place like previous year. Likewise, engineering and technology holds the second position, though its contribution has dropped from 24.48% to 19.84% during the same period. The third most important field of research is natural sciences (10.74%).

9. Sustainable economic development (35.58%) is the leading spender of R&D funds with increasing trend compared to 2014 (31.35%) in meeting the socio-economic objectives in 2015. Society (19.94%) and advanced experimental and applied sciences (19.06%) have assigned the second and third place, respectively with decreasing trends in comparison with the previous survey in 2014.

10. R&D personnel have grown by 19.33% from 114,539 in 2014 to 136,683 in 2015, recording an enormous increase. Also, the total number of researchers has increased significantly from 84,516 in 2014 to 89,861 in 2015, growing by 6.32% over the last two years. The increase in manpower is possibly due to the organisations' increased focus in R&D activities.

11. Total FTE of R&D personnel has increased from 22,287.29 in 2008 to 82,360.33 in 2015, with an average annual growth of 20.53% in total FTE of R&D personnel from 2008 to 2015.

12. Headcount of researchers per 10,000 labour forces has increased from 60.66 in 2014 to 61.88 in 2015.

13. Female participation in R&D has steadily increased from 2008 to 2012 which records the highest female participation of 49.92% in 2012 but subsequently drops to 48.78% 2014 and 47.76% in 2015. Even though there is an increase of 4.11% in the number of female researchers from 2014 to 2015, it does not match the increase of male researchers by 8.43% during the same period.

14. The breakdown of researchers by qualifications has a mixed trend since 2008 to 2015. The Masters researchers only comprise 36,417 (42.99%) headcounts in 2015, whereas the 2014 survey represented 52,175 (63.81%) headcounts of Masters. The Bachelor researchers represents 24,165 (28.53%) headcount followed by PhD 22,740 (26.84%) and non-degree/diploma holders 1,392 (1.64%) headcount of the total population. Note that there has been significant increase in Bachelor degree holders (122.80%), which has pulled down the percentages of Masters researchers drastically. These figures do not include 5,147 researchers whose qualifications are not specified in the completed questionnaires.

15. The majority of R&D projects of BEs are located in Selangor (28.69%) Penang (14.08%) and Wilayah Persekutuan Kuala Lumpur (13.07%), while the majority of R&D projects by the HLIs are located in Selangor (25.48%), Wilayah Persekutuan Kuala Lumpur (11.80%), and Johor (8.17%). Meanwhile, the highest percentage of R&D projects of GRIs are located in Selangor (24.83%), followed by Sarawak (13.85%) and Wilayah Persekutuan Kuala Lumpur (12.54%).

16. Six HLIs outsourced their projects (RM79.99 million) within Malaysia, while five of them outsourced projects abroad (RM9.91million). A total of 22 BEs and 26 GRIs outsourced their projects but did not indicate location and amount.

17. A total of 58,962 publications by HLIs and GRIs are recorded in 2015 which is 17.10% less than the publications recorded in 2014 with 71,121. Indexed journal publications, conference proceedings and books also record decrease with 25.42%, 34.50% and 48.63%, respectively compared to similar types of publications recorded in 2014. The huge drops in these publications are a matter of great concern. Possible reasons should be identified by the relevant authority separately and appropriate measures should be taken to rectify the problem, if any. Only non-indexed publications records 9.48% increase from 8,674 in 2014 to 9,496 in 2015. Chapters in book remains almost equal in 2014 (2,878) and 2015 (2,886).

18. The number of patents awarded has dropped in 2015 with 388 compared to 745 patents awarded in 2014. Trademarks also decreased from 738 in 2014 to 390 in 2015. The reason for decline in both cases should be identified by the relevant authority. 143 number of Industrial Designs were in 2015 which is lesser than the number (183) in 2014.

8.2 Conclusion

This National R&D Survey report presents the details of R&D activities in 2015. In addition to this, the report provides a comparative analysis on R&D activities starting from the year 2008. Comparisons are made with respect to expenditure, headcount of researchers, type of research and R&D outputs including publications, patents and copyrights.

The R&D researches have been classified as applied, basic and experimental. It is observed that, in 2015 applied research has dominated the other two, though compared to 2014, its contribution has decreased from 75.53% to 70.48%. The researches in other two sectors have witnessed marginal increase. From the 2015 survey data, it is found that BEs and GRIs concentrate more on applied research, whereas HLIs contribute more towards basic research.

The Survey finds overall increase in the expenditures and headcounts, but decreases in research output. Gross expenditures on R&D has been increasing gradually from RM6,071 million in 2008 to RM15,058 million in 2015. However, to achieve the target of 2.00% of GDP expenditure, Malaysia needs to allocate more budgets for R&D.

Another notable point is that HLIs share to GERD has decreased in 2015 (from 46.13% in 2014 to a paltry 24.48% in 2015). However, BEs share to GERD has increased from 45.66% in 2014 to 51.95% in 2015. Likewise, GRIs share to GERD has significantly increased from 8.21% in 2014 to 19.57% in 2015.

BEs' contribution as sources of funds has increased significantly from 25.23% in 2014 to 49.60% in 2015. Government has traditionally been the main funder for R&D activities, but in 2015, government funds have decreased from 44.96% in 2014 to 35.77% in 2015. Likewise, the funds coming from other than BEs and government also have decreased from 29.81% in 2014 to 14.64% in 2015.

In 2008, the number of R&D personnel was 40,840; in 2015 this number stood at 136,683. This means over the last seven years, the average number of R&D personnel increase has been 18.83%. The headcount of researchers per 10,000 labour forces also has increased from 60.66 in 2014 to 61.88 in 2015. In congruence with this, there has also been impressive average growth (20.52%) of FTE of R&D researchers over the last seven years.

In terms of qualifications of researchers, there has been unprecedented growth of Bachelor degree holders in 2015, the increase being 122.80% compared to 2014 data. Researchers having PhD qualifications have also increased 33.10% compared to 2014. However, the researchers who have Master's degree have decreased by 43.27% with respect to 2014 figure.

In terms of R&D outputs, 2015 demonstrates downward trend in terms of publications. The number of publications has fallen from 71,121 to 58,962 by a whopping 17.10%. In consequence, the sub-categories like indexed journal publications, conference proceedings and books record decrease with 25.42%, 34.50% and 48.63%, respectively. Only non-indexed publications has increased (9.48%). Patents awarded drops from 745 in 2014 to 388 in 2015. Similarly, trademarks also decreases from 738 in 2014 to 390 in 2015.

In the global context, Malaysia has improved her performance marginally in 2015; however, the country needs to improve in both GERD and BERD. The highest GERD per GDP comes from Israel with 4.25% followed by Republic of Korea with 4.22%. In this context, Malaysia ranks on the 29^{th} place with 1.30%. The countries whose GERD per GDP ratios above 2.00% are China Mainland, Iceland, Slovenia, France, Singapore, Belgium, USA, Germany, Finland, and Denmark. In terms of BERD, in 2015 Malaysia ranked on the 26th place at 51.95% BERD per GERD. In this case, the top five spenders are Israel, Japan, Taiwan, Republic of Korea, and China Mainland.

8.3 Recommendations

8.3.1 Overall recommendations for national R&D

The present team of researchers have formulated some recommendations to enhance the R&D activities in the country. Malaysia has taken a sound step by creating a Research Management Agency (RMA) as per the charter of the Eleventh Malaysia Plan (2016-2020). The purpose of creation of this agency is to monitor inter-agency coordination, particularly to manoeuvre ties between universities and BEs in order to foster innovation and improve the commercialisation of intellectual properties. In turn, this agency may expand its role further in streamlining the activities of the Research Management Centres at various HLIs. The agency can also work as intermediary for collaboration between HLIs and BEs.

In another strategic step, The Ministry of Higher Education has recognised 16 Higher Institution Centre of Excellence (HICoE) at various public and private universities. These HICoEs are considered as leaders at the national level in their respective niche areas. Engaging further efforts are recommended to increase the number of HICoEs to boost country's competitiveness in terms of research outputs and intellectual property. Remaining within the realm of higher education sector, these centres can be catalyst to push Malaysia's demand-driven research agenda enshrined in the Eleventh Malaysia Plan.

Malaysia needs to step up further efforts to increase the number of researchers per 10,000 labour force. According to the survey conducted in 2014, Malaysia had 60.66 researchers per 10,000 labour force; this figure nominally increased to 61.88 in 2015, still well-short of the national target of 70 researchers per 10,000 labour force by 2020.

Finally, as it has been suggested before, there is an urgent need for greater collaboration and cooperation among the three sectors dealt in the present survey, in particular, GRIs and BEs. For Malaysia, to become a high-income nation and achieve the status of a developed country by the year 2020, it needs to expand further and consolidate R&D activities that are targeted at commercialisation.

8.3.2 Recommendation for Business Enterprises (BEs)

BUSINESS ENTERPRISES (BEs)
ISSUE IDENTIFIED: Limited financial resources
RECOMMENDATION: To increase funding for BEs
It is recommended for the government to introduce a levy system imposed to the business enterprises. To implement this the government will need to pass an act and to establish an entity called R&D&I Fund (RDIF). For the levy purpose, primary industry will need to be identified. A levy will be imposed on the enterprises in the identified primary industry. A minimal percentage (2%-5%) of total payroll to be contributed to the fund. This contribution will later be paid to the contributing enterprises for their R&D activities through a reimbursement method. If the business enterprises pay their levy late or they do not pay, they will be penalised at the rate of 2% per month. This will compound on the total of the unpaid amounts, including any penalties the enterprises have already accrued, until they have paid the outstanding levy in full. This will also affect their eligibility for reimbursement.
ISSUES IDENTIFIED: Lack of knowledge of scientific research Lack of skilled R&D personnel
RECOMMENDATION: To employ and retain talents
Having qualified staff is key to a company's ability to develop and implement innovations and thus to enhance its competitiveness. The quality of human resources defines the quality of research performed and is the prerequisite for the development of new knowledge and new technologies. As R&D becomes more competitive and markets increasingly global, it seems right that hiring people from a wider variety of backgrounds will create an R&D team with a breadth of experiences, approaches and insights that adds up to a competitive advantage. Human resources specialists involved in hiring and developing R&D staff need to rethink the agreement that is made between companies and employees, recognising that expectations about the skills they bring, their career development, and how long they will stay have all changed. This will have a knock-on effect on the way in which business enterprises present themselves to potential recruits in the markets. The new recruits want to know how fast they can move up. Business enterprises need to offer a credible value proposition and to show rapid capability building. The process begins with university and school partnerships, good branding and strong marketing. Once the talents are recruited, business enterprises need to retain this people. Personal feedback, performance management, career maps and more flexible benefits packages may also help keep people. Enriching their jobs, by adding responsibility or expanding its scope, are also a useful incentive.

8.3.3 Recommendation for Higher Learning Institutions (HLIs)

HIGHER LEARNING INSTITUTIONS (HLIs)

ISSUE IDENTIFIED:

Lack of Private and International Funds

RECOMMENDATION:

To identify key funders and re-align R&D needs

The survey reported the cooperation with major foreign funder was lacking. As it is important to be amongst the forefronts of R&D players in the world in solving global issues, the source of funds to support R&D activities must be sustainable and portion of the funds must come from foreign sources.

Hence, it is recommended to align our national strategic needs, strength in term of local resources and expertise and the interest of major foreign research funders (ie NIH -US, Horizon2020- EU etc).

Dedicated unit to carry the tasks could be established at national level. The unit must actively engage in looking for any grant opportunities and should provide platform for the researchers to communicate with the funders for possible pairing between the entities.

ISSUE IDENTIFIED:

Lack of coordination in managing research outputs

RECOMMENDATION:

To develop standardised tool to manage research outputs

The survey reported a high degree of commitment by the government to continuously support the R&D activities across all the sectors, especially in HLIs and GRIs in term of providing financial and human capital. This was reflected by the figure of key indicators in the survey namely the size of research expenditure, source of funds, headcount of research personnel, and research outputs generated from the R&D activities. In term of research outputs, the product of R&D activities need to be efficiently managed as the information about the products is useful for risk management process, and development of strategy to diversify research funding. The coordination in this aspect however is lacking.

Hence it is recommended for the government to develop a specialized tool to manage these research outputs so as to provide common understanding of technology status of products of R&D activities.

This is important to help in managing the decision making process concerning the stage of product development together with its transitioning technology that suits the national needs.

ISSUE IDENTIFIED:

Lack of collaboration in research activities

RECOMMENDATION:

To develop integrated research incubators

As the government aspires to develop efficient innovation ecosystem, academics in the HLIs, business enterprises, research institutes, government and local communities have to come together in partnership to collaborate in setting up research incubators and accelerators, where researchers can build their business incubation, and commercialise their research ideas.

As such it is recommended for the government to identify top HLIs to learn and form from the success story of other top university incubator programmes whose function amongst others are to :

- Integrate key technologies and incubation of technological entrepreneur to help the resided industrials innovate products and manage profit.
- Help the resided industrials to compete in gaining various innovative supports from external resources and promoting their competency and success.
- Provide the soft/hard administrative and academic resources of the HLI to the industrials for smooth operation, including services of manpower, technology, and apparatus.
- Assist the industrials as a partnership; strengthening the cooperation and achieving win-win situation through the feedback-system.
- Promote industrial and academic cooperation and building up and academic entrepreneur environment through the involvement of R&D and industrial.

ISSUE IDENTIFIED:

Lack of innovation cultures

RECOMMENDATION:

To inculcate innovation values in researchers

Prosumerism is a term composed from the words producer and consumer, entailing the tendency towards a market where the distinction between producers and consumers decreases, where consumers are producing their own products and services. This is a new trend that takes place due to individual, societal, technological and economic changes, particularly caused by the rapid advances in the information and communication technology.

For many researchers, developing new products and services originated from their creative and innovative minds seldom end up in the commercial market. Amongst the main reason is due to the inability to relate and sell the products or ideas to the right business entity.

Hence it is recommended for the government to organise more events that are geared towards cultivating creative, innovative and entrepreneurial minds among researchers such as product pitching.

8.3.4 Recommendation for Government Agencies and Research Institutes (GRIs)

GOVERNEMENT AGENCIES AND RESEARCH INSTITUTES (GRIs)
ISSUE IDENTIFIED: Limited R&D budget
RECOMMENDATION: Allocate more budget for R&D activities
Malaysia's GERD per GDP is 1.30% in 2015, which is well below the target 2.00% by the year 2020 and stands at rank 29th in the world. This underscores the importance of taking various measures to increase the expenditure on R&D. The sources of funds must be diversified and must not rely only on the government's contribution. To supplement the budget contributed by the government of Malaysia, the GRIs are advised to increase the rate of commercialisation. Since GRIs are directly funded by the government, therefore, the government must dictate and monitor the usage of the fund so that the resources are spent for the national priority areas in an optimal way. GRIs are advised to be more aggressive in opening up multiple fronts of consultancy for the BEs.
ISSUES IDENTIFIED: Limited collaboration among GRIs, HLIs, and BEs
RECOMMENDATION: Forge strong collaboration among GRIs, HLIs, and BEs
There is an urgent need to forge strong collaboration among GRIs, HLIs, and BEs. This will be a catalyst for mutual exchange of research ideas, mobility of research staff and to ensure that there is no redundancy of R&D activities. Strong collaboration among them is critical for development as well as enhancement of skills, generation and acquisition of knowledge and promotion of entrepreneurship. This relation can also help coordinate R&D agendas, avoid duplication of research, exploit synergies and complementarities of scientific and technological capabilities. The following actions can be taken: - The Ministry should reward the institution which has strong linkages with GRIs and BEs - Ministry of Higher Education should make policy that every HLI in the country must partner with GRIs and BEs - MoUs and MoAs between GLCs and HLIs - Increase secondments of university researchers to GRIs as well as Bes -

ISSUES IDENTIFIED:

Limited full-time research personnel

RECOMMENDATION:

Ensure sufficient number of full-time research personnel with necessary expertise in each GRI

According to the feedback received, most of the GRIs lack full time research personnel with requisite expertise. Possibly, researchers are burdened by additional activities imposed by their respective organisations which may limit their full time availability to carry R&D activities. Therefore, taking the following measures are recommended:

- Government should ensure that every GRI has requisite number of full-time research scientists
- Every GRI must instil the spirit of continuous learning in the institute and enhance research skills by organising regular seminars, symposia and workshops. Attending in these programs of continuous learning should be made compulsory and KPIs can be developed accordingly.

ISSUES IDENTIFIED:

Insufficient research output

RECOMMENDATION:

Facilitate high-impact publications

Overall, it is found that GRIs' research outputs are mostly disseminated by conference presentations and publishing in proceedings. However, for the access of wider audience, GRIs are advised to publish their works in international referred journals. It has also been found that some GRIs, namely Malaysia Palm Oil Board, Institute for Medical Research, Malaysia Genome Institute, Forest Research Institute Malaysia have done exceptionally well in terms of research outputs. These organisations can be regarded as benchmarks to other organisations. In general, the following recommendations are put forward for the GRIs:

- Develop incentive systems for publishing in high impact journals.
- Develop KPIs for full-time research personnel to publish in indexed journals, especially WoS indexed journals.
- Develop KPIs for each GRIs regarding number of patents applied, patents awarded, trademark, copyright and industrial design.
- Organise more international conferences and seminars at the GRIs.
- Benchmark KPIs for researchers as well as the institutes as a whole and this must be comparable with international standard.

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