The current biotechnology outlook in Malaysia

Stadiul actual al biotehnologiei în Malaezia

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Abstract

Blessed with extremely rich biodiversity, Malaysia is all geared up to explore new high technology to utilize the advantage it possesses whilst to protect its environment. Biotechnology has been identified as an appropriate driver that can deliver economic gains through research and development, improvement of food security, creation of entrepreneurial opportunities for industrial growth, health and environmental sustainability. This paper attempts to address the evolution of biotechnology institutions and the stumbling blocks in developing the Malaysian biotechnology industry. This paper identifies three main impediments in the current Malaysian biotechnology, namely lack of skilled human capital; weak industrial base; and lack of commercialization effort. Besides, a set of strategies are discussed with aim to further improve and strengthen the Malaysian biotechnology industry. In general, the arguments are presented by mapping out the symbiotic relationship between data from elite interviews, archival data and observations.

Keywords: *Malaysian biotechnology industry, human capital, industrial base, commercialization*

Rezumat

Dotată cu o biodiversitate extrem de bogată, Malaezia este orientată spre explorarea noilor tehnologii înalte pentru a utiliza avantajul de care dispune şi în acelaşi timp, pentru a proteja mediul său. Biotehnologia a fost identificată ca un driver adecvat, care poate asigura câştiguri economice prin cercetare şi dezvoltare, îmbunătăţirea securităţii alimentare, crearea de oportunităţi de antreprenoriat pentru creşterea industrială si un mediu sănătos şi durabil. Această lucrare încearcă să abordeze evoluţia instituţiilor de biotehnologie şi obstacolele în dezvoltarea industriei biotehnologiei din Malaiezia. Acest document identifică trei obstacole principale în biotehnologia actuală malaieziană, şi anume: lipsa de capital uman calificat; baza industrială slabă; şi lipsa efortului de marketing. În plus, sunt discutate un set de strategii cu scopul de a îmbunătăţi şi consolida în continuare industria biotehnologiei malaeziane. În general, argumentele sunt prezentate prin cartografierea relaţiei simbiotice între datele de la interviurile de elită, datele arhivate şi observaţii.

Cuvinte-cheie: *industria biotehnologică din Malaezia, capitalul uman, baza industrială, comercializare.*

JEL Classification: L65, E24, J24

Introduction

In the last 50 years, Malaysian economy has been transformed from a protected low income supplier of raw materials to a middle income emerging multi-sector market economy driven by manufactured exports, particularly electronics and semiconductors. The transition of Malaysian economy is a fascinating story with a dramatic history that challenges many conventional models of national development. During the pre-independence period, Malaysian economy was largely dependent on mining, agriculture and plantation. In plantation industry, rubber was one of the most sought after product, in regard of the development of automobile industry in industrial countries, especially in the United States (Drabble, 2000). Hence the rubber industry, combined with expansion of tin mining industry, made Malaysia one of the most prosperous economy of the era.

After independence, Malaysian economy moved into a rapid development zone, especially in the 1960s, where the traditional export economy was renewed by a very successful program of replanting rubber estates and production of palm oil. In the 1970s and 1980s, the most important source of Malaysian economic growth has been the development of a substantial oil and natural gas industry.[1] During the same period of time, Malaysia followed the footsteps of the Asian Tigers (Singapore, Hong Kong and South Korea) and committed itself to transition from reliance on mining and agriculture to manufacturing, particularly in electronics and textiles.[2] With Japan's assistance, Malaysia's manufacturing and heavy industries flourished in a matter of years. As a result, Malaysia experienced one of the highest growth rates of about 8 percent per annum from the mid-1980s until 1997 before the country was hit with the Asian economic crisis. However, it rebounded commendably, registering annual growth ranging from 4 to 5% since 1999.[3]

In the new millennium, biotechnology along with information technology has emerged as a powerful technology that shows big potential for a number of economic sectors. The convergence of these new technologies provides a greater opportunity to develop better strategies and approaches to deal with current and future economic challenges in the fields like agriculture, medicine, food processing, environmental protection, mining, and even nanoelectronics (Zylstraa and Kukor, 2005). Besides, biotechnology has proven to be an industry that able to generate huge amount of revenues. For instance, the global biotech industry grew by 10.6% in 2007 to reach a value of RM611.6 billion. And by 2012, the market is forecasted to have a value of RM983.5 billion, an increase of 60.5% than 2007.[4] While in Malaysia, the global research house Frost & Sullivan predicted that the biotechnology industry would able to generate RM45 billion in revenues by 2013, at an average rate of 15 per cent annually.[5] This certainly has prompted the Malaysian Government to recognise biotechnology as one of the key strategic drivers that will propel the nation's social and economic development further.

Furthermore, biotechnology is expected to expand societal well being and wealth creation by unlocking the value of the country's natural resources and human capital talents.

Importance of biotechnology to Malaysia

IBIS*World* in its Global Biotechnology Industry report defined biotechnology as "The application of science and technology to living organisms as well as parts, products, models thereof, to alter living or non-living materials for the production of knowledge, goods and services".[6] Actually, biotechnology is not something new as it has been practiced since thousands of years ago, for instance using yeast in bread, beer and wine production. Furthermore, bacteria were used to extract minerals from ore, in agriculture and manufacturing industry to produce food, chemicals, medicines and many other products that have been of benefit in many areas including nutrition, and human and animal health (Duffy, 2001). Over the time, this technology was further improved through the use of more advanced techniques of modern biotechnology which can be used to enhance both quality and quantity of the product (Maliro, 2001).

In Malaysia, biotechnology, by virtue of its nature, has much to offer for the sustainable development in agriculture, environment, bio-industries and other sectors. Since Malaysia is an agriculture country, there is a real need to engage biotechnology to avoid losing boat with bigger industrial players. Today, the agricultural sector contributes about 9.7 percent to the overall gross domestic product (GDP) of Malaysia.[7] However, the Malaysian agricultural sector is facing two major challenges. The first are in the realm of addressing national food security, as to produce sufficient amount of food to meet the national needs.[8] Currently, the country is unable to produce sufficient amount of food for the population, which led to an increase in the import of food. For instance, local rice production are only capable to cater approximately 60-65% of domestic requirements.[9] Therefore, the shortfall is being supplemented by imported rice from other countries like Thailand and Philippines. According to a respondent, the second major challenge is related to creating wealth for the nation through production of value added food and food products, which are more competitive in the open market, and to support the manufacturing sector through production of sufficient amount of raw materials. Hence, a crucial injection of new high technology is required to transform the agricultural sector to be more productive especially in meeting the specified two challenges.

Besides, Malaysia is blessed with rich biodiversity and natural resources that are useful as a basis for the biotechnology research and development (R&D). In fact, Malaysia is ranked 12th in the mega-diversity countries, creating the necessary motivation to develop a biotechnology industry (Badawi, 2007). The extremely rich biodiversity and natural resources indicates that Malaysia has a rich gene pool comprising of an estimated 15500 known species of plants, 300 species

of mammals, 150000 species of invertebrates with insects being the largest single group, 1200 species of butterflies, 12000 species of moths and over 8000 species of fishes (Latiff and Zakri, 2000). These genetic resources have long been a source of important raw materials in agriculture and medicine. The rapid advancement in biotechnology has increased the potential uses of genetic resources and their economic value. For example, the global bulk drugs industry which utilises genetic resources to develop new and improved drugs was estimated to be worth RM276.5 billion in 2005 and is expected to rise at a compounded annual growth rate (CAGR) of 10.6% by the end of 2009.[10] Furthermore, it has been reported that 33% of drug products in the highly industrialised countries are derived directly from plants and most of these are tropical plants growing in equatorial countries such as Malaysia (Jusoh, 2006).

In consideration of these opportunities and challenges, Malaysia has certainly identified biotechnology as an appropriate vehicle that can deliver economic gains through research and development. With the strong backing of natural resources, Malaysia is all set to venture into this high technology that are able to improve food security, promote the sustainable use of natural resources and at the same time create new business opportunity and employments.

Development of Biotechnology Institutions in Malaysia

Generally, biotechnology development in Malaysia can be categorized, (Figure 1), into four main phases; first phase was prior to 1995, second phase was from 1995-2000 and third phase was from 2001-2005 and fourth phase was beyond 2006. The first phase of biotechnology development in Malaysia began with the establishment of basic infrastructures, necessary equipments and set up, in addition to basic expertise to undertake biotechnology research and development (R&D). In the beginning, number of research institutions such as Malaysian Agricultural Research and Development Institute (MARDI), Rubber Research Institute of Malaysia (RRIM), Palm Oil Research Institute of Malaysia (PORIM), Universiti Putra Malaysia (UPM), Universiti Sains Malaysia (USM) and Universiti Kebangsaan Malaysia (UKM) were assigned to carry out the R&D.[10] Furthermore, a National Working Group on Biotechnology was set up under the Ministry of Science, Technology and Environment (MOSTE) to oversee and coordinate biotechnology activities in the country.

During the second phase of development, implementation of the national agenda on biotechnology was further enhanced with the establishment of the National Biotechnology Directorate (NBD) under MOSTE. The objective of the directorate is to spearhead the development of biotechnology in Malaysia through research and related activities directed at commercializing biotechnology, and to establish Malaysia as a leading centre for biotechnology industry. At the same time, Biotechnology Cooperative Centers (BCC) which falls under NBD was

established to assist in coordinating the National Programme in Biotechnology; developing a network among universities, research institutions and industries, and accelerate the diffusion of knowledge to the relevant industry. Besides the BCC system, another mechanism called the Contact Group Programme was also established by NBD to facilitate direct communication and linkage with participating institutions of the public and the private sectors.

During the third phase of development, MOSTE proposed the establishment of three national institutes that specializes in R&D with national strategic importance. But after further studies and research, the Ministry proposed that these institutes to be developed within a Malaysian Biotechnology Cluster, known as BioValley Malaysia that are expected to best assure the success of the institutes. Furthermore, the formation of BioValley was expected to accelerate the research and commercialization of technologies that are crucial for the development of Malaysia's regional and global competitiveness in the industry. The BioValley Strategic Plan was developed through collaboration between the National Biotechnology Directorate and Massachusetts Institute of Technology (MIT), through the Malaysia-MIT Biotechnology Partnership Program (MMBPP). A joint workshop was held from 29 January to 2 February 2001 which was attended by fifty three Malaysian experts from research institutions, universities, and industry.[12] The plan was based on the cluster concept where groups of specialized companies support each other to create a center of excellence. Companies within the cluster can take advantage of the presence of physical infrastructures, facilities, human resource, entrepreneurship and sharing of ideas to enable them to compete at a global level.

In May 2003, BioValley was launched by then Prime Minister, Tun Dr.Mahathir Mohammad. But soon after its launch, there was no much development or progress in the BioValley as expected. Although the plan was drawn up by famed Japanese architect Kisho Kurokawa, the project was shrouded by problems (Cyranosk, 2005). So much so that the plan had been overhauled and a new strategy unveiled. On April 28, 2005, the former Prime Minister of Malaysia, Tun Abdullah Ahmad Badawi launched the National Biotechnology Policy to stimulate the biotechnology sector into a new economic engine to enhance prosperity and wellness of the nation by 2020. To implement the policy, the Malaysian Biotechnology Corporation (MBC) was created as a one stop agency to spearhead the development of the sector, including coordination of regulatory policy among different agencies. MBC is overseen by an Implementation Council and advised by an International Advisory Panel, both under the leadership of the Prime Minister of Malaysia. MBC, which come under the purview of the Ministry of Science, Technology and Innovation (MOSTI), are responsible to facilitate the market driven R&D and commerce via funding and industry development services; and catalyzing commercial spin offs to the private sector (Ahmad, 2005). As a continuous effort to develop biotechnology industry, government of Malaysia has introduced a mechanism called BioNexus. BioNexus is essentially a network

of 'centre of excellence' throughout the country, comprising companies and institutions which specialize in specific biotech subsectors (Yunus, 2006). As to date, three centres of excellence have been established as part of the BioNexus, namely the Centre of Excellence for Agro-biotechnology (MARDI and UPM); Centre of Excellence for Genomic & Molecular Biology (UKM); and Centre of Excellence for Pharmaceuticals & Nutraceuticals (USM and UPM).

The activities in the fourth phase of the development are best explained by the 9th Malaysia Plan (2006-2010) in particular, Chapter 6 of the Plan. Under the 9th Malaysia Plan, the government of Malaysia allocated US$550 million for biotechnology development (Abdullah, 2006). The government recognizes the importance of a conducive regulatory framework to ensure the success of its biotechnology endeavor. In this regard, the promotion of foreign and domestic investments and close collaboration with foreign entities to access new technology, expertise and markets will be intensified. At the same time, efforts are being taken to improve the Intelectual Property (IP) policy and management framework in order to foster innovation and safeguard investment in the biotechnology sector.

Stumbling-blocks in Malaysian Biotechnology

From a public policy perspective, we are still really in the world of expectations when we talk about biotechnology, especially in Malaysia. In Malaysia, the hype, expectations, and variations of prospect in biotechnology are often detailed in many different reports. However, the problem with biotechnology in Malaysia is that many of these expectations have not yet been realized except in very small ways. According to interviewed respondents, although the National Biotechnology Policy was well documented, the problems often arise in the implementation stage. This is largely due to the lack of skilled human capital, lack of industrial bases and many research products have no commercialization values.

Biotechnology is a multidisciplinary science and it is an area that needs high capacity of human resources to achieve substantial benefits. Biotechnologist apart from having a good basic knowledge of basic molecular biology requires knowledge in bioinformatics, information technology, engineering, statistics, genetic epidemiology, business management, product development and legal issues (Puchooa, 2004). Therefore, thrust five of the National Biotechnology Policy (NBP) focuses on building human capital in biotechnology through education and training.

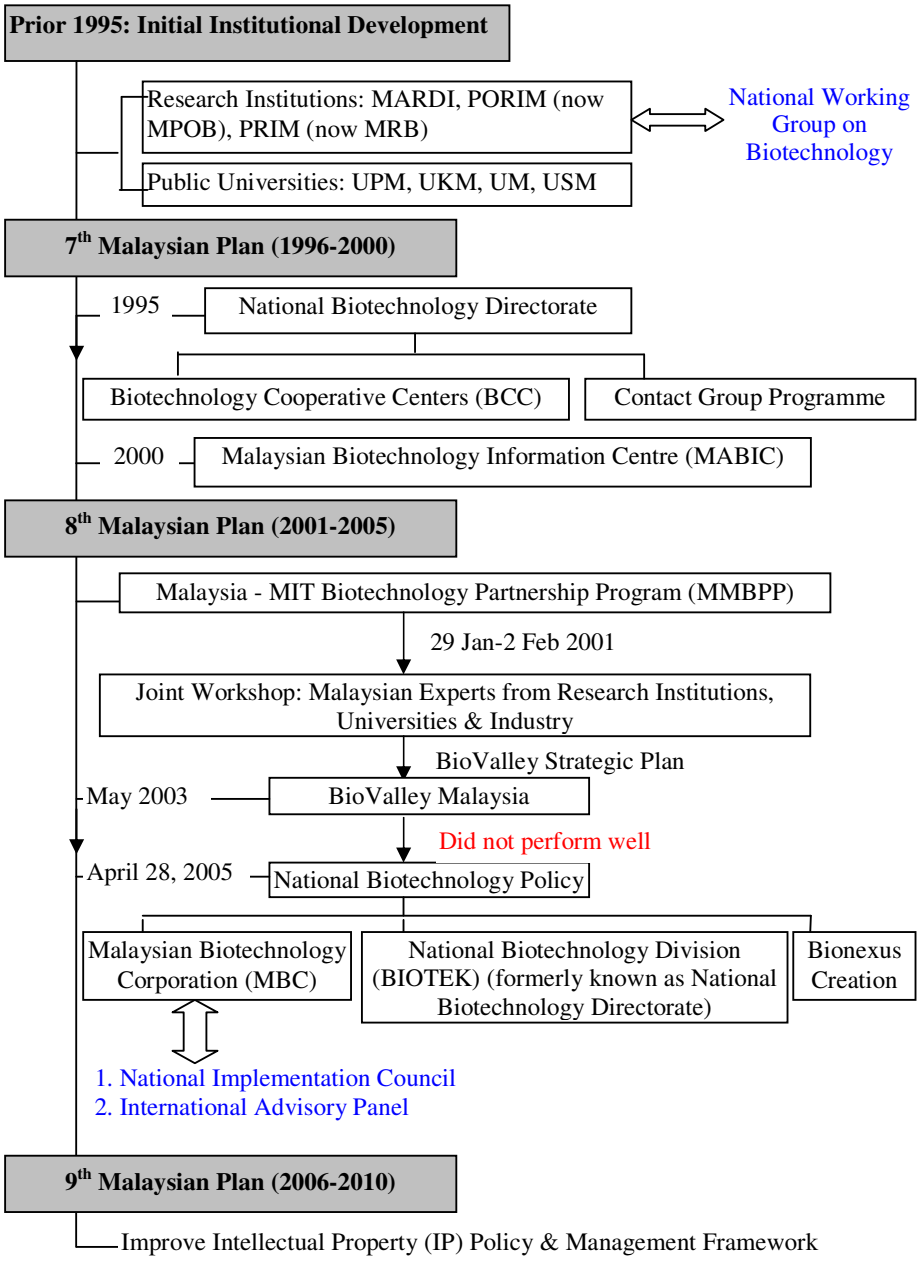

Figure 1. History of biotechnology development in Malaysia

However, the current statistics shows that there is an alarming shortage of skilled manpower trained in biotechnology. According to the figures released by MOSTI, there were only 507 students graduated with minimum qualification of masters during the period of 8th Malaysian Plan.

Number of students graduated from top-down RMK-8 Research Project

Table 1

Priority Areas	Graduates			Total
	Post Doctoral	PhD	Master	
Animal	3	43	78	**124**
Plant	2	5	13	**20**
Food	-	8	26	**34**
Biopharmacy	-	16	49	**65**
Medical	-	28	58	**86**
Molecular Biology	2	32	95	**129**
Environment/industry	-	19	30	**49**
Total	**7**	**151**	**349**	**507**

Source: BIOTEK, MOSTI (as May 2008)

Human capital in terms of fresh undergraduates is definitely not lacking in Malaysia as there are many universities and private colleges offering biotechnology courses at undergraduate level. As a result, an average of 1900 students majoring in biotechnology or biotechnology related programmes graduates from public higher learning institutes every year (see Table 2). But despite the huge number of fresh graduates, biotechnology companies in Malaysia is facing problem in securing the right candidate to fill various job portfolios. This is because these fresh graduates are very much lacking in hands-on experience and incomprehensive in meeting the demands of biotechnology companies. A respondent acknowledged that the problem actually lies deep within the Malaysian tertiary education system which is still practicing the traditional approach where the students are only trained academically while missing out soft skills needed by the industry. Hence, we can say that the human capital management in Malaysia is not equilibrium with the biotech industry's need and demand.

Although the focus on building human capital in biotechnology is vital and crucial step to fuel the growth of biotech industry, the effort is considered waste without having a strong industrial base. Obviously, Malaysia is lacking in this aspect which is important to absorb and train young scientist churned out from local and foreign universities. According to Malaysian Biotechnology Corporation (BiotechCorp), there were only 13 public-listed biotechnology and life-sciences companies in 2008, an increase of 18% than in 2007. At the same time, there were 92 companies with Bionexus status and most of them are small and medium size enterprises. The relatively small and feeble biotechnology industry in Malaysia is

obvious with unimpressive market capitalization of RM 2.5 billion in 2007 and this figure decreased 32 percent in 2008 to RM1.7 billion.[13]

Students graduated from the Public Higher Learning Institutes (Biotechnology and biotechnology related programmes)

Table 2

	Academic Session	
Field (B.Sc)	**2005/06**	**2006/07**
Biochemistry	69	51
Molecular Biology	0	0
Microbiology	41	74
Plant Biotechnology	33	23
Plant Science	162	183
Animal Science/ Zoology	25	44
Food Science	726	472
Marine Science	132	70
Bioinformatics	0	16
Genetic	33	15
Pharmacy/ Pharmacology	256	327
Biotechnology	268	266
Forensic Science	27	35
Biomedic	352	227
Total	**2124**	**1803**

Source: Ministry of Higher Education, Malaysia (MOHE)

Comparing to Australian biotechnology industry, the market capitalization of the health sector alone has reached RM110.9 billion, with the life science sector in particular growing in value by 81 percent over the past five years. According to a new PriceWaterhouseCoopers (PWC) BioForum biotech industry report, the market capitalization of the 111 Australian life science companies grew from RM28.7 billion to RM52 billion representing an 81 percent increase.[14] According to a respondent, the relatively weak biotechnology industrial base in Malaysia is a result of interest clash between the scientists and investors. Biotechnology is a huge investment industry and the profits can only be enjoyed after few years of operation. Investors who don't understand the complexity of the biological processes often become disillusioned and not interested in this industry. Apart from that, lack in number of locally available skilled and knowledge workers also shunned away the potential investors, who are willing to invest in neighboring countries like Singapore despite a higher set up cost.

In Malaysia, many researches are conducted mainly at public universities and public research institutes. Although the volume of researches is encouraging, the number of research products with commercialization value is disappointing. One of the factors that lead to lower commercialization in Malaysia is the fact that most researches are funded by the government or governmental agencies with only 0.68% university R&D funding coming from the industry as compared to the more advanced countries, such as Canada (11.8%), Germany (7.5%), UK (6.2%) and the USA (5.5%) (Jusoh, 2007). Typically, the government agencies won't provide proper guidelines compared to industries, which helps the local scientist to commercialize their products as most of them don't have sufficient knowledge about business, Intellectual Properties (IP), and marketing. Furthermore, commercialization also depends on the intention of the patent owners. Some patent owners apply for patents to protect future research rather than seek commercialization. At the same time, some products such as pharmaceuticals may require regulatory approvals from relevant authorities and this process can consume huge amount of money as well as time. As a result of bureaucracy, many scientists tend to shun away even if their research products have high commercialization value.

Comparison of the product commercialization in Malaysia with that of other countries with active biotechnology industry suggests that the lack of connectivity between the universities and research institutes with industries may hinder the commercialization activities. Rasli (2005) acknowledged that commercialization of R&D has not been traditionally a high priority of universities in Malaysia. During the 7^{th} and 8^{th} Malaysia Plans, only 5.1% out of 5232 R&D projects implemented were considered as having commercialization potential but none of them was commercialized on a national scale (Mokhtar, 2005). The key reason behind the poor university-industry linkage in Malaysia is due to the lack of biotechnology industrial base. The current biotechnology industries in Malaysia prefer to be labor intensive and not invest into R&D in technology to gain competitive advantage. A respondent states that even though universities in Malaysia begin to realize the importance of product commercialization, the effort to date has been quite modest.

Interviews with some of the prominent industrial players involved in the National Biotechnology Policy making process revealed that apart from the problems mentioned above, the Malaysian government still unable to fine-tune a proper working mechanism for the biotechnology industry. This is due to over consultations with the different interest groups such as academicians, scientists, and investors made government indecisive to make bold decisions and actions. Furthermore, some of the consultants engaged were foreign based and according to the respondents, these consultants taken easy way to reproduce the findings prepared by the local consultants with some adjustments. Although the foreign consultants have included new ideas and suggestions, the respondents clearly felt that they have overdone with the documents since they doesn't know the

environment and real situation about Malaysian biotechnology industry. Hence, many of the suggestions were only good in paper and impractical in the real situation.

Strategies to strengthen the biotechnology industry

Although there are some hiccups in the current biotechnology sector in Malaysia, the government strongly regards biotechnology as a technology which is not only important for the economical well-being but also for a clean, efficient and pollution-free environment. In order to accomplish the full potential of biotechnology with significant impact on society, Malaysia should begin to create environment conducive for R&D and innovations to achieve the perceived agenda and objectives. There is severe need in dynamic adjustments, both at institutional as well as at social levels in Malaysia. But first and foremost, the government itself must change its approach and strategies in developing the biotechnology industry.

All this while, the Malaysian government has been practicing the 'functional industrial policy' when developing the biotechnology industry. The 'functional industrial policy' refers to a policy by which the state confines itself to stimulating an ideal market by fulfilling general economic functions (Haque, 2007). Contrary to much developed countries like Japan and Singapore, their biotechnology industry was developed through the 'sectoral industrial policy' approach. The 'sectoral industrial policy' refers to a policy by which the state directs resources to targeted industries identified as crucial for their future competitiveness (Nolan and Pack, 2003). For a developing country with limited capital and relatively small market size, it is sometime argued that Malaysia should begin to concentrate and support its biotechnology industry to achieve sufficient economies of scale to compete in world markets, and then use the benefits of the industry to stimulate other domestic sectors. In another word, Malaysia should adopt a sectoral industrial policy to subsidise technological upgrading; to help industrial players move away from low-tech production and areas of established competitiveness. However, the effectiveness of a sectoral industrial policy is very much depends on the ability of government, which is shaped by socio-political factors such as the internal working mechanism of a government and its interactions with various interest groups.

In this aspect, Malaysia should look at Singapore's ability in developing their biotechnology industry. Lacking in natural resources and land supply as compared to Malaysia, Singapore has fewer alternatives but to commit to higher value-added industry such as biotechnology. Despite a small domestic market, Singapore was focused in facilitate and support its biotechnology endeavor. Part of its sectoral effort, Singapore government directed the universities, especially the science and engineering departments to orientate toward market-driven technological research and international linkages. As Singapore was lacking in skilled human capital in the field, the country began to recruit expatriates to run the

industry. Besides, the government contributed substantial financial support to train undergraduate and post-graduate in the field of bioscience. Many schemes were established to support personnel from the industry and academic for taking short courses and research attachments overseas; and to encourage companies to send employees to local universities to work on projects for technological learning (Tan and Byrne, 1996). Furthermore, Singapore also established a conducive legal and regulatory climate to promote R&D and investments for the industry. Singapore is a signatory of the Patent Cooperation Treaty (PCT), a patent approved in the country is valid in the other 44 PCT countries including US and Western European Countries (Eisenberg, 2001). The formulation of the patenting schemes was one of the masterstroke step taken by the Singapore government to enhance its biotechnology industry.

Malaysia also may draw some lessons from Cuba's experience in developing their biotechnology industry. Biotechnological development in Cuba was given a substantial boost as a result of an epidemic of dengue fever that broke out in 1981.[15] Since then, Cuba was very much focused on developing their health care sector using biotechnology. Modern biotechnology was used to facilitate product diversification and import substitution especially vaccines. Besides, Cuba recognizes that participating in the global market involves forging alliances with a wide range of enterprises, especially those that have extensive marketing networks. Cuba's biotechnology industry is an example of the importance of political leadership on technological matters, domestic funding for research activities, creation of appropriate research institutions, and international alliances for product commercialization.

Unless purposeful action is taken to move towards new activities, Malaysia may not be able to overcome the current shortcomings that are backlogging its biotechnology industry. Hence, Malaysia should seriously begin to focus on solving the shortcomings, especially in the aspect of human capital; funding; commercialisation effort; and technical collaborations to strengthen their industrial base.

The key strategy to foster the development of biotechnology industry is the building, mobilization as well as the efficient utilization of scientific expertise through training and education. In this aspect, new curriculum should be developed to cater the needs for the required human resource. The Ministry of Science, Technology and Innovation (MOSTI) and Ministry of Higher Education (MOHE) should work together in developing syllabus and curriculum which is on par with the industry's requirement and demand. Graduate and undergraduate training underpin the development of in-country capability in the basic biological sciences. This is vital in the effort to produce highly qualified and skilled human capital. Malaysia also should improve the current post-doctoral fellowship system by establishing considerable number of postdoctoral fellowships which are a key component of keeping abreast of the latest advances worldwide. Besides, Malaysia

should consider recruiting expatriates or professional scientist from foreign land, at least for the start, to run the industry along with local manpower.

Although Malaysia is allocating considerably fair amount of money for the research and development purpose, the funding should be focused on the niche area of R&D only. Since biotechnology is a high cost venture, there is a special need for long term planning in resource allocation for the optimal utilization of any infrastructure set up. The drying-up of funds at intermediate stages and limited operating budgets are identified as a main cause for low achievements and have reduced benefits to a fraction of that expected. In this aspect, Malaysia may follow Cuba's strategy in sectoral funding for research activities. With proper financial planning providing for sustained funding, R&D in Malaysia can become more efficient and productive.

Comparison of the biotechnology development in Malaysia with that of Singapore or other countries with active biotechnology networks suggests that the absence of collaboration and technical network could have limited the development of the industry. Therefore, alliances between the country's public biotechnology R&D agencies and leading private companies which form the pool of scientific expertise in biotechnology could help in building competent and competitive industry. So far, research collaborations in Malaysia are usually set up by individual institutions with specialized local or foreign laboratories on specific projects only. Hence, there is a pressing need for Malaysia to join as many research networks as possible, particularly those involving other developing countries with comparable economic status and similar research interests. However, this effort would require continues public sector investments from domestic and external resources, innovative funding mechanisms from international development agencies, and involvement of both local private sector companies and transnational companies. At the same time, joint ventures or collaborations between local and foreign companies would encourage product commercialization. Foreign companies may need the market and access to natural resources whilst local firms need access to the technology. The win-win situation will not only enables the domestic firm to get full access to the protected knowledge of the foreign firm, but also provide a suitable platform to commercialize their research products.

Conclusion

Overall, it must be concluded that the biotechnology industry in Malaysia is still in the infant stage. Even though Malaysia has introduced National Biotechnology Policy in 2005, the desired result is yet to be seen as consequences of unfavourable implementation. Thus, Malaysia needs to clearly redefine and focus on the national agenda with planned strategy to best achieve them. Generally, most of the constraints that are holding back the biotechnology sector in Malaysia can be resolved with the appropriate policies. Furthermore, biotechnology needs to be addressed from a global point of view, from human resource development to

commercialisation. Manpower training will play a determinant role and emphasis should be put on producing high-level scientists rather than technicians. With the need to extend these skills, the strategic planning will have to make ample provision for human resource development with greater role by MOSTI and MOHE. It will also be of vital importance for Malaysia to join as many biotechnology research networks as possible as we cannot progress in isolation. These networks, in addition to providing local scientists with opportunities for training, collaboration in research and the acquisition of new technology at low cost, can become important technical forum to help Malaysia develop a strong biotechnology base. As we move into the future, proper funding and planned investment in the right biotechnologies can help to promote sustainable use of natural resources and at the same time create new wealth for the country.

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