

Developing Competitive Scientific Infrastructure for Knowledge-based Economies in Southeast Asia: A Comparative Study of Malaysia and Singapore

Sajit Chandra DEBNATH^{*} and Kenji YOKOYAMA^{**}

Abstract

The economic ramifications of the creation of a knowledge-based economy (KBE) are that it would increase the competitiveness of a country and at the same time increase its stock of knowledge for future economic innovations. Economists have now shifted their focus to the creation and diffusion of knowledge to explain the varying levels of this economic growth and development. In the last couple of decades, many countries have shown high economic performance by knowledge creation and diffusion to the various sectors of the economy. This has come to be described as Knowledge-based Economy (KBE). Malaysia and Singapore, among Southeast Asian countries, have shown tremendous success in economic development by transforming their economies and have moved on to creating knowledge-based economies. This paper explores the scientific infrastructure development in Southeast Asian knowledge-based economies using a case study about Malaysia and Singapore. The case analysis shows that Singapore is one of the most successful countries in the region that pursued appropriate policies to develop its scientific infrastructure towards becoming a knowledge-based economy. Malaysia, while showing some developments in its scientific infrastructure is yet to attain a status comparable to Singapore.

Keywords: Knowledge-based Economy; Scientific Infrastructure; Singapore; Malaysia.

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Introduction

Explanations of economic growth by classical economic theories are inadequate to explain contemporary economic growth among countries. The influences and interactions of multiple factors like foreign direct investment, cross-country mobility of the factors of production (*Economic Social and Commission for Asia and the Pacific*, 1999), levels of democracy and inequality (Sen, 1999), technology and information flow (Orna, 1990), integration and regionalism (Fort and Webber, 2006) have introduced newer factors. Compared with the 1990s, the world's gini-coefficient in 2005 was 0.67, an increase of 10 percent. This increase has largely been credited to the use of knowledge. As a consequence, economists have now shifted their focus to the creation and diffusion of knowledge to explain the varying levels of this economic growth and development. Since the late 1980s, many countries have shown high economic performance by knowledge creation and its diffusion to the various sectors of the economy. This has come to be described as Knowledge-based Economy (KBE). Many East Asian countries, among many in the world, have shown tremendous success in economic development by transforming their economies into a knowledge-based economy.

The concept of knowledge-based economy (KBE) is relatively new (OECD, 1996; Leydesdorff, 2006; David and Foray, 2002). The term KBE was first introduced by the Organization of Economic Cooperation and Development (OECD). OECD (1996:7) describes KBE as an economy that is directly based on the production, distribution and use of knowledge and information. Asia Pacific Economic Cooperation (APEC) later extended this idea and came up with a definition of KBE as 'an economy in which the production, distribution and use of knowledge is the main driver of growth, wealth creation and employment across all industries' (APEC, 2000:2).

This paper attempts to apply the key determinant of KBE, which is scientific infrastructure, to understand how the determinants of a knowledge-based economy can be developed overtime by the ongoing processes of theoretically informed deconstructions and reconstructions (Cowan *et al.*, 2000: 211-253; Foray, 2004). This paper, in addition, investigates how scientific infrastructure, the key determinant of KBE is subject to manipulation by government policy formulations to transform the economy towards KBE through anticipating future outcomes.

Knowledge in Economic Transformation

In contemporary global economy where the competition is very enormous and uncertainty is associated with everything (Nonaka, 1995), the importance of knowledge creation and diffusion is an absolute requirement in every sector of society. In such a situation, the importance of knowledge creation is a high priority for any sector of society where government policies play a great role in the integration among and within different sectors. Many OECD countries are doing this task successfully. In Southeast Asia, Singapore is frequently used as an example in the studies of policy directed knowledge-based economy (Bercuson *et al.*, 1995; Low, 2001). It is often compared with other countries like South Korea, Hong Kong, Taiwan and Malaysia as the emerging knowledge-based economy (Mani, 2005; Mustapha and Abdullah, 2000). As the term 'knowledge based economy' is relatively a new concept in the discussion of economics, it would be practical to have a case study analysis of some knowledge-based economies. Case study perspective allows us to better comprehend the government policies that help define and create a knowledge-based economy. Malaysia and Singapore are used in this paper as cases for examining the significance of scientific infrastructure development in the development of KBEs. Both countries have shared historical experiences of having been British or Japanese colonies and both have transformed their economies through strong government involvement. Despite some scholars attempt to use the "flying geese model" to explain the growth model of East Asian countries, recent scholars (Mani, 2005; Mustapha and Abdullah, 2000) note the fact that all East Asian countries have been pursuing strong government policies to transform their economies into knowledge-based economies.

In a rapidly changing global environment the transformation of the economy to a knowledge-based economy is challenging for any country. In creating a knowledge-based economy, countries are now facing the challenges of formulating effective policies as part of government-initiatives in promoting knowledge-based economy. The demand of competition in the global market has forced them to increase and diffuse knowledge that has true economic value. This paper is significant, as it will address broadly the issue of economic development through the theory of knowledge creation and diffusion and will contribute to helping the countries that are in the transition period or on the threshold of switching their traditional economic systems into a knowledge-based economy. This paper will examine Malaysia and Singapore in their pursuit to create a knowledge-based

economy to foster their economic growth. The insights from the comparative case study will provide guidelines for many other countries that are trying to create a knowledge-based economy.

The KBE Framework

The four determinants of KBE have been advanced as the role of government, educational infrastructure, technological infrastructure, and the scientific infrastructure (See Figure 1). In a KBE, acquisition, sharing, creation, and application of knowledge are the main drivers of growth, wealth creation and employment. In order to strengthen the processes of acquisition, sharing, creation, and application of knowledge there must be investments in developing infrastructures. These infrastructures are educational, technological and scientific in their underlying characteristics. The KBE infrastructure, thus involves knowledge inputs (KI) and knowledge networks (KN). Knowledge inputs (KI) include R&D, technological development, patent rights, employment of engineers and technicians, innovations, and knowledge stocks and flows (KSF), while knowledge networks (KN) incorporate government-industry partnerships, government-academia partnerships, industry-academia partnerships, and government-industry-academia partnerships.

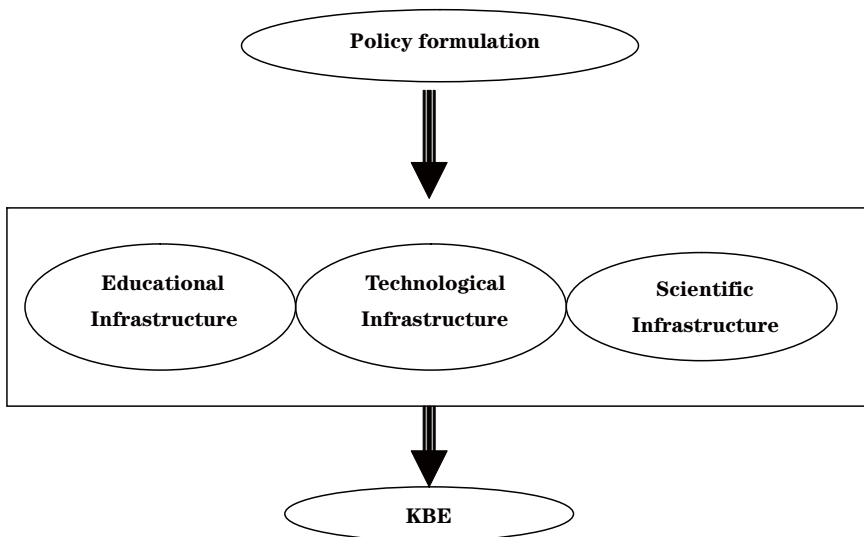


Figure 1. Proposed Policy Framework for Knowledge-based Economy

In this paper, only the scientific infrastructure will be considered as to how they are planned, designed and implemented through public and private investments in Malaysia and Singapore. Much has been written about the necessity of a major shift in the investment in KBE infrastructure because the role of knowledge-based workers and expected behaviors is very different from the traditional models of growth (Michael Porter, Hirotaka Takeuchi and Mariko Sakakibara, 2000). Knowledge needs to be continuously re-created and re-constructed through dynamic inputs in the scientific infrastructure of a KBE. The role of the policy makers here is not to control but to stimulate, provide policy directions and address other facilities that are required for the sound development of the scientific infrastructure.

Methodological Issues

A KBE framework specifies that a country has to work on harmonizing policy and KBE determinants to its own characteristics and surrounding circumstances (fit). In the event that the circumstances are not favorable, the country has the option to adjust its policy and the KBE determinants to fit within its context or to change its context to be conducive to its policy.

A limitation of the proposed framework is that it is derived from the theory with limited empirical evidence of the correlation among the KBE determinants. Another limitation is that due to the complex nature of this study, many other inputs and factors overlap and cannot be clearly defined. As a result, the case study methodology used in this study will be to provide a 'test' for this framework.

Policy Formulations in Malaysia

Malaysia realized the need for a KBE when Vision 2020, a national blue-print for transforming the country to the status of developed countries, was launched in February 1991. Among many alternatives, Vision 2020 recognized the crucial importance of a scientific and progressive society that was innovative and forward-looking. It was to be a society that not only was a consumer of technology but also a contributor to the scientific and technological civilization of the future, an economy that is technologically proficient, fully able to adapt, innovate and invent. Malaysia was to become technology-intensive, moving in the direction of higher levels of technology and an economy driven by brainpower, skills and diligence, in possession of a wealth of information, with the knowledge of what to

do and how to do it.

After the policy formulation for Vision 2020 in 1991, Malaysia launched the Multimedia Super Corridor (MSC) initiative which was related to becoming a KBE. The National Information Technology Agenda (NITA) is also another related effort to the MSC that aimed to foster the development of IT as a strategic enabler of dynamic economic growth. In fact, both projects were to take Malaysia into the knowledge-intensive high technology era through a number of important flagship applications by 2020.

Malaysia's vision to build a strong, resilient, vibrant and competitive economy driven strongly by a steep increase in the application of knowledge to production and the development of new knowledge-intensive industries emphasized on raising the growth rate of Total Factor Productivity (TFP) in a knowledge-based economy (Knowledge-Based Economy Master Plan, 2001:27). This was seen as reflecting the increasing importance of knowledge, human capital, innovation and investment in Information and Communication Technology (ICT) in a knowledge-based economy.

Malaysia aimed at an average annual GDP growth of 7 percent in their Knowledge-Based Economy Master Plan (2001:27) by transforming the production economy into knowledge-based economy. Since the execution of the Knowledge-Based Economy Master Plan 2001, Malaysia achieved considerable success in many sectors of the economy. Figure 2 shows the competitiveness landscape of Malaysia among 51 countries in the Asia and Pacific region in 2007. If we scrutinize Malaysia's achievements in various sectors among the 51 countries in the region, we will see that in some sectors, the country achieved very significant developments while in some, the achievements are not that significant in 2007. The scientific infrastructure is one sector where the country could not show extremely significant development (See Figure 2).

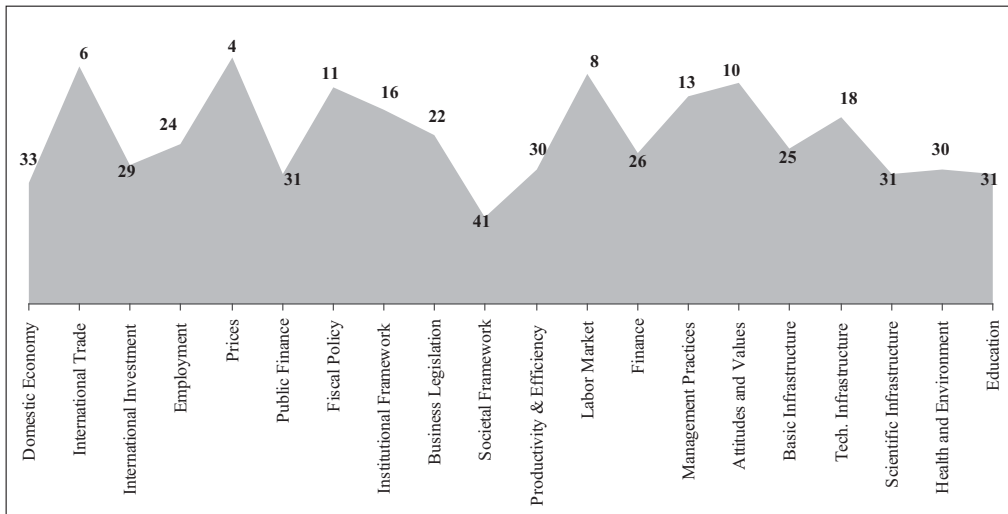


Figure 2. Competitiveness Landscape of Malaysia in 2007

Source: Adapted from International Institute of Management Development (IMD) World Competitiveness Yearbook (WCY) Online. Updated: May 2007.

Policy Formulations in Singapore

Singapore maintains twin goals of heavy investment in science and technology as well as to attract high tech foreign direct investment. Today, Singapore is well on its way of being the knowledge hub of the Southeast Asian region. Both private and public sectors in Singapore have been steadily investing in R&D and the large volume of those R&D investments is channeled into electronic research, engineering and information technology where the country is already a world player in creating KBE. Singapore's high commitment to maintain one of the world's best national information technology infrastructures is creating avenues to apply information technology to all sectors of the economy. The government of Singapore, in this regard, has been extremely active in supporting the development of KBE through complementary policy formulations. In the five-year science and technology plan released in October 2000, the government promised to spend US\$ 4 billion to identify and build world-class capabilities in selected leading-edge niche technologies in order to advance a knowledge-based economy.

The role of government policies on scientific infrastructure development has taken on added importance as Singapore moves to an innovation based growth in a knowledge-based economy. In terms of the development of scientific capability,

there was a sustained shift from learning to use with high reliance on multinational corporations (MNCs), then, to learning to adapt and improve via “learning by doing” within MNCs as well as “learning by transacting” in local firms acquiring external technology. The next shift was learning to innovate, mainly, through applied R&D in product or process, and finally, learning to pioneer by creating indigenous technology and commercializing it in the marketplace through new ventures (Koh and Wang, 2003:17). Discussing on the Third National Science and Technology Plan, Koh and Wang (2003) further mentioned:

“Reflecting the shift in focus to basic research under the Third National Science and Technology Plan, the NSTP was re-organized in 2000 to focus on promoting research and developing R&D manpower, taking on a role similar to that of the National Science Foundation (NSF) in the United States. Two research councils were set up; namely, the Bio- Medical Research Council (BMRC) to award research grants and develop R&D manpower in the life sciences, while the Science and Engineering Research Council (SERC) was set up to oversee research in selected scientific and technological fields. In 2000, the Singapore government announced a strategic push to promote life sciences research and industry development, following the completion of the Global Genome Mapping project.”

Koh and Wang (2003:25)

Singapore was ranked number one in terms of its innovation policy, winning top scores for its effectiveness in protecting intellectual property, as well as for its support of R&D through various tax incentives and grants in the 2002-2003 WEF (Global Economic Forum) Global Competitiveness Report. These efforts at building sustainable progress in scientific creation capabilities have boosted Singapore’s ranking in national innovative capacity.

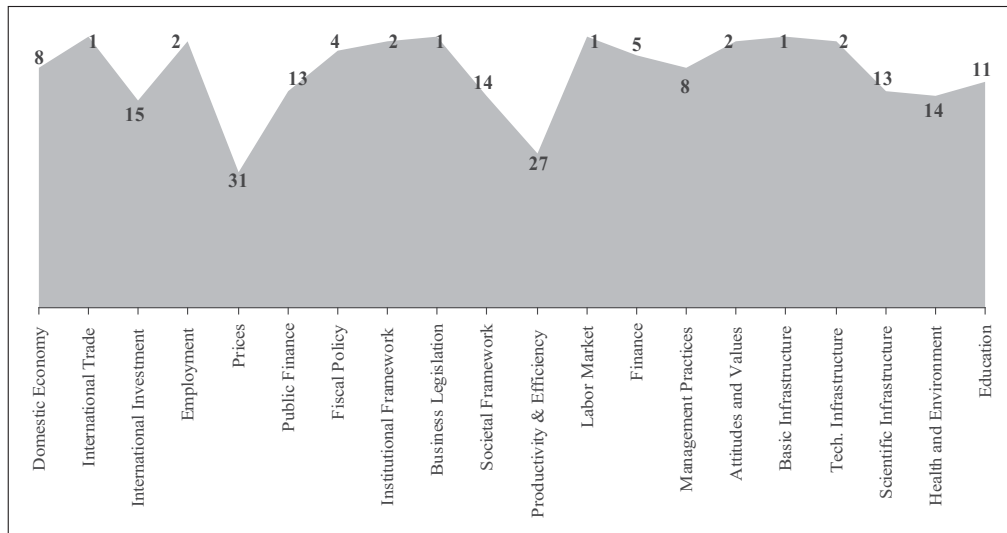


Figure 3. Competitiveness Landscape of Singapore in 2007

Source: Adapted from International Institute of Management Development (IMD) World Competitiveness Yearbook (WCY) Online. Updated: May 2007.

In 2006, Singapore's real GDP growth was 7.9 percent, which is better than many other economies in Southeast Asia. Since the embarkation into knowledge-based economy in 1998, Singapore achieved high success in almost all sectors of the economy. Figure 3 shows the 2007 Competitiveness Landscape of Singapore among 51 countries in the Asia and the Pacific region. In many areas, the country ranked top, which clearly shows the outcome of the policy formulations to create the knowledge-based economy in Singapore. In 2007, Singapore ranked top in the government efficiency rating by IMD among the 51 countries in the Asia and Pacific region. The scientific infrastructure development has been very rapid in Singapore since the government prioritized the infrastructure development to support the knowledge-based economy.

Comparative Analysis of Malaysia and Singapore

This section attempts a comparative analysis of Malaysia and Singapore. In order not to make a simplistic conclusion based on comparison of two countries, Singapore and Malaysia are also compared with other knowledge-based economies in the Asia and Pacific to clarify the position of both countries in the region as both are related to other KBEs in the region. This is to elicit a better understanding of the KBE development between them as well as globally. In

doing so, this section will compare Malaysia and Singapore with Australia, China, Hong Kong, India, Indonesia, Japan, Korea, New Zealand, Philippines, Taiwan and Thailand.

Japan was the first country in the Asia and Pacific region that transformed its economy into a knowledge-based economy in the 1960s. After World War II, Japan's policy of adopting and adapting external knowledge in the domestic economy brought tremendous growth and as a consequence, by the 1970s, Japan became the second largest global economy after the United States. Japan created favorable environment for the industries to grow through the creation and diffusion of knowledge. Japanese corporations led the journey towards knowledge-based economy (Nonaka, 1995).

Japan's rapid growth attracted the attention of the four tigers of Asia such as Korea, Taiwan, Hong Kong and Singapore in the race for high growth development through foreign direct investment. Today all the four tigers are on their way to transform their economies into knowledge-based economies. Later People's Republic of China, Indonesia, Philippines, and Thailand also received huge foreign direct investment through which the technological know-how began flowing into these countries. All the above states have been depending largely on FDI for the development of the infrastructures and thereby to create a supportive infrastructure for the development of knowledge-based economy.

India, on the other hand, developed its IT sector to provide best qualified IT personnel both to the domestic and international markets. Bangalore, which is considered the Silicon Valley of India, is a place where the cutting edge technological innovations are taking place mostly in foreign companies where the best Indian brains are working. Today, many developed countries are outsourcing IT to India. Thus, the development of knowledge-based economy in India is having a greater impact on its economy.

Australia and New Zealand are two other nations in the region that are also moving very fast towards becoming knowledge-based economies. The policy of both countries differs more than that of the policies of the other countries in the region. The main policy of both countries has been to attract the best brains from other countries and provide them with the best education to feed the knowledge-based economy. Presently, large number of students from India, China, Bangladesh, Sri Lanka and many other countries go to Australia and New Zealand for higher education and are absorbed into jobs there.

The scientific infrastructure also covers very huge area like the other two infrastructures and as a result, for this study some specific areas will be discussed

such as expenditure on R&D, availability of R&D personnel, basic research, patents, patent productivity, scientific articles, science degrees, science in schools, youth interest in science, intellectual property rights, and legislation for scientific research.

All the countries that are formulating policies for creating a KBE are putting special attention into building the scientific infrastructure because in any KBE, the scientific infrastructure counts most as it directly promotes the creation and diffusion of new knowledge through innovations, which involves various factors such R&D and innovations, private and public initiatives in R&D, availability of R&D personnel and scientific educations. Both Singapore and Malaysia aim to develop scientific infrastructures to support continuous innovation and thereby create new knowledge in order to remain competitive in a knowledge-based economy.

Since the journey began towards becoming KBE's, both countries' total expenditure on R&D has been increasing although the total amount is far below that of Japan (See Figure 4). Investment in R&D largely increases when the country has already realized the knowledge-based economy. In this region, Japan is the first country to realize the knowledge-based economy after 1945 and as a consequence, the R&D expenditure is the highest in Japan. All other countries in the region are still at the beginning of the economic transformation towards knowledge-based economy and as a result, the R&D expenditure is yet to reach the level of the OECD knowledge-based economies. However, of the two countries, Singapore is ahead of Malaysia in total expenditure in R&D. The total expenditure on R&D as percentage of GDP (See Table 1) and total expenditure on R&D per capita have been increasing (See Table 2) in most countries of the region since 1996. Singapore has achieved significant development in both factors and in 2005, the country was in the fourth position in terms of total expenditure on R&D as percentage of GDP and in the second position in terms of total expenditure on R&D per capita among the countries in the Asia and Pacific. On the other hand Malaysia experienced very slow growth in both factors over the last ten years.

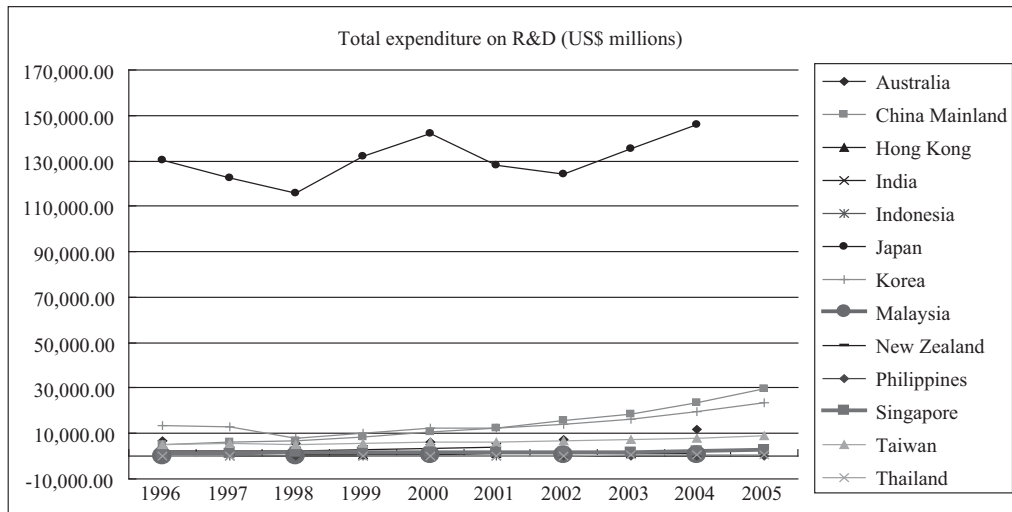


Figure 4. Total Expenditure on R&D, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

Table 1. Total Expenditure on R&D (% of GDP), Asia and Pacific

Countries	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Australia	1.69	N/A	1.51	N/A	1.55	N/A	1.74	N/A	1.82	N/A
China Mainland	0.60	0.64	0.65	0.76	0.90	0.95	1.07	1.13	1.23	1.33
Hong Kong	N/A	N/A	0.43	0.47	0.47	0.55	0.59	0.69	0.74	N/A
India	0.60	0.59	0.66	0.72	0.79	0.84	N/A	N/A	N/A	N/A
Indonesia	0.16	0.12	0.06	0.06	0.07	0.05	N/A	N/A	N/A	N/A
Japan	2.76	2.87	3.00	3.02	3.04	3.12	3.17	3.20	3.17	N/A
Korea	2.79	2.48	2.34	2.25	2.39	2.59	2.53	2.63	2.85	2.98
Malaysia	0.22	N/A	0.40	N/A	0.49	N/A	0.69	N/A	0.63	N/A
New Zealand	N/A	1.09	N/A	0.99	N/A	1.14	N/A	1.15	N/A	N/A
Philippines	N/A	N/A	0.08	N/A	N/A	N/A	0.15	0.14	0.12	0.11
Singapore	1.38	1.48	1.81	1.90	1.88	2.11	2.16	2.13	2.24	2.36
Taiwan	1.80	1.82	1.91	1.98	1.97	2.08	2.20	2.35	2.44	2.52
Thailand	0.12	0.10	N/A	0.26	0.26	0.27	0.26	0.26	0.26	0.24

Source: IMD World Competitiveness Online. Updated: May 2007.

Table 2. Total Expenditure on R&D per Capita (US\$ per capita), Asia and Pacific

Countries	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Australia	376.04	N/A	299.65	N/A	315.12	N/A	365.39	N/A	577.68	N/A
China Mainland	3.97	4.97	5.34	6.52	8.54	9.87	12.11	14.39	18.28	22.87
Hong Kong	N/A	N/A	110.56	115.05	119.49	135.67	142.68	163.15	180.10	N/A
India	2.25	2.56	2.57	2.97	3.32	3.61	N/A	N/A	N/A	N/A
Indonesia	1.88	1.28	0.26	0.44	0.54	0.37	N/A	N/A	N/A	N/A
Japan	1,034.71	969.80	916.74	1,042.03	1,119.36	1,004.98	973.94	1,060.33	1,143.43	N/A
Korea	296.80	278.81	175.08	215.00	260.57	263.72	290.81	334.54	403.34	490.03
Malaysia	10.31	N/A	12.87	N/A	18.73	N/A	26.83	N/A	29.26	N/A
New Zealand	N/A	195.30	N/A	151.40	N/A	153.23	N/A	230.44	N/A	N/A
Philippines	N/A	N/A	0.70	N/A	N/A	N/A	1.41	1.36	1.27	1.26
Singapore	346.30	373.39	379.19	395.87	433.39	436.02	455.32	469.55	566.99	634.01
Taiwan	233.41	250.84	240.59	267.28	284.12	270.66	288.22	312.26	347.18	383.62
Thailand	3.64	2.53	N/A	5.09	5.08	4.86	5.16	5.83	6.32	6.36

Source: IMD World Competitiveness Online. Updated: May 2007.

From 1996-2005, both Malaysia and Singapore experienced growth in R&D personnel nationwide as in most countries in the region (See Table 3). However, the number is not very significant yet for both countries, although Singapore is way ahead of Malaysia. Both countries have scope for further development in this aspect.

Table 3. Total R&D Personnel Nationwide (Full-time work equivalent, FTE thousands), Asia and Pacific

Countries	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Australia	90.69	N/A	91.58	N/A	95.62	N/A	107.21	N/A	119.38	N/A
China Mainland	804.00	831.20	755.20	821.70	922.10	956.50	1,035.10	1,094.80	1,152.60	1,364.80
Hong Kong	N/A	N/A	9.02	10.12	9.80	11.04	12.89	16.86	18.85	N/A
India	187.59	N/A	330.49	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Indonesia	N/A	N/A	N/A	N/A	56.36	51.54	N/A	N/A	N/A	N/A
Japan	891.78	894.00	925.57	919.13	896.85	892.06	857.30	882.41	896.21	N/A
Korea	135.70	136.60	128.67	137.87	138.08	165.72	172.27	186.21	194.06	215.44
Malaysia	4.44	N/A	6.66	N/A	10.06	N/A	10.73	N/A	17.89	N/A
New Zealand	N/A	12.91	N/A	13.09	N/A	17.77	N/A	21.41	N/A	N/A
Philippines	N/A	N/A	15.61	N/A	N/A	N/A	9.33	13.47	13.47	13.47
Singapore	11.13	12.06	13.80	15.10	19.37	19.45	21.87	23.51	25.49	28.59
Taiwan	90.00	98.60	105.09	104.54	104.57	107.76	120.01	127.63	138.60	149.15
Thailand	10.21	14.02		20.05	N/A	32.01	N/A	42.38	N/A	36.97

Source: IMD World Competitiveness Online. Updated: May 2007.

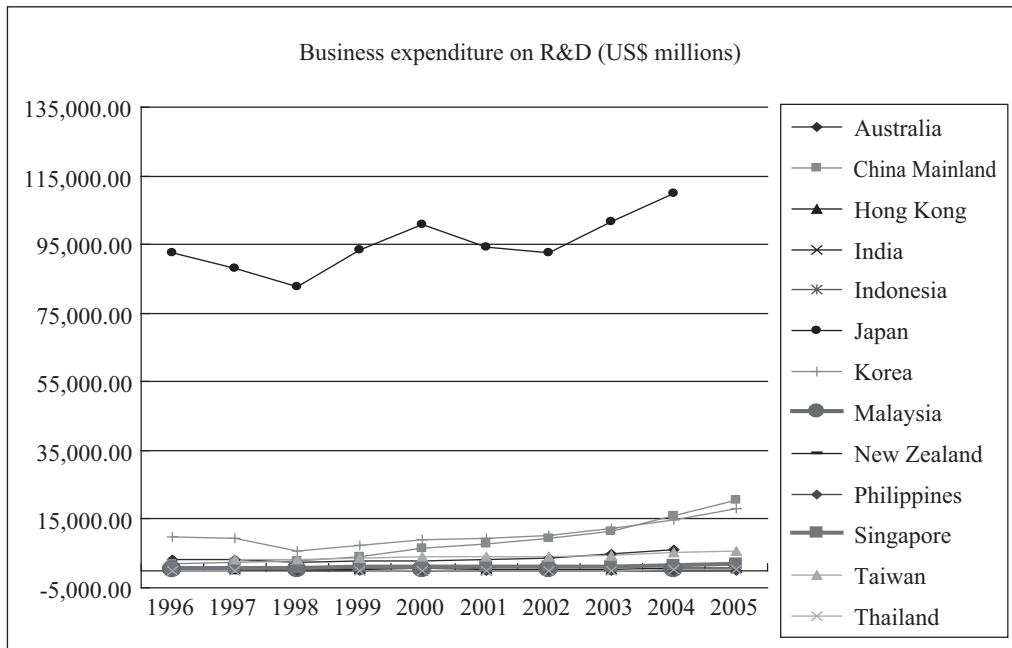


Figure 5. Business Expenditure on R&D, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

Parallel to the government's continuous efforts to increase the investment in R&D in the country, the business sector also has been playing very important role in over all advancement of R&D in the private sector over the years in all the countries of the region. Both in Malaysia and Singapore, the private sector has been continuously subscribed by foreign direct investment which indeed is helping the R&D grow in the private sector. Business investment in R&D has been continuously increasing since 1996 (See Figure 5) in both countries. However, both Malaysia and Singapore are still behind Japan, mainland China, Korea, Taiwan and Australia in this aspect. However, during the same period, in terms of the business expenditure on R&D as a percentage of GDP Singapore is in better position than Malaysia (See Figure 6).

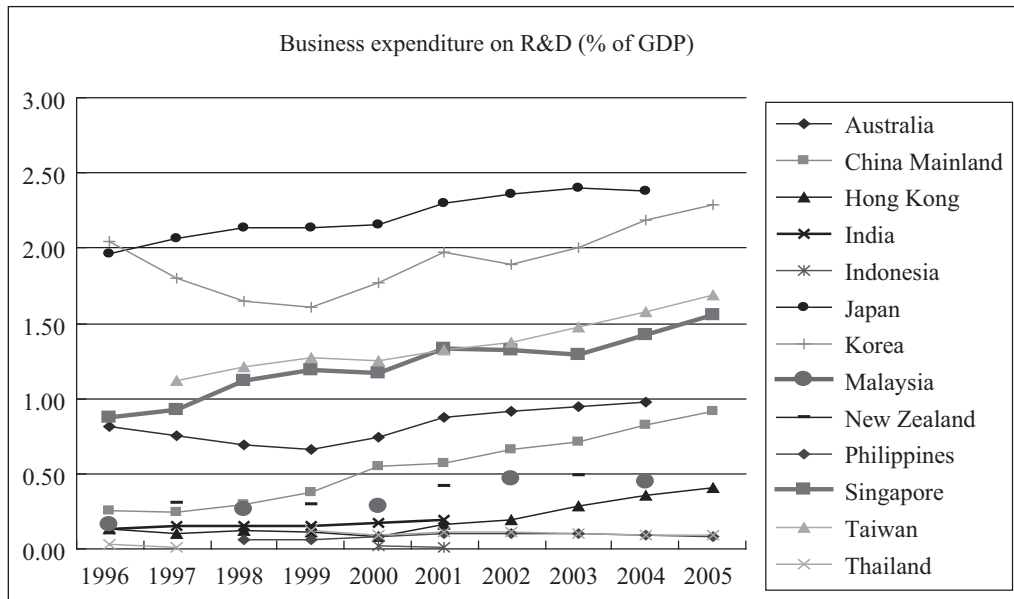


Figure 6. Business Expenditure on R&D (% of GDP), Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

The increasing investments in R&D by the private business sector helped increase the total number of R&D personnel working in business enterprises over the last ten years (See Figure 7) in most of the countries. Among all the countries, China has shown very noteworthy growth in the number. Singapore because of its small size is still moving behind in this aspect whereas Malaysia, despite having a larger population than Singapore, could not achieve significant growth compared to that of Singapore. In terms of the total R&D personnel in business enterprises as percentage of GDP Singapore is in the third position while Malaysia is in the ninth position which shows that Singapore achieved better growth in this regard (See Figure 8).

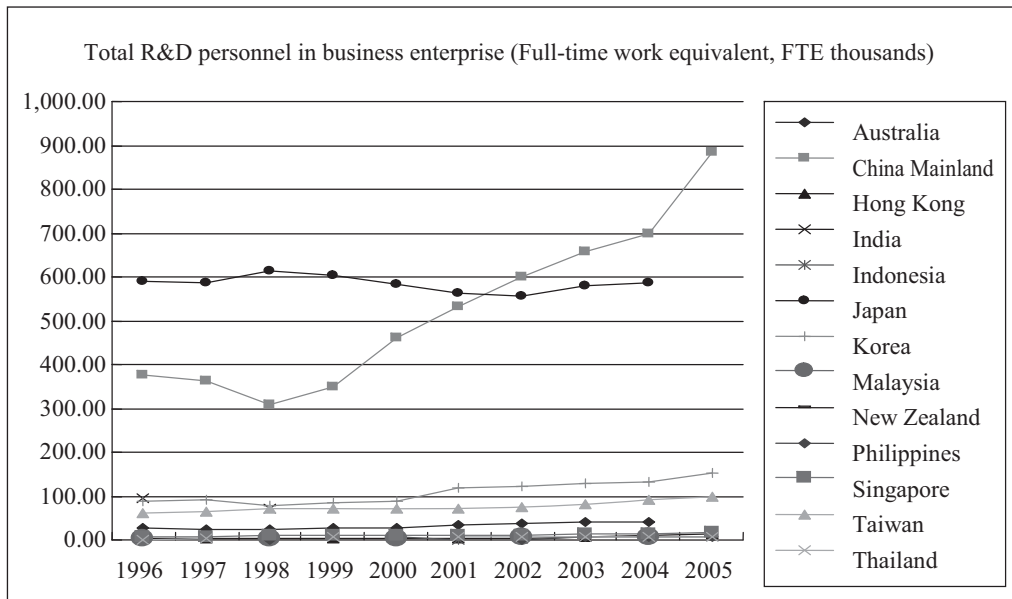


Figure 7. Total R&D Personnel in Business Enterprise, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

The research quality, both in public and private sector, also improved as the investments in R&D increased over the last ten years in most of the thirteen countries in the region. Singapore and Malaysia achieved significant development in raising the quality of research that enhances long term economic development. In the 2007 IMD ranked Singapore and Malaysia in the top and second position respectively (See Figure 9). However, the number of total patents granted to residents (See Figure 10) and total patents secured abroad (See Figure 11) by country residents have not been that significant compared to Japan, Korea, Taiwan and Australia. As the number of total patents granted to the residents and total patents secured abroad by country residents are very much the outcome of a KBE, the number is not that significant yet for Malaysia and Singapore.

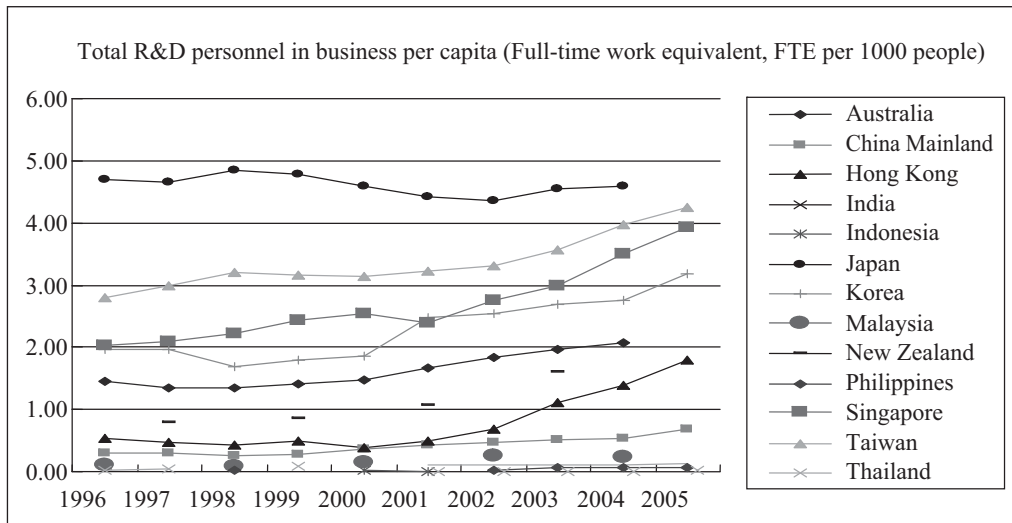


Figure 8. Total R&D Personnel in Business per Capita, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

Although the number of patents in force has increased since 1996 both in Malaysia and Singapore, the growth is not very significant in Malaysia (See Figure 12). In terms of patent productivity both countries are moving behind many other countries in the region such as Korea, Taiwan, Japan and New Zealand (See Figure 13).

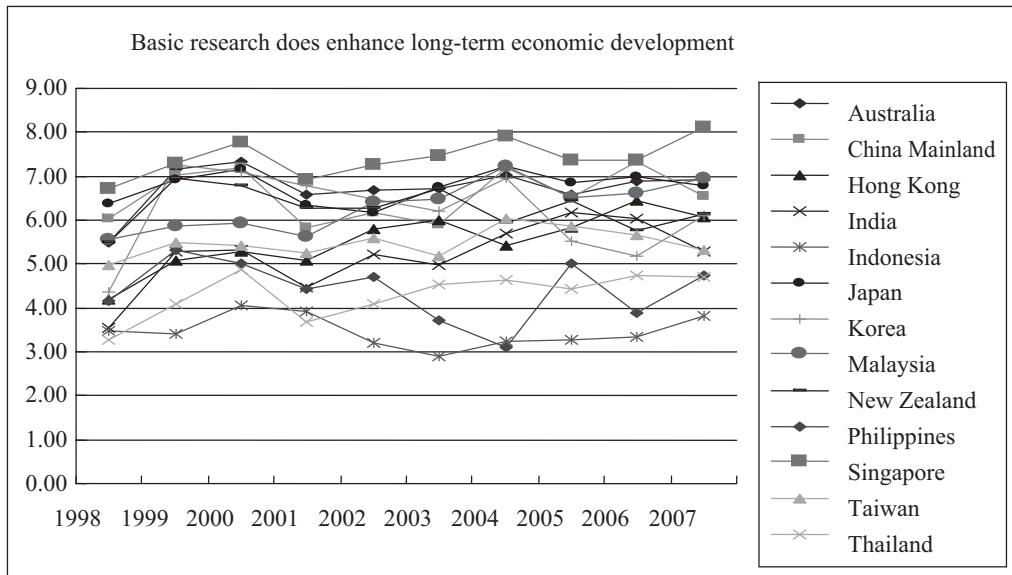


Figure 9. Basic Research*, Asia and Pacific

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

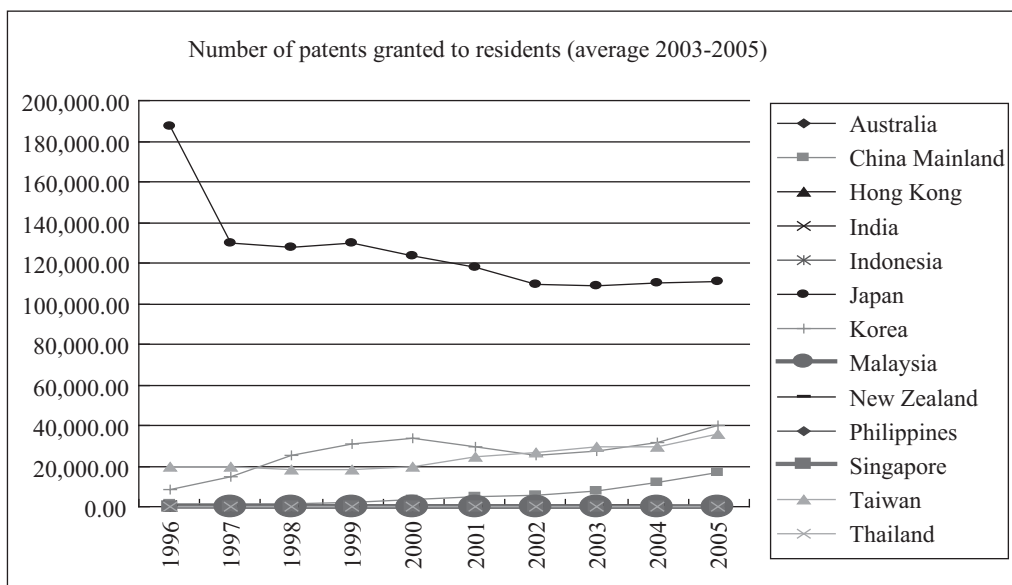


Figure 10. Number of Patents Granted to Residents, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

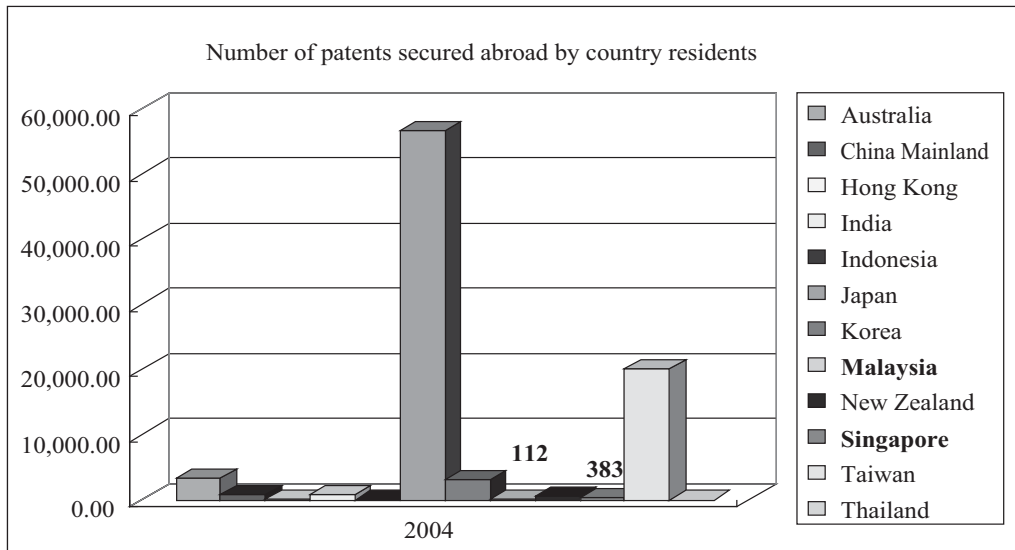


Figure 11. Securing Patents Abroad, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

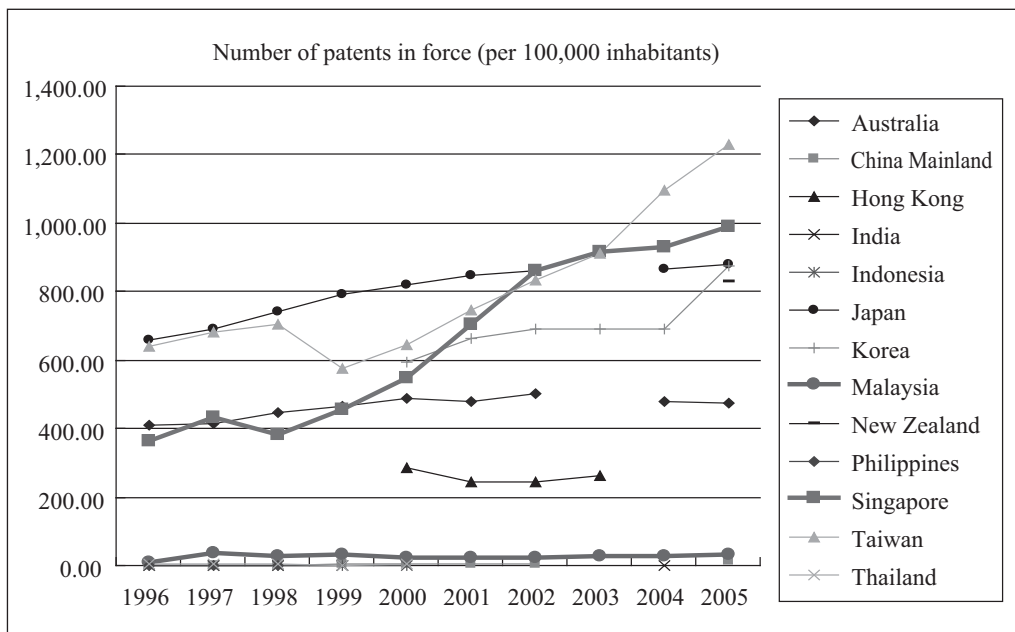


Figure 12. Number of Patents in Force, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

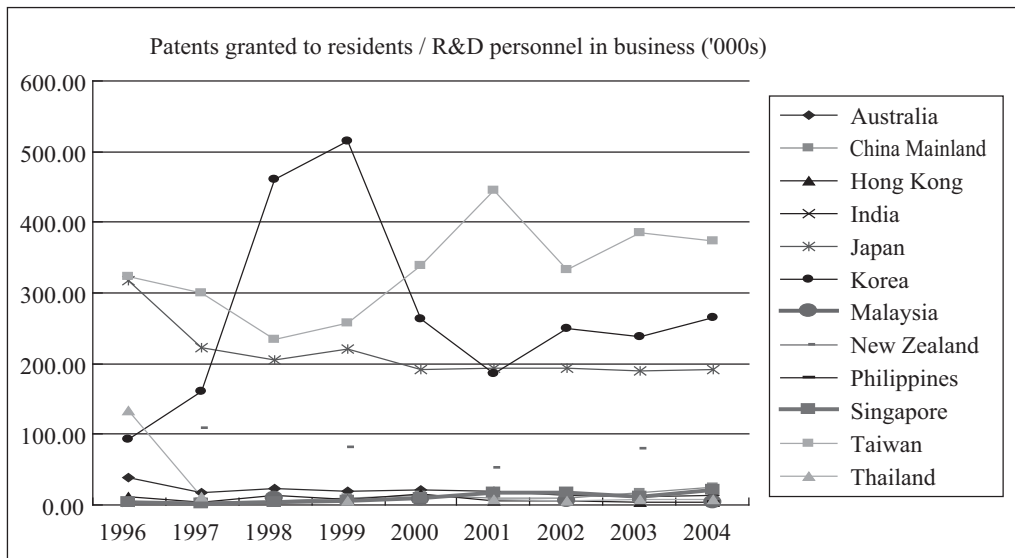


Figure 13. Patent Productivity, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated on May 2007.

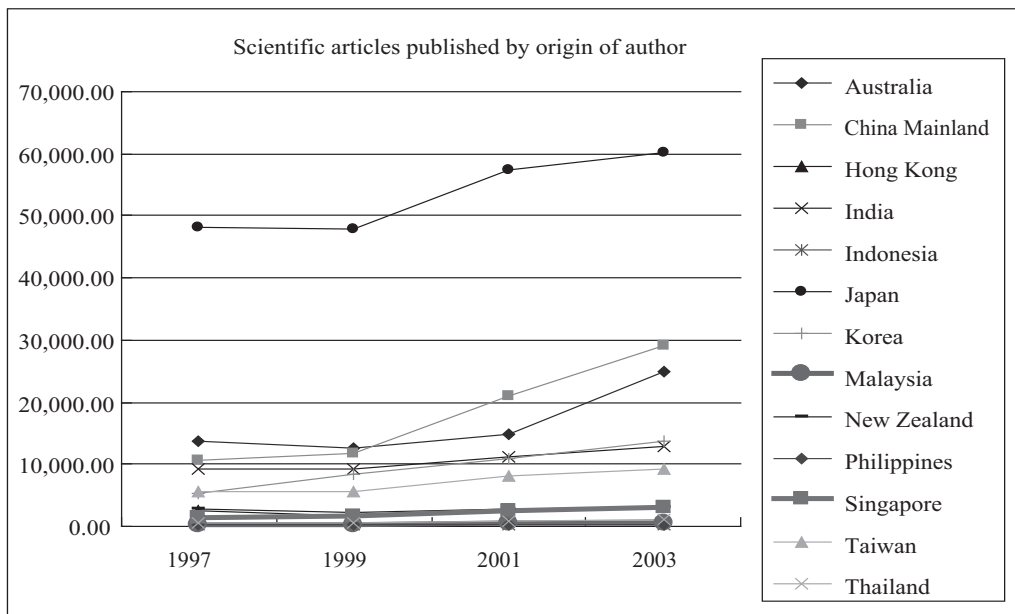


Figure 14. Scientific Articles, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

In terms of scientific articles published both Singapore and Malaysia are way behind many other countries in the region (See Figure 14). However, with the new policies pursued by the government of both countries to become a KBE, they boasted the number of science degree holders (See Figure 15), emphasize in science in schools (See Figure 16) and youth interest in science (See Figure 17). Especially, the developments of the above three factors in Singapore has been very dramatic and in 2007, according to IMD ranking, Singapore secured the top position in the development of all the above three factors.

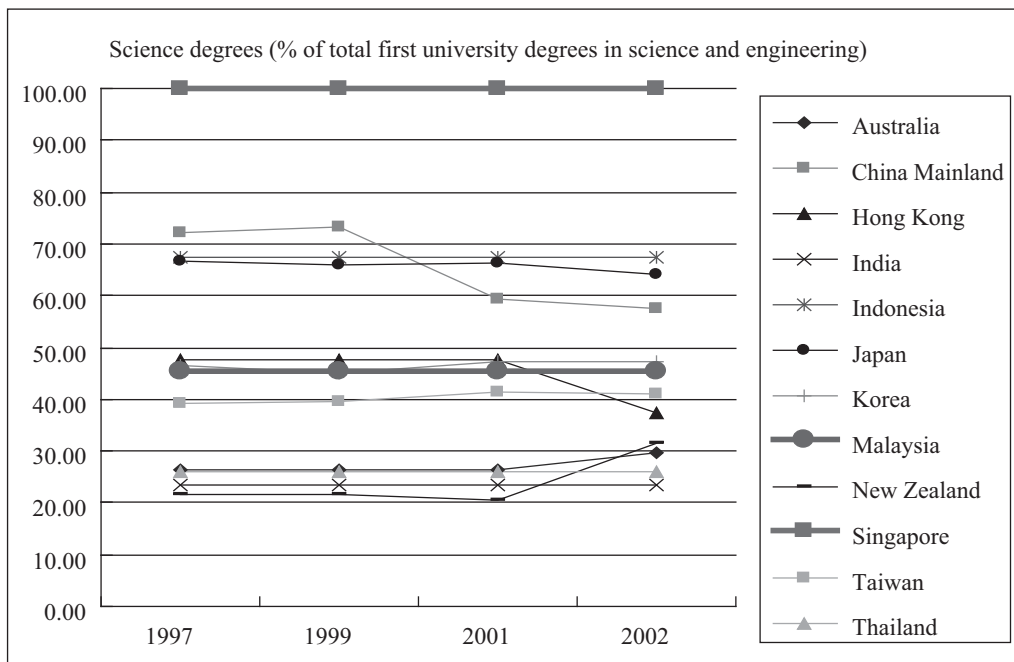


Figure 15. Science Degrees, Asia and Pacific

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

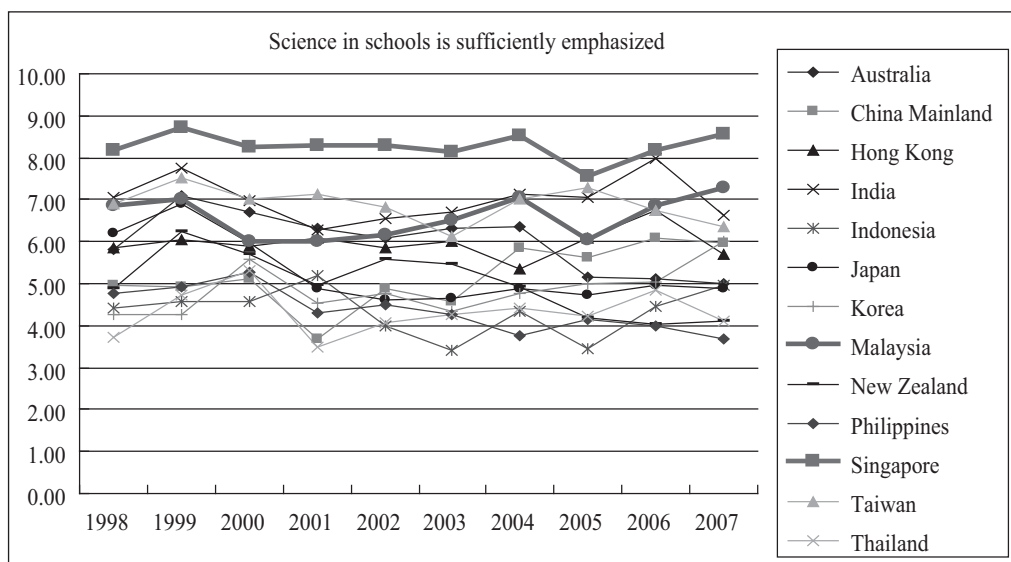


Figure 16. Science in Schools*, Asia and Pacific

*IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

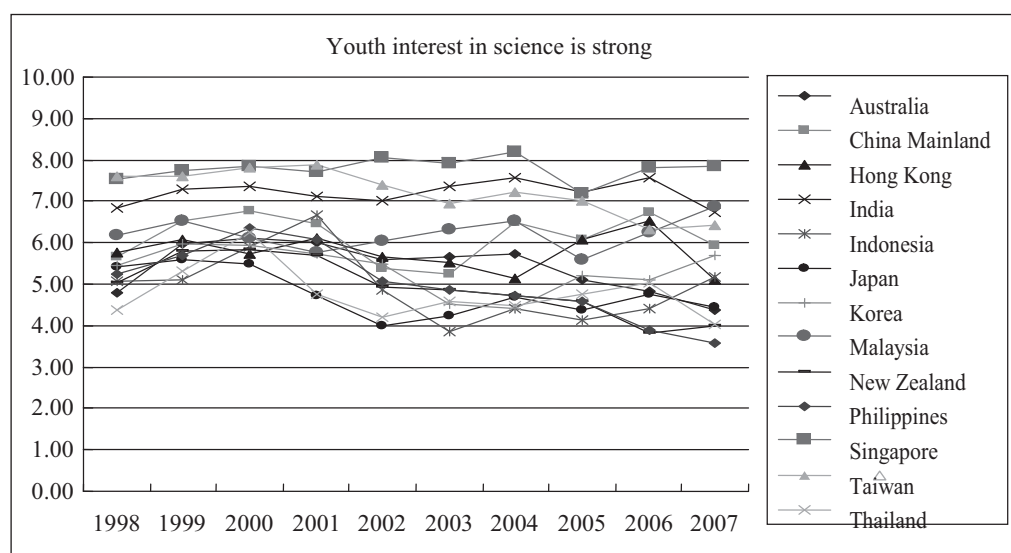


Figure 17. Youth Interest in Science*, Asia and Pacific

*IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

Again, the efforts for the appropriate enforcement of the intellectual property rights (See Figure 18) and development of legislation to facilitate scientific research have been very extremely good (See Figure 19) in Singapore over the ten years. In 2007 IMD ranking, Singapore scored highest in terms of both appropriate enforcement of the intellectual property rights and development of legislation to facilitate scientific research. Malaysia also has shown significant development in both areas compared to many countries in the region. The legal enforcement of intellectual property rights and legislative support to scientific research is playing a very crucial role in bringing up the intellectual people to fit in the right place in Singapore and Malaysia to enhance the excellence in scientific research and development.

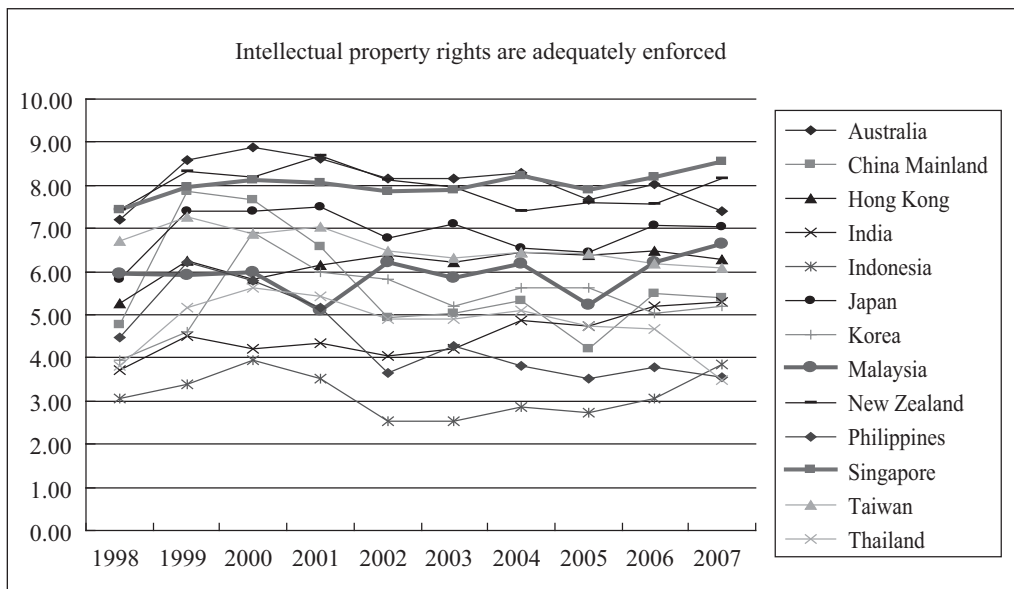


Figure 18. Intellectual Property Rights*, Asia and Pacific

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

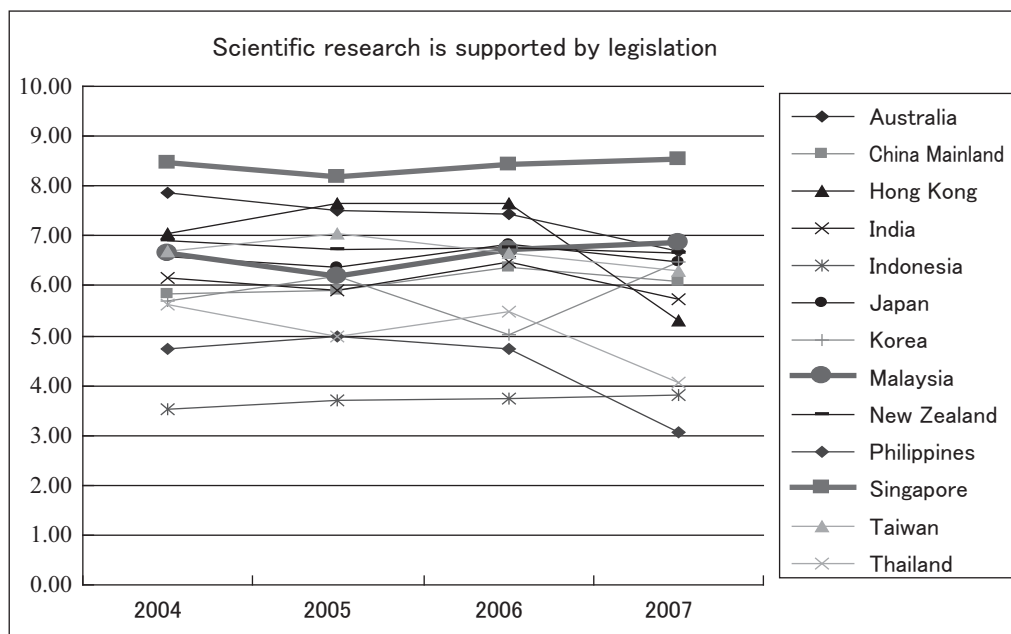


Figure 19. Scientific Research*, Asia and Pacific

*IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online.

Updated: May 2007.

As summary for the scientific infrastructure development in Malaysia and Singapore it is evident that both countries have shown growth in many sectors such as expenditure on R&D, availability of R&D personnel, basic research, patents, patent productivity, scientific articles, science degrees, science in schools, youth interest in science, intellectual property rights, and legislation for scientific research. However, Singapore has shown superior performance than that of Malaysia.

Major Findings

It is evident that both Malaysia and Singapore have been pursuing policies to build up the necessary infrastructures for becoming knowledge-based economies. Reviewing the available data for achievements in different aspects of scientific infrastructures in Malaysia and Singapore we also compared them with Australia, China Mainland, Hong Kong, India, Indonesia, Japan, Korea, New

Zealand, Philippines, Taiwan and Thailand in the Asia and Pacific region. From available data analysis, it is now evident that Singapore is moving far ahead of Malaysia in creating the necessary infrastructure development to become a KBE. In 2007, Singapore ranked first in terms of government efficiency and third in terms of infrastructure in the IMD ranking whereas Malaysia ranked twenty-first and twenty-sixth in the respective areas which provide a clear picture that policy formulation in Singapore have been more efficient than that of Malaysia to build up the necessary KBE infrastructure. However, if we look at the whole Asia and Pacific region, we will realize that Malaysia also has remarkable success in KBE infrastructure building compared to many other countries in the South and Southeast Asia.

In scientific infrastructure development, Singapore showed eminence in basic research quality that enhances long term economic development, percentage of university degree holders in science and engineering which is almost 100%, emphasis on science education in schools, youth interest in science, enforcement of intellectual property rights and availability of necessary legislative support for scientific research among all the countries in the Asia and Pacific. Malaysia, in terms of scientific infrastructure development, experienced better achievements in basic research quality that does enhance long term economic development, emphasizing science in schools, increasing youth interest in science education, adequate enforcement of intellectual property rights and legislative support for scientific research. However, the developments are not as significant as those for Singapore. As a result, it may be concluded that Malaysia may have to re-examine some of its policies to become a knowledge-based economy and make necessary readjustments to compete with other knowledge-based economies including Singapore.

There are many similarities and differences in both countries' policy formulations. However, both countries are moving towards attracting talented foreign nationals in order to supply necessary human resources to become knowledge-based economies. In this regard, Singapore has been more successful in attracting a large number of foreign talents whereas Malaysia has not been so far that successful to attract similar number of foreign talents to support the building up of KBE. Many critics say that Malaysia's progress in the necessary KBE infrastructure building has been slowed down because of Bumiputera Policy which failed to bring out the talented individuals from all ethnic groups of Malaysia. Further, this policy is also restricting Malaysia to get talented foreign nationals because of difference in social and other benefits between the

Bumiputra and other ethnic groups. In this regard, Singapore's policy of equal treatment to everyone is attracting talented foreign nationals from all over the world.

Conclusion

The future trends in the efforts of Malaysia and Singapore for becoming knowledge-based economies will be to further reshape some of their existing scientific infrastructure. From the comparative analysis, it is obvious that both countries are already putting considerable efforts in pursuing necessary policies to promote a knowledge-based economy. In the last ten years, both countries have shown positive performance in developing the scientific infrastructure.

Singapore's future policy formulations will be to create new avenues for the knowledge workers so that the country can make the best use of scientific infrastructure that is already available in Singapore. Singapore's future ability to supply world class knowledge workers and attract world class companies for research and development in Singapore will bring more benefits for its knowledge-based economy.

In the case of Malaysia, the country experienced huge economic growth by pursuing 'Vision 2020' policy which also led Malaysia's attempt to become a knowledge-based economy. Malaysia's continuous efforts to build the scientific infrastructure put Malaysia ahead of many nations in the Southeast Asian region. Despite remarkable efforts by Malaysian government and private sector, the country is far behind Singapore in creating a knowledge-based economy. As a consequence, the future trend in policy formulations of Malaysia to become a knowledge-based economy will have to try and reduce the gap with its neighbor in terms of attracting talented foreigners, large foreign companies for R&D development.

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