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SCIENCE, TECHNOLOGY AND INNOVATION IN MALAYSIA: WHAT DO THE KEY INDICATORS SUGGEST?

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ABSTRACT

This study investigates the readiness of Malaysia in science, technology and innovation from the macroeconomics perspective. The question of whether Malaysia is prepared to lead the innovative economy was the main concern of the study. An extensive assessment of innovation system in Malaysia was performed by analyzing the three main indicators namely input, output and innovation indicators. Indeed a comparative study was undertaken to determine the extent to which these indicators were in place in creating an innovative society. It was found that relatively Malaysia still lacks in placing the proper mechanisms especially with regards to education, R&D and other fundamental mechanism to accelerate the process of innovation in the country. It is proposed that the fundamentals of the innovation system be strengthened before one can see the success to move towards innovative economy and even to that of techno entrepreneurs model of growth.

Key words: Innovation, Science and Technology, Indicators
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Presented at "IRPA seminar on 25-27 February 2005, Marriott Hotel, Putrajaya. This report is part of an ongoing IRPA project undertaken by the researchers. Comments are most welcome. It should be cautioned that some might argue that the key indicators discussed in this paper are not the true proxy for innovation. However, it is found that these indicators could provide some understanding for the development of innovation policy especially for the developing countries that need a starting point to establish their innovation policies.

1.INTRODUCTION

Economically Malaysia has evolved from import-substitution to industrialization through export-oriented growth. Such a development has also changed the factors of competitive advantage, such as low cost labor, land availability and capital incentives to an intangible asset, which is primarily information and knowledge. Hence, this has bred of a new economy known as "knowledge economy". In the era of the knowledge economy, much importance is given to innovation and creativity and subsequently focus the operations and task in bringing innovation to the market and to the hands of users or customers. The burden to bring idea to market is now on the shoulder of our Malaysian government and the agenda of commercialization of new technology will be critically centered by the universities, research institutes and the industries, mainly the SMI's. Universities around the world are being forced to venture in new directions to exploit the wealth of knowledge they possess and turn them into intellectual property, which may eventually be re-exploited to bring about monetary returns. Wealth will increasingly accrue to the nation with the capacity and capability to transform knowledge into new products and processes. It is through technology commercialization that Malaysian could join the rank of advanced nations.

2. NATIONAL POLICY ON SCIENCE AND TECHNOLOGY

Understanding and realizing the importance of technology development, innovation and commercialization in 1986, the Malaysian government

formulated the First National Science and Technology Policy with the purpose of outlining a framework for science and technology development in Malaysia. This particular framework aims to ensure achievement of continuous scientific and technological development in accelerating economic growth, industrial development and creating high-tech (advanced) society.

The National Science and Technology Policy was then incorporated into the Fifth Malaysia Plan (1986-1990) and in 1991, the National Action Plan for Industrial Technology Development was launched. This plan outlined the strategies for strengthening science and technological capabilities to overcome the structural weakness that have been associated with the national industrial development. During the Sixth Malaysia Plan (1991-1995), the goals set for science and technology were to obtain a continuous scientific and technological development in Malaysia by providing basic infrastructure incentives and supporting services to science and technology (Economic Planning Unit). Emphasis was made to ensure that public R&D programs became more market oriented by exploiting the commercialization of research and technology. The private sector, on the other hand, was expected to complement the Government in expanding the R&D and science and technology using appropriate technology assimilation, diffusion and application. During the period of the Seventh Malaysia Plan (1995-2000), the focus was on economic growth and competitiveness by increasing productivity. It was recognized that Malaysia needed to develop its technological infrastructure further and expand its capacities for technology adoption and assimilation.

Thus, this paper attempts to use the current level of indicators to explore the issue of the Malaysian readiness in developing its indigenous technology. Indeed this study will further critically compare the current level of science and technology in Malaysia relative to other developing nations. Constructive suggestions are then developed for the future policy direction especially with regard to science technology and innovation.

3. KEY INDICATORS

3.1 INPUT INDICATORS

3.1.1 Education System

The roles of education, training and dissemination of information are vital for the process of industrialization especially in developing innovative product and process. Indeed the continued surge for productivity through education is a key factor in strengthening a firm's profit or even for the successful contribution of universities and research institutions with regards to innovation and technology commercialization. For example, with the rapid expansion of competition, pricing power remains non existent in many sectors yet ever improving productivity has enabled firms to squeeze costs and rebuild their bottom line. Even, the Corporate Sector Survey in 1998/1999 has indicated that firms employing workers with higher education (diploma/degree) are able to withstand the economic crises better than those who are not.

One essential policy issue would be building a well-defined infrastructure for education and the development of a science oriented society in line with the industry needs. Indeed recent studies suggest that required skills of employees in four main industrial clusters that are highly dependent on knowledge such as computers & semiconductor, telecommunication, instrumentation, health and medical products have risen greatly. The best contribution the government can make is to work on knowledge producing agendas. Progressive measures in facilitating the creation of knowledge based economy through information highway and smart school should be given top priority for economic growth as well as for the development of innovative society. Strengthening of the vocational and technical training schools should be emphasized to a great extend in facilitating the growth and development of innovation activities.

Malaysia has done fairly well in the adults and young literacy rate compared to other countries[1]. However, it is insufficient to say that Malaysia has the needed human resources to fulfill the innovative economy needs since high literacy and enrolment rate does not reflect the quality of education that is available and recent rapid expansion of new educational institutions (colleges, universities and training institutes) does not promise a great return if quality of graduates deteriorates and if a large portion of the programs available in these institution are focused towards non-science and technical subjects. The industrial institutions such as German Malaysian Institute, Japan-Malaysian Institute and Malaysian France Institute and others should establish a network with the industries for better synergy and in future to reduce the demand supply deficits of the high tech industries. For example, a study by Rajah Rasiah (2001), indicated

[1] Due to the space constraint the figures are not reported in the study. Figures can be requested from the author.

that Penang and Klang Valley failed to enjoy sufficient supplies of high tech human capital because of lack of effective coordination of supply and demand of high human capital. Indeed Malaysia is lacking in terms of tertiary level enrolment especially in science and technology (ISIS, 2002, UNDP 2002). and the ranking of our international innovativeness and competitiveness has deteriorated over for the last few years. Building technological capability in Malaysia owes its existence to an early nurturing of its human capital and strong commitment by the government to support a new education system that fosters creativity, innovation and critical thinking. Malaysia has realized the importance of technology and has begun making large investments in this area. However, it is virtually impossible to gain without having a better higher education system. In order to move into high innovative economy, strategies and policies in Malaysia should focus on four distinct areas. There is an urgent need to:

1. Place greater emphasis on enrolment of tertiary students in science, mathematics and engineering and tertiary level curriculum should emphasis on basic and applied science and technology
2. Enhance coordination and linkages between the higher education institution and industries
3. Expand creation of knowledge workers by emphasizing in quality of education rather than quantity. This includes quality of students, quality of teachers, learning aids, school facilities and others.
4. Provide vocational and technical education and training with the motive to supplant the industrial needs rather than for the purpose of encouragement

3.1.2 Professional and Scientist

Apart from education, the availability of human resources in science and technology fields are crucial determinants of an innovative economy. Comparatively Malaysia is far behind the other countries in terms of number of scientists and engineers in R&D and researchers (Table 1). This shortage is reduced even further because of the brain drain problems.

Innovation policy should take into account both the demand side (e.g. tax credit for R&D and research grants) and supply side (e.g. supply of qualified researchers, scientists and engineers) for enhancing the process of discovery and innovation. In addition, opportunities should be given to the best available resources, where it may promise a better outcome.

TABLE 1: Scientist and Engineers

Country	Number of Researchers per 10,000 Labor Force	Scientists and engineers in R&D (per million people) 1996-2000[a]
Singapore	83.5 (2000)	4,140
Korea, Rep. of	60 (1998)	2,319
Malaysia	15.6 (2000)	160
Thailand	5 (1991)	74
Philippines	3 (1991)	156 (e)
China	N/A	545
Viet Nam	N/A	274(e)
Indonesia	3 (1991)	130(e)

Source: UNDP, Human Development Report, 2003 and Ministry of Science, Technology and Environment, 2001
Note: Some of the data refer to the most recent year available during the period specified.

3.1.3 Investment in R & D

Technological effort is vital to Malaysia, even though it is clear that Malaysia are not "innovating" at the frontier. Another policy issue concerning the Malaysian quest for innovation is the strength of research and development activities in Malaysia. So far Malaysia has learned to use the imported new technology and equipment from the more advanced countries. However it is time to upgrade Malaysia from the assembly stage to manufacturing, design and development of new products.

Comparing the R& D expenditure (Table 2) it is clear that Malaysia is still way behind many of the other nations such as Korea, Singapore, India and China. Therefore, the government should focus on shaping the national system of innovation, and provide more proactive R & D infrastructure to enable the progress of an innovative society.

TABLE 2: R & D EXPENDITURE

Country	Research and development (R&D) expenditures (as % of GDP) 1996-2000[a]
Hong Kong, China (SAR)	0.4
Singapore	1.9
Korea, Rep. of	2.7
Malaysia	0.4
Thailand	0.1
China	1.0
India	1.2

Source: UNDP, Human Development Report, 2003

However, it should be noted that increasing the spending on R&D does not mean greater innovation. The emphasis should be directed towards quality of research work among the academia and industries and also the quality of inputs mentioned earlier (Romer, 2000). For example, attention is much needed in:

1. providing training grants to research organizations
2. new type of fellowship, partnership and internship
3. selection criteria of scientific research work should focus more on industrial needs
4. monitoring the outcome of research to utilize the output of R&D

3.1.4 Technology Diffusion

Recent literature reviews tend to emphasize the role of Information, Communication and Technology (ICT) infrastructure as the driving force for economic growth and indirectly to the innovation system. Investment in ICT has to be improved since it serves as a supplement to the development of innovative and the knowledge based society. For example, through video conferencing, people work faster and more efficiently with greater flow of information and knowledge. In addition deploying broadband means a cheaper solution for entrepreneur and business. The ICT development is also crucial in fostering knowledge worker where these types of workers are highly needed as Malaysia moves towards technology driven industries

TABLE 3: TECHNOLOGY DIFFUSION AND CREATION (2001)

Country	Telephone mainlines (per 1,000 people)	Cellular subscribers (per 1,000 people)	Internet users (per 1,000 people
Hong Kong, China	580	859	386.8
Singapore	471	724	411.5
Korea, Rep. of	486	621	521.1
Brunei	259	401	102.3
Malaysia	198	314	273.1
Thailand	99	123	57.7
Philippines	42	150	25.6
China	137	110	25.7
Indonesia	35	31	19.1
India	38	6	6.8

Source:UNDP, Human Development Report, 2003

Many other countries (for example Singapore, Japan and Canada) are aggressively progressing in establishing and making broadband infrastructure available to the industries and public. Indeed in Australia the information economy is seen as the key ingredient to business survival and innovative system. South Korea on the other hand, has invested $850 million in broadband infrastructure and promise another $850 million over the next four years (Business Week, 2004). All this, would foster a better avenue and environment for the innovation system.

Referring to Table 3, Malaysia is ranked number three as a whole promising better establishment of ICT. Since Malaysia has better ICT establishment, its success in altering its economic growth through innovation is considered far ahead of other developing countries. However, it should be noted that it takes a few years to get down the learning curve and figure out ways to use the ICT as a means to accelerate innovation. Emphasizing Malaysian policies to gear up the usage of IT would provide an earlier start for innovation and creativity. Despite innovation, ICT improvements is also a key element in attracting FDI, which serves as the short cut for innovation through spillover from the MNCs although it is quite limited in the sense of innovation.

3.2 Output Indicators

3.2.1 Patents, Licensing and Royalties

Given today's competitive environment the development of new products and processes will be the lifeline of the success of a nation. Opportunities should be created through academic research especially by encouraging the partnership between universities, research institutions and the private sector. Potential research projects in any of these institutions should be identified and given the support necessary to facilitate the flow of innovation and new ideas. The direct outcome of these collaborative efforts would be in terms of patents, licensing and royalties.

Based on Table 4, it is evident that Korea and Singapore (high patent grants and royalties) have an understanding of the relationship between the outcome of research and economic growth. It is evident that Malaysia is weakly positioned in this aspect. Thus, Malaysia must spring to the mind of investors as the center of technology venture capital. Malaysia is capable of channeling much investment capital into tech startups with better intellectual property protection. One move towards encouraging venture capital to invest in Malaysia is by improving the law that will safeguard intellectual property. Even Russia

with her handful skilled technical talent and supply of unemployed engineers has experienced little investment in high tech because of Russian law, which didn't safeguard intellectual property.

Table 4: Patents, Royalties And License Fees For Selected Countries

Country	Patents granted to residents (per million people)	Receipts of royalties and license fees (US$ per person)
	1999	2001
Hong Kong, China	4	16.0
Singapore	12	..
Korea, Rep. of	931	14.6
Malaysia	..	0.9
Thailand	..	0.1
China	2	0.1
India	1	0.1

Source:UNDP, Human Development Report, 2003

To boost the expected outcome from research, Malaysia should direct its efforts towards:

1. improving intellectual property rights
2. encourage more collaborative efforts between research organization and industries
3. provide more funding for technology commercialization
4. redirect some of the academia's efforts merely from consultation work to market oriented product and process development
5. improve the mobility of personnel
6. establish string links to leading international R&D organizations
7. create high intensities of R&D and research application

3.2.2 Bibliometrics

Apart from the indicators mentioned above, bibliometrics indicator has been used for policy purpose for 20 years, since 1976, by many developed nations. This indicator provides opportunities concerning the new theories of innovation; especially network within and between national systems. It provides some insight on diffusion of knowledge, acts as a proxy for quality, trace of linkages between institutions and nations and reflects collaborative efforts (joint authorship). Indeed citations are a strong multiplier indicating the use of research by industries (Katz & Hicks, 1998).

Table 5: Bibliometric Ranking of Countries (1997)

Country	Articles per GDP
Malaysia	1.8
Singapore	16
Hong Kong	15
South Korea	8.6
India	6
Taiwan	17.9

Source: MOSTE, 2003

With this in mind, examining the bibliometrics ranking of countries (Table 5) it is found that Malaysia is very much below the other developing countries in terms of articles per GDP. There is a lack of joint research and publication with international organization which indeed limits the expansion of knowledge. Individual organization and the government should establish a better network for researchers both in private and public sectors.

3.2.3 High Technology Industries

Porter (1998) suggested that locating critical masses of linked industries and institutions in one place help firms to enjoy competitive success. Clustering benefits the industry by providing efficient concentration of suppliers, efficient access for information, close relationship and coordination, enhanced diffusion of knowledge on best practices and stimulate innovation.
In this respect Malaysia should be more proactive in establishing cluster developments. In Malaysia the Second Industrial Master Plan adopted a cluster based industrial development to sustain the growth of the manufacturing sector. One promising cluster development in Malaysia is the creation of the Multimedia Super Corridor which promises to be renowned, vibrant and strategic regional hub for Information Technology trade and services, education services, medical services and telecommunication. However of late, hi-technology investors are shying away from Cyberjaya forcing the government to market its project as affordable alternative for call centers, back offices operations and low tech administrative subsidiaries. Furthermore, the adoption of cluster based industrial development does not show significant concomitant growth of the supporting industries that will fuel the engine of growth for the economy.

Although Malaysia has successfully moved to the exports of high technology industries (57% of Malaysia's export in 2001 is in high technology industries) (Chandran et al. , 2003 & 2004), it is found that Malaysia is still largely depended on foreign

technology. Indeed, the spillover effect from the MNCs has not greatly promoted the indigenous technology capabilities. The following reasons could significantly be the contributing factors.

1. Malaysia is basically engaging only in assembly stage of the manufacturing
2. Failure in attracting foreign head quarters to be located in Malaysia (HQ significantly contribute to research and development activities)
3. Lack of skilled professionals in supplementing the industries
4. Lack of entrepreneurship and innovative culture among Malaysian

3.3 Innovation Indicators

Based on the National Innovation survey, it is found that 35% out of 749 manufacturing companies indicated that they carry out innovation activities. The main sources of innovation for these companies are clients or customers and suppliers. Although most of the research grants are provided to the public research organization it is surprising to find that research organization contribution are still low. Indeed, this shows the failure of research organization in establishing network with the industrial sectors. Many of the innovative companies also indicated that they didn't receive sufficient government support, assistance and incentives. This may further indicate the need to investigate the effectiveness of the government's support in enhancing the innovative capabilities of the firms. It is also claimed that factors such as high cost of innovation, lack of skilled personnel, lack of information on technology and market appropriate to be the major hindering factors for innovation. A comparison of the innovation expenditure as a share of total turnover suggested that Malaysia with 0.8% compared to UK (3.2%), Sweden (7%), Norway (2.7%), Denmark (4.8%) is still far behind other countries (MOSTE, 2003). As such more proactive measures should be formulated to enhance the innovative capabilities especially among the local SMIs. In addition, improvement in areas such as avoiding bottleneck for government support to industries, providing on time information, improving the efficiency of government services and developing more funds for commercialization should be focused.

4. CONCLUSIONS

The analysis in this paper, which is driven by observing the key indicators, suggests that Malaysia should further improve its fundamental agendas in order to strive to be a knowledge and technology driven economy. The research has indeed provided some insights on policy improvements as the tool in fostering innovation in Malaysia. Although a number of key indicators such as technology diffusion, high technology industries to some extent supports the movement of Malaysian economy towards a technology based economy, further improvement is vital especially in education, research and development, and human resources to enhance the current efforts towards innovative economy. Thus, the undeniable importance for Malaysia to be knowledge based economy is to create and adopt national policies to complement the emergence of the innovative activities. Malaysia should take a pro-active approach concerning the policy developments.

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