ASSESSING THE SOCIO-ECONOMIC BENEFITS OF PUBLIC R&D ACTIVITIES IN MALAYSIA

Ahmad Zafarullah Abdul Jalil[1]
Noor Al-Huda Abdul Karim[2]
Sallahuddin Hassan[1]

ABSTRACT

As an open economy, Malaysia needs to constantly generate and establish new sources of economic growth in order to remain competitive in the long run. 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. Therefore, the Government of Malaysia has introduced various science and technology programmes for the purpose of encouraging R&D and technological innovation to acquire and to advance technological capability. The existence of such programmes shows that the Government is aware of the importance of R&D towards achieving a more prosperous economy and as such, it has played an active role in promoting R&D in the country. The Government-funded R&D programmes are established for the purpose of generating knowledge, creating wealth, and upgrading societal well-being. The involvement of the Malaysian Government in promoting R&D activities has started since the Fifth Malaysia Plan, 1986-1990 with the introduction of the Intensification of Research in Priority Areas (IRPA) grant. This study used econometric analysis in order to examine the extent to which R&D activities contributed towards social and economic development in Malaysia. Our findings suggest that R&D public investments are important to promote economic growth in a long-term period.

[1]: Senior Lecturer, College of Arts & Sciences, Universiti Utara Malaysia
[2]: Senior Lecturer, College of Law, Government and International Studies, Universiti Utara Malaysia

1. INTRODUCTION

In order to remain competitive in the world economy, 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. According to these studies, R&D programmes can generate knowledge spillovers and then contribute to technological progress and eventually productivity and economic growth. For example, Griliches (1979) found that the stock of knowledge, measured by R&D, spills over from one firm to another. These findings are in concordance with Romer (1990) who argued that R&D does not only affect the firm that produces it, but also other firms via positive externalities.

Therefore, the Government of Malaysia has introduced various science and technology programmes for the purpose of encouraging R&D and technological innovation to acquire and to advance technological capability. The existence of such programmes shows that the Government is indeed aware of the importance of R&D towards achieving a more prosperous economy and as such, it has played an active role in promoting R&D in the country. As it is, R&D programmes are established by the Government for the purpose of generating knowledge, creating wealth, and upgrading societal well-being. More precisely, it is hoped that R&D programmes can boost the new economy through the development of human capital and intellectual property rights and to reduce the knowledge gap. Furthermore, R&D programmes are regarded as the effective way to bring added value to the existing resources and to create new resources to enhance national competitiveness and to ensure sustainable development through knowledge-based economy. R&D programmes can also help enhance the well-being of the society by improving the quality and sustainability of life in the knowledge and environmental-friendly community.

This paper is organised as follows. The next section discusses the involvement of the Malaysian government in the R&D activities. Section 3 provides a brief review of literature. The empirical analysis and results are discussed in section 4. Finally, section 5 concludes.

2. GOVENMENT-FUNDED R&D PROGRAMMES IN MALAYSIA

The involvement of the Malaysian Government in the promotion of R&D activities has started since the Fifth Malaysia Plan, 1986-1990 with the introduction of the Intensification of Research in Priority Areas (IRPA) grant. The IRPA grant was set up to stimulate R&D activities on areas which have potential for enhancing the national socio-economic position. During the Fifth Malaysia Plan, a total of RM413.8 million had been disbursed by the Government in order to spur R&D activities in the country. The IRPA grant was continued in the Sixth Malaysia Plan, 1991-1995 and the amount being disbursed had increased to RM 629 million. During the Seventh Malaysia Plan, 1996-2000, several new research grants were introduced by the Government. The introduction of these grants was in line with the change in the Government policy with regard to R&D activities. Prior to the Seventh Malaysia Plan, R&D activities were mainly aimed towards building capaicty in Science & Technology (S&T) and generating new knowledge. Therefore, most researches that were funded by the IRPA grants can be categorised as knowledge-driven where little or no attention at all were being given to the marketability of the outcomes of these researches.

Beginning from the Seventh Plan, R&D activities started to be viewed as the potential source of income that can contribute greatly to the economy of the country. The Government has thus felt the necessity to encourage researchers to venture into R&D activities in which the outcomes can latter on be transformed into commercialised products. As such, several new grants have been set up in attempt to attract more researchers to conduct market-driven type of research. Furthermore, in parallel to the current trend worldwide, the Government has decided to give special attention to two areas of research namely the Information and Communication Technology (ICT) and Biotechnology by creating two special grants - the BIOTEK grant and the MGS grant.

It also noteworthy that starting from the Seventh Malaysia Plan, 1996-2000, public R&D grants under MOSTI were no longer confined to public universities and research institutes. Private entities are now eligible to apply for grants that are solely intended for them namely Technology Acquisition Fund (TAF), Commercialisation of R&D Funds (CRDF), Demonstrator Application Grant Scheme (DAGS), Multimedia Super Corridor R&D Grant Scheme (MGS) and Industry Grant Scheme (IGS).

In the Ninth Malaysia Plan, 2006-2010, the IRPA and the IGS grants have been discontinued and no new funds have been disbursed under these schemes. However, there are still few uncompleted projects under these two grants that are being brought forward to the Nineth Malaysia Plan. There are also several new grants that have been introduced under the Ninth Malaysia Plan: ScienceFund, InnoFund, TechnoFund, E-Content Industry Development Fund (E-content), STI Policy Study, Human Capital Development (HCD), Strategic Funding for ICT, Technopreneur Development – MSC Pre Seed Fund, Agro Biotek R&D Initiatives, Genomics & Molecular Biology R&D Initiatives, Pharmaceutical & Nutracetical R&D Initiatives, Brain Gain, Biotechnology Commercialisation Grant and

Biotechnology Acquisition Grant. ScienceFund, InnoFund and TechnoFund are the three main grants under the Ninth Malaysia Plan with an allocated amount totalling RM1.47 billion or more than 54 percent of the total allocation. ScienceFund is a grant provided to support R&D projects which can generate new knowledge and develop new products or processes that can be further developed and commercialised within strategic basic and applied sciences. InnoFund is a grant scheme for small companies, community groups and individuals that fund the development or improvement of new or existing products, process or services with element of innovation. There are two types of InnoFund grant: Enterprise InnoFund (EIF) and Community InnoFund (CIF). As for TechnoFund grant, it is introduced to undertake pre-commercialisation of cutting edge technologies. There are two types of funding available under this grant scheme: (1) pre-commercialisation and (2) pre-commercialisation and Intellectual Property (IP) acquisition. Table 1 below shows the details of R&D programmes under different Malaysia Plans.

In addition to the R&D grant schemes, the Government of Malaysia has also announced various initiatives and incentives such as double deduction on expenses for the use of facilities and services of approved research institution/companies, double deductions on cash contribution to research institutions, double deduction on revenue expenditure for approved research projects and exemption on import duty, excise duty and sales tax on machine/equipment materials, raw materials and components parts and samples used for R&D activities. The amount of expenses granted for double deduction relief had increased sharply from RM 122.9 million in 2002 to RM 499.5 million in 2004. These incentives can spur the nation's competitiveness in R&D and to improve STI capability, particularly in the biotechnology and ICT sectors. In fact, the national focus in these emerging technologies will not only spawn new industries but also strengthen the traditional sectors such as agriculture towards greater productivity.

Despite all the incentives introduced by the Government in order to stimulate R&D activities in the country, R&D activities conducted by public and private sectors are still considered low compared to other countries. As a percentage of the GDP, Malaysian R&D expenditures are still lagging behind those of the USA, Japan, Taiwan and Singapore. In 2005, expenditure on R&D programmes was less than one percent of GDP, which is much lower than Singapore where the figure stood at more than 2 percent (see Table 2). The table uses the national total expenditure on R&D (that includes R&D expenditure from MOSTI) in comparison with those total R&D expenditures in other countries. Besides R&D expenditure, R&D human resource effort can also be used in comparing R&D achievement between countries. One way of measuring human resource effort in R&D activities is by using the Full-Time Equivalent (FTE) which is based on the actual proportion of times a researcher, technician or support staff spends on R&D during the surveyed year. Figure 1 shows FTE of researchers in Malaysia as compared to few selected countries. From the figure, the FTE for Malaysian researchers stood at 9,694 which is relatively small compared to other countries such as Germany with an FTE of 268,100 or Singapore with an FTE of 23,789.

Table 1: Types of R&D Grant Implemented under Five-Year Malaysia Plan

Malaysia Plan			
5th and 6th	**7th**	**8th**	**9th**
1) Intensification Research Priority Area (IRPA)	1) Intensification Research Priority Area (IRPA) 2) Industrial Grant Scheme (IGS) 3) Demonstrator Application Grant (DAGs) 4) MSC Malaysia Research & Development Grant Scheme (MGS) 5) Technology Acquisition Fund Women (TAFW) 6) Commercialisation of R&D Fund (CRDF) 7) Technology Acquisition Fund (TAF)	1) Intensification Research Priority Area (IRPA) 2) Industrial R&D Grant Scheme (IGS) 3) Demonstrator Application Grant (DAGs) 4) MSC Malaysia Research & Development Grant Scheme (MGS) 5) Technology Acquisition Fund Women (TAFW) 6) Commercialisation of R&DFund (CRDF) 7) Technology Acquisition Fund (TAF) 8) R&D Biotechnology 9) National Oceanography Directorate (NOD)	1) Techno Fund 2) Inno Fund 3) Science Fund 4) National Oceanography Directorate (NOD) 5) Dags Roll Out (DAGs) 6)E-Content Industry De velopment Fund (E-content) 7) STI Policy Study 8) Human Capital Development (HCD) 9) Strategic Funding for ICT 10) MSC Malaysia Research & Development Grant Scheme (MGS) 11) Technopreneur Development – MSC Pre Seed Fund 12) Commercialisation of R&D Fund (CRDF) 13) Technology Acquisition Fund (TAF) 15) Agro Biotek R&D Initiatives 16) Genomics & Molecular Biology R&D Initiatives 17) Pharmaceutical & Nutracetical R&D Initiatives 18) Brain Gain 19) Biotechnology Commercialisation Grant 20) Biotechnology Acquisition Grant

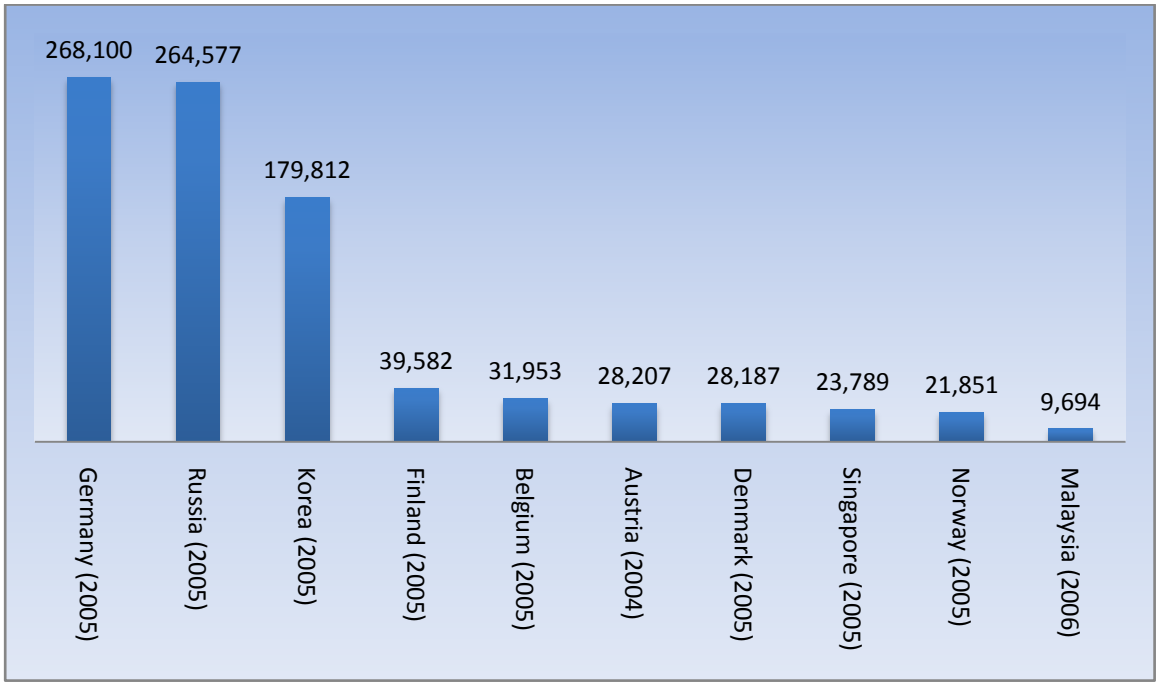
Source: MOSTI

Table 2: The Facts of R&D Expenditure of Malaysia and Other Countries, 2005

Facts	Country				
	Malaysia	**USA**	**Japan**	**S. Korea**	**Singapore**
Gross R&D Expenditure (RM Billion)	3.64	1,183.60	552.92	89.33	10.43
R&D Expenditure as a percentage of GDP	0.64	2.67	3.17	2.98	2.36
Total Expenditure on R&D per capita (RM)	137.10	4,030.60	4,330.16	1,855.67	2,401.02

Source: MOSTI, National Survey of R&D 2008

Figure 1: Full-Time Equivalent (FTE) of Researchers for Selected Countries



Source: UNESCO, Statistics on Research and Development, 2007

3. LITERATURE REVIEW

Among others, the purpose of R&D programmes impact study is to ensure that there is no wastage in the usage of government fund. In the United States, R&D impacts studies were first conducted in the years 1950s. However, beginning from the 1990s, these types of studies were given more prominence by the United States government with the enactment of the Government Performance and Results Act (GPRA) in the year 1993.

But measuring the benefit of R&D is not an easy task. Many problems in assessing the benefits of publicly funded basic research stem from limitations of the models used to evaluate economic and non-economic benefits that are generated from these activities. Publicly funded basic researches normally produce spill-over from the government sector to other economic activities and the entire society. Arrow (1962) pointed to the informational properties of scientific knowledge that can be considered as a public good that is non-rival and non-excludable. The main product of publicly-funded research is mainly economically useful information which is freely available to all firms. Callon (1994) however argued that scientific research is not a public good. According to the author, scientific knowledge is not freely available to all, but only to those who have the right educational background and to members of the scientific and technological networks. Thus, estimated magnitude of those benefit are usually underestimated.

There are various methodologies to measure and to evaluate the effectiveness of R&D programmes and funding. According to Salter & Martin (2001) there are three main methodologies or approaches that are usually adopted to evaluate the benefit of R&D in the literature. These methodologies are economic theory/econometric methods, surveys, and case studies, which are used to measure economic performance, productivity growth and improvements in social welfare.

Martin *et al.* (1996) analysed some of the earliest studies that have been done on the impact of R&D activities. According to these authors, most of these studies have shown that R&D programmes that were financed by the public sector have a return that is positive and significant. However, the rate of return of R&D programmes is different from one study to another. For example, Griliches (1958) that has evaluated the impacts of a research project conducted to produce a type of hybrid corn estimated that the level of return for that project was in the range of 21-40 percent. Cline (1968) that evaluated the impacts of a few agriculture researches estimated a higher rate of return ranging between 40-50 percent. It is clear from these studies that even-though there are differences between these studies, on average the rate of returns were estimated to be significantly positive ranging between 25-40 percent.

In yet another interesting study, Dowrick (2003) reviewed the literature on studies that looked at the relationship between productivity growth and government expenditure in R&D programmes. According to Dowrick, on average, the rates of return on government social expenditure in R&D programmes were between 5.8 percent and 7.8 percent.

In the case of Malaysia, two studies have been commissioned by MOSTI in order to evaluate the impacts of R&D activities financed by the IRPA grants. According to the study on the IRPA grant under the Sixth Malaysia Plan, 1991-1995, there have been many important achievements from these projects. These achievements include in the area of food production, research on rubber and oil palm, medical research and development of new technologies in the food and chemical engineering sub-sectors. According to the study, the impacts of IRPA programmes during the Sixth Malaysia Plan have made major contributions to the development of products, technologies and services which are useful for the development of the country.

Another study on the impacts of the R&D programmes under the Seventh Malaysia Plan, 1996-2000 was conducted by the UBC Consultancy Group. The study found that there were significant impacts on human resource development and commercialisation. However, the study also found that the economic impact of IRPA programmes under the Seventh Malaysian Plan, 2001-2005 was minimal. With respect to social betterment, which is defined as improvement towards the enhancement of the quality of life, the findings of the study showed that the R&D programmes did not contribute significantly to the nation's social betterment. However, research undertaken in sectors such as agriculture has significantly contributed to social betterment.

Other than these two studies, there is yet other study that tries to evaluate the R&D programmes in details. Studies on R&D in Malaysia are mostly narrative in form and descriptive in nature (Lai & Yap, 2004; Mani, 2000). These studies only discussed a few aspects of R&D activities in Malaysia by analysing some variables that are considered as proxies of the R&D activities. Nevertheless, there are also a few empirical studies that attempted to study the relationships between variables that are related with R&D activities and the level of country's economic activities (Hassan *et al*., 2003; Rahmah Ismail *et al*., 2000). These studies however only look at the macroeconomic aspect without discussing the R&D activities in more depth.

In general, this review of literature shows that the impact studies on public and private R&D programmes are not a new field that are yet to be explored. R&D impact studies have been conducted since more than half of a century ago. Some countries are more serious than others in evaluating their R&D programmes as shown by the initiative undertaken by the United States as well as Australia. Aside from that, this review of literature also shows that in general, public R&D programmes have significant positive impact. As far as Malaysia is concerned, the review shows that there are not many studies on impact of R&D activities that have been conducted. And the few studies that exist seem to concentrate more on macro aspect of the issue by analysing R&D activities in general without discussing them one by one in a more detailed manner. This is quite unfortunate especially given the fact that the Government of Malaysia has introduced diverse programmes aimed to encourage R&D activities in the country.

4. ECONOMETRIC ANALYSIS

One important question in this study is to what extent the R&D programmes sponsored through Five-Year Malaysia Plan (FYMP) can generate national economic and social development? To answer this question, an econometric method is used to analyse the following relationship:

$$Y = f(R\&D) \quad (1)$$

where Y is the output growth to represent Malaysia's economic and social development and R&D is the R&D expenditures to represent R&D programmes in the country

The hypothesis tested is:

H_0 : there is no relationship between Y and R&D

H_1 : there is a relationship between Y and R&D

Data on R&D expenditures in various sectors of economy in Malaysia is used to test the above-mentioned relationship. In sections 4.3 and and 4.4, the impact of R&D expenditures on national economic and social development is also estimated.

4.1 Scenario of Malaysia's Sectors of Economy

In the macroeconomic analysis, sectors of economy are categorised into five: 1) Agriculture, forestry, livestock & fishing, 2) mining & quarrying, 3) manufacturing & construction, 4) transport, storage & communications, finance, insurance, real estate & business services, and 5) government services. Table 3 shows all the five sectors of economy and their output performance in 1990, 2000 and 2008.

As shown in the table, the output growth of mining and quarrying was the largest with more than 60 percent but it recorded less than zero percent growth in 2008. Manufacturing and construction experienced a growth rate of more than 10 percent in 1990. However, its output growth rate declined to less than 2 percent in 2008. In agriculture sector, there was an improvement from negative to positive output growth rate during the period 1990-2008.

Table 3: Malaysia's Sectors of Economy by Output Growth

Sectors of Economy	Output growth (in percent)		
	1990	**2000**	**2008**
Agriculture, forestry, livestock & fishing	-7.25	-7.43	4.04
Mining & quarrying	27.30	60.53	-0.77
Manufacturing & construction	14.37	14.09	1.36
Transport, storage & communications, finance, insurance, real estate & business services	8.21	22.98	5.95
Government services	5.06	10.17	11.06

Source: Adapted from Malaysia Economic Reports and ADB

4.2 Data

The analysis on Malaysia's sectors of economy in relation to R&D only covers a constant ten points of time in the period 1990-2008 because of limited time series data on the explanatory variables for all cross-section units. Data on gross domestic product (GDP) were obtained from annual economic reports of Malaysia and Asian Development Bank (ADB). Data on government expenditure on R&D were obtained from the reports of National Science and Technology Databook 2000 and 1996, and National Survey of Research and Development 2008.

Missing data of 1988, 1990, 2002 and 2004 for the lagged government expenditure on R&D were extrapolated on the basis of the trend of research intensity in Malaysia for the years (Evers & Gerke, 2005). Data on employment were obtained from the annual series of Asian Development Bank report. Missing data of 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005 and 2007 for the lagged employment of two sectors (transport etc. and government services) were interpolated by taking an average data of two years, respectively and on the basis of the ratio of the two sectors. For example, the average data of 1988 and 1990 were taken to estimate the missing data of 1989 and so on.

4.3 An Analysis on Gross Domestic Product

i. Economic model

For our study, an economic model of gross domestic product is specified as follows:

$$GDP = f(R\&D, LP) \quad (2)$$

where GDP represents the level of output by sector of economy in Malaysia (in RM), R&D is the level of government expenditure on R&D by sector (in RM) and LP is the level of labour productivity by sector (in RM). The GDP and LP variables had been adjusted by Consumer Price Index (CPI) to remove inflation effects at the base year 2000=100.

The sign of the coefficient on R&D variable is expected to have a positive relationship with GDP. The positive sign means larger R&D investment by the government may contribute to an increase in the level of GDP in Malaysia's sectors of economy. The variable of labour productivity (LP) is formulated from the percentage ratio of GDP and total employment. The LP variable is also expected to have a positive sign as an increase in labour productivity stimulates total output in economic sectors.

ii. Econometric model

A pooled log-linear model of gross domestic product (GDP) is estimated using sample data of five major sectors of economy.

$$InGDP_{it} = b_0 + b_1 \ln R\&D_{it-2} + b_2 \ln LP_{it-1} + \varepsilon_{it} \quad (3)$$

where b_0 is the intercept, b_1 and b_2 are the slope coefficients that measure the *GDP* elasticity with respect to the lagged explanatory variables, ε is a random error term, and *i* and *t* refer to the *i*-th sector of economy in the *t*-th time period (cross-sectional unit of $i = 1, 2 \ldots 5$ and the time period t = 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008).

iii. Estimation results

Table 4 shows the elasticity values of the estimated coefficients in the economic output model. The *R&D* and *LP* coefficients have the right sign of theoretical expectations and are statistically significant at the 1 percent level to explain the level of output in the sectors of economy.

The positive sign of the *R&D* coefficient suggests that higher R&D investments in economic sectors help contribute to economic growth in Malaysia. In comparison, the R&D elasticity is higher than the *LP* elasticity of output.

In this analysis, the model has fitted the data very well. The model specification explains about 94 percent of the output variation in Malaysia. In the overall test of significance of the estimated regression, the calculated p-value of the F-statistic suggests a strong significant model of GDP.

Table 4: Estimates of GDP Elasticities with Respect to Government Expenditures on R&D and Labour Productivity

Variable	Estimated Coefficient	Standard Error	t-ratio	p-value
Government Expenditures on R&D (*R&D)*	0.30316	0.0158	19.24	0.000
Labour Productivity *(LP)*	0.11366	0.0399	2.846	0.007
Constant	17.627	0.3550	49.65	0.000

Notes: No. of observations: 50. Buse (1973) R-square = 0.9356.
F-ratio = 341.29 (p-value = 0.000).
R&D and LP are significant at the 1 percent level.

4.4 An Analysis on Employment

i. Economic model

For this analysis, an economic model of employment is

$$EMP = f(R\&D) \tag{4}$$

where EMP is the level of employment by sector of economy in Malaysia (in thousands) and R&D is the level of government expenditure on R&D by sector (in RM). The sign of the coefficient on R&D variable is expected to have a positive relationship with EMP.

ii. Econometric model

As in the analysis on GDP, a pooled log-linear model of employment is estimated using sample data of five major sectors of economy.

$$InEMP_{it} = b_0 + b_1 \ln R\&D_{it-2} + \varepsilon_{it} \tag{5}$$

where b_0 is the intercept, b_1 is the slope coefficient that measures the *EMP* elasticity with respect to the lagged explanatory variable (*R&D)*, ε is a random error term, and *i* and *t* refer to the *i*-th sector of economy in the *t*-th time period (cross-sectional unit

of i = 1, 2…5 and the time period t = 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008).

iii. Estimation results

In Table 5, the *R&D* coefficient has the right sign of theoretical expectation and is statistically significant at the 1 percent level to explain the level of employment in Malaysia's sectors of economy. The positive sign of the *R&D* coefficient suggests that a large size of investment on R&D can increase level of employment in economic sectors. In this analysis, the model has moderately fitted the data that it explains about 68 percent of the employment variation in Malaysia. As in the analysis on GDP, the overall test of significance of the estimated regression indicates a strong significant model of employment in relation to public investment on R&D.

Table 5: Estimates of Employment Elasticity with Respect to Government Expenditures on R&D

Variable	Estimated Coefficient	Standard Error	t-ratio	p-value
Government Expenditures on R&D (*R&D)*	0.4319	0.0429	10.06	0.000
Constant	5.6602	0.8105	6.984	0.000

Notes: No. of observations: 50. Buse (1973) R-square = 0.6784.
F-ratio = 101.24 (p-value = 0.000).
R&D is significant at the 1 percent level.

5. CONCLUSION

The general objective of this study is to provide an empirical analysis on the achievement and impact of R&D activities on the level of economic and social development in Malaysia. Our findings suggest R&D public investments are an important factor to promote economic growth and employment in a long-term period. R&D investment activities in various sectors of economy are expected to increase the size of demand for output in both local and foreign markets. In the implementation of R&D investment policies, an intensification of R&D is needed in levels of production in such a way that there will be increases in the quality, safety standards and values of products. At national level, R&D investment activities can significantly increase employment opportunities for local people in various economic sectors in the long-term too. These findings imply that the government should continue supporting R&D activities in Malaysia and the expenditure on R&D should be increased in order to gain socio-economic benefits from its impact for the welfare of Malaysian society.

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