

Innovation and Firm Creation Strategies in the Emerging Biotechnology Industries

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ABSTRACT

Innovation and firm creation are enablers of industry development, especially in industries that are technology-intensive. In the contexts of an emerging industry, industry development supports the transformation of an emerging economy into a developed one. Therefore, by understanding innovation and firm creation strategies and the variables that influence them entrepreneur-managers will be able to design strategies for the development of their firms, and policy makers will be able to institute a conducive environment which support rapid growth of the industry. This study examines the strategies for innovation and firm creation adopted by 92 companies in the emerging Malaysian biotechnology sector. The objective is to gain an understanding of the variables that influence their innovation and firm creation strategies. To achieve this objective, content analysis methodology was utilized and data was gathered from sources in the public domain. Findings reveal industry's contextual variables influence innovation and firm creation in the emerging biotechnology industry. Some of the emergent strategies for companies in this industry are establishing a family of firms, collaborating with business partners, locating their operation close to resources, and internationalizing their operation. These strategies, in turn, are influenced by the age and size of the companies. These findings can be explained by three major theories of competition; the influence of the external environment can be explained via the industrial organization perspective, while the resources and innovative conduct, being of strategic imperatives can be described through the resource-based and the Schumpeterian

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views. These insights offer entrepreneur-managers and policy makers directions toward enhancing the process of innovation and firm development, which in turn can support the development of technology-intensive companies and industries.

Keywords: Innovation, firm creation, strategic management, biotechnology, technology-intensive industry, emerging economy

INTRODUCTION

Biotechnology, as defined in this study, is any technological application that uses biological systems, living organisms, and/or their derivatives, to develop new products and/or to improve on existing products or processes. It has diverse applications in agriculture, healthcare and industrial processes, products and services (BiotechCorp, 2009a:8). The field of biotechnology also includes development of processes and methods in related fields or domains, such as those that contribute to the development of bioinformatics. Biotechnology is one of the most important innovations today; among others, biotechnology innovation helps to advance food and medical technologies and thus contributes to the progression in the health and well-being of society. Therefore, the development of innovations in the field of biotechnology has a very high potential of contributing toward the sustainability and well-being of the world, and the economic development of a location or region.

Theories of economic development and strategic management emphasize that development of an industry is supported by the growth of firms within it. In turn, the growth of these firms is determined by how well they innovate and what types of innovation they make. In fact, one important assumption in relation to this is that innovating is equated with strategizing. This perspective stresses the significance of innovation not only in making profits for firms in a particular industry, but also in sustaining the whole industry in the long-run. This is because a firm's profitability contributes to its growth, which in turn helps promote industry development, which then encourages economic development of a society. Thus, a firm's innovativeness benefits the firm and consumers, as well as the society at large (Jacobson, 1992; Schumpeter, 1934; 1942).

The above discussion highlights innovation and firm creation as constructs that influence industry development. Indeed, industry development is crucial in emerging economies such as Malaysia. Malaysia's biotechnology industry has been designated as one of the catalysts for Malaysia's goal to achieve its developed country status in 2020. The government had committed about USD500 million to promote the overall biotechnology industry development policy, which was launched in April 2005 with the goal of developing the biotechnology industry into one that would

contribute 2.5% of the Malaysian GDP in the year 2010 (BiotechCorp, 2007). The underdeveloped state of this industry indicates that the industry is still in its infancy.

The government's biotechnology industry goal requires that the infant industry be strategically developed and sustained. This, in turn, requires that the firms operating in this industry to strategize their efforts toward achieving high growth, while policy makers are responsible for designing a support structure that will ensure that the industry continues to prosper and bring strategic advantages to the country's economics aims. In promoting the growth of the industry, entrepreneur-managers need to have knowledge about innovation and firm creation strategies in the industry and the variables that influence them; this is to enable them to design strategies to develop their firms and support policy makers in instituting a conducive environment which will help support a rapid growth of the industry. This study, therefore, examines strategies of innovation and the structure of firm creation in the Malaysian biotechnology industry. The objective of this study is to generate a set of variables that influence strategizing in the industry.

The firms chosen for this study were companies with the BioNexus status, a status awarded to biotechnology firms that have met the criteria set by BiotechCorp. The most important criterion is the ability of the firms to exploit leading-edge biotechnologies in the three focus areas (agriculture, healthcare, and industrial) of the Biotechnology Policy. The BioNexus Program, which was introduced in 2006, is a comprehensive support program for biotechnology product and firm development. The status provides biotechnology firms access to tax incentives, government funding and relevant industry networks (BiotechCorp, 2007). The aim of these is to promote rapid growth of the companies and encourage more foreign direct investments in the biotechnology industry. BiotechCorp is a government-based agency established in 2005 as a part of the Malaysian Biotechnology Policy initiative to support the industry's development. The agency operates under the Ministry of Finance, and is managed by both the Ministry of Science, Technology and Innovation (MOSTI) and the Prime Minister's Department. It administrates the granting of BioNexus status to selected biotechnology firms and the dispensing of government incentives, including financial grants.

In this study, a list of BioNexus companies totalling 92 firms was compiled from the BiotechCorp database at the end of 2008. To achieve the study's objective, we included all 92 companies in our analysis, and utilized content analysis methodology with data gathered from sources in the public domain.

The term *innovation* in this study refers to biotechnological innovation; *strategies of innovation* refer to the company's products or services, or both, and grouped according to the sector in which they were positioned, including agriculture, healthcare, and industry. *Strategies of innovation* also include the types of markets

served by the company. *Strategies of firm creation*, on the other hand, were measured by the location of the biotechnology firms and type of organization, either public-listed or privately-held, and whether they were independent or part of a group of companies, as well as the existence of collaborative alliances or partnerships.

The structure of this study first provides some background information on the policies and biotechnology industry in Malaysia. Second, it presents the theoretical perspectives on innovation and firm creation strategies and the conceptual framework. Third, it describes the research methodology and the data collection process. Finally, the study analyzes the findings and discusses its main conclusions.

BACKGROUND OF THE BIOTECHNOLOGY POLICIES AND INDUSTRY IN MALAYSIA

In 2005, the Malaysian government launched the Biotechnology Policy and designated the biotechnology industry as a strategic industry; the industry has since received a lot of support from the government. The policy reflects a comprehensive plan for the industry's development. Instead of developing Malaysia's capabilities in biotechnology from the basic (as in the case of an earlier Malaysian government policy on the development of the ICT and multimedia industry), the biotechnology policy fosters the industry's growth by designating the *agriculture, healthcare* and *industrial* sectors as focus areas of development. The three sectors were amongst the country's major focus areas of development in the government's earlier policies. In this way, the capabilities in biotechnology can be developed from the existing bases, as the three sectors are already established industries.

Under the Malaysian biotechnology policy, the development of these three sectors are directly supported by extensive R&D efforts, human capital, financial, and legislative development, which are aligned with market positioning strategies in the international markets. These supports are provided mainly through BiotechCorp, the central biotechnology industry development agency, with the aid from many other agencies (Iskandar Mizal, 2009; BiotechCorp, 2009b; BIOTEK, 2011).

One of the most important mechanisms in promoting the development of the biotechnology industry is the BioNexus program, which grants the BioNexus status to biotechnology firms that meet the criteria set by the BiotechCorp. The BioNexus program enables innovative companies to get tax-deferred advantage, receive priority in getting funding from government agencies, and gain access to the expertise networks of BiotechCorp (BiotechCorp, 2007). The BioNexus programs are supported by a network of about 50 agencies, some of which are newly created units, while others are existing agencies with re-focused goals to support the implementation of the biotechnology policy (Khairul Akmaliah,

Hasmiah, Mohd Fuaad & Igel, 2012). The new agencies include the BiotechCorp and InnoBio. The latter is a government entity that provides direct consultancy and contract research to client biotechnology organizations. It primarily supports firms in the field of biopharmaceuticals, which include research institutes and pharmaceutical companies. It also provides training to researchers at universities and research institutes to help them keep abreast with the latest technological development. InnoBio has also planned to operate an incubation facility to support the development of biotechnology firms (InnoBio, 2010).

Expanding or refocusing the functions of several existing agencies enables the biotechnology policy to 'piggyback' on these agencies' existing structures. These agencies include the Technology Park Corporation (TPM) and Malaysian Technology Development Corporation (MTDC). TPM, a science park operator and manager, was formed in 1996 in conjunction with the launching of the Multimedia Super Corridor (MSC) Program; From 2005, TPM's roles have been expanded to directly support the implementation of the biotechnology policy, including through the operation of an incubating facility for biotechnology R&D. Its subsidiary, TPM Biotech is directly involved in handling biotechnology R&D and commercialization, and providing biotechnology R&D, commercialization, manufacturing, and marketing services to client companies that are located within and outside of its park (TPM, 2010; TPM Biotech, 2010). Another agency is MTDC, which was formed in 1992 and its function was strengthened in 1996 to support the earlier-launched MSC Program. However, since 2005 its roles have been expanded to directly support the biotechnology policy implementation, through administering three university-based incubators, handling the Commercialization of R&D Funds and the Technology Acquisition Funds, as well as managing and organizing the Symbiosis Program, which is a comprehensive support program for commercialization of universities' intellectual properties (BIOTEK, 2009).

One of the services provided by BiotechCorp is its online portal, called the Triple Helix, which acts as a centralized database of R&D output and facilities in Malaysia. This portal, which enables the virtual clustering of talent, research and industries, is aimed to provide a more efficient exchanges within the biotechnology sector, including those of BioNexus firms. More recently, BiotechCorp has expanded its role to assist in an infrastructure-based project, called the Bio-Xcell project. This project is an effort by the agency to link the development of the biotechnology industry to its supporting physical infrastructure, in which established anchor companies are invited to set up their operations. The objective is to attract other biotechnology firms to locate close to these anchor companies (Bio Xcell, 2010).

An earlier study found that the Malaysian biotechnology industry has already had all the necessary elements that directly support R&D efforts, human capital,

financial and legislative developments, as well as market positioning strategies in the international markets (Khairul Akmaliah, Hasmiah and Mohd Fuaad, 2011). For example, a lot of effort has been made to ensure that a steady number of biotechnology inventions are produced by local universities. By the end of January 2009, 12 public universities had conducted biotechnology research and their efforts spanned from agriculture-biotechnology research to DNA recombinant exploitation. Five universities, Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Malaya (UM), Universiti Sains Malaysia (USM), and Universiti Malaysia Sabah (UMS), had a department or institute dedicated to biotechnology research. In the same period, the amount of grants awarded by the Malaysian government to these universities for biotechnology research amounted to more than USD50 million. Additionally, 14 research institutes had also carried out biotechnology research, with 13 of them were government-owned institutes while one was a privately operated entity. These research institutes performed researches that were more applied in nature compared to university-based researches, which were more science-based. The Malaysian government had also provided several grant schemes for the commercialization of biotechnology products and services.

The biotechnology policy also has in place several comprehensive programs that transcend the usual innovation value chain process and involve many players. They include the a) MTDC Symbiosis program, which supports the entire spectrum of the innovation process as well as firm development; b) BiotechCorp BioNexus Program, which comprises a comprehensive development package for biotechnology firms; and c) MOSTI's grant programs which fund research and development (i.e., the Science Fund) and pre-commercialization phase of product development (i.e., the Techno Fund). These follow-through efforts are aimed to increase the success of support programs for the development of biotechnology industry. Within these comprehensive programs, there exist efficient networks among the agencies involved in a specific program (for example, UKM and MTDC in the Symbiosis program) and among the specific program (for example, the MOSTI grant and the BiotechCorp BioNexus program) (Khairul Akmaliah, Hasmiah, Mohd Fuaad and Igel, 2012).

THEORETICAL PERSPECTIVES ON INNOVATION AND FIRM CREATION STRATEGIES

There are three perspectives for business strategies that support firm growth and sustainability; 1) Industrial Organization (I/O) perspective, 2) Resource-Based View (RBV), and 3) Austrian School of Strategy or Schumpeterian-Strategy (SS) perspective (Barney, 1986). In general, the I/O perspective emphasizes supportive

industry structure, the RBV stresses on availability of internal resources, while the Schumpeterian perspective focuses on developing innovative products or business activities and gaining marketplace advantage for long-term business sustainability (Barney, 1986; Jacobson, 1992; Porter, 2008; Grunert & Hildebrandt, 2004). Specifically, the I/O perspective proposes that a firm's strategies for innovation and development are shaped by external factors in its environment. In this perspective, firms formulate their strategies based on their understanding of external situation (i.e. the characteristics of industry structure) (Porter, 2008). This allows firms to manipulate the structural elements of their industry to help them develop innovation and formulate strategies which will allow them to achieve profitability and sustainability in business. In this sense, strategies for innovation and firm growth are attempts to modify firms' own internal processes in response to the structures in the industry.

The RBV perspective, on the other hand, believes that the factors influencing firms' ability to make higher profit and perform better are the effective deployment of their own internal resources, unique skills, and distinctive competencies. Resources, skills and/or competencies are *technical know-how, patents, trademarks, firm's reputation, brand awareness, and/or managers' ability to cooperate*, which may vary across industries (Barney, 1991; 2001; Chamberlin, 1933). Generally these resources must be valuable, inimitable, rare, and organized in ways that can give firms competitive advantage over their rivals (Alvarez & Busenitz, 2001; Barney, 1991; 2001). Firms then need to design strategies that exploit these 'positive' differences that they have over their rivals. Thus, based on the RBV perspective, firms must design strategies for innovation and growth that will allow them to exploit their internal resources, skills, and/or capabilities that will give them a competitive edge.

The last perspective, the SS, suggests that industries are either revolutionized or incrementally affected by the introduction of new technologies or modifications of existing technologies and/or systems (Schumpeter, 1934; 1942). Thus, the SS perspective suggests that, firms must have the entrepreneurial and innovativeness abilities to support sustainable operations. The SS perspective believes that a market is never stable in terms of supply and demand, and that business opportunities will always exist when there is a difference between supply and demand. This gap causes unfulfilled needs amongst customers (Jacobson, 1992), which then can be acted upon by entrepreneurs by introducing new products/services to customers. However, although opportunities for business always exist, entrepreneurs must be able to recognize them and be able to gather information about them. Therefore, in the SS perspective, prior to developing strategies, firms must be able to identify new opportunities that exist in the market. At the same time, the strategies that

firms plan to adopt must help them to fill this market gap by offering new products/ services (innovation).

While some authors emphasize the significance of each of these perspectives, i.e. the I/O (e.g. Porter 2008), RBV (Chamberlin, 1933; Barney 1991; 2001), and Schumpeterian perspectives (Barney, 1986; Jacobson, 1992), some efforts have been made to complement these perspectives. For example, Alvarez and Busenitz (2001) augment the entrepreneurship theory, which originates from the Schumpeterian-strategy concept, through the resource-based perspective. Armstrong and Shimizu (2007), on the other hand, suggest incorporating industrial elements when examining the resources of firms to further refine the conceptualization of firms' resources. Barney (1986) views the I/O and RBV perspectives as complementary, with the I/O focusing on elements within firms' industry, while RBV emphasizes on the factors within them when firms decide which resources should be exploited when implementing their strategies. Barney (1986) further proposes an integrated view of the three perspectives which complement each other. In particular, he emphasizes the importance of complementing the three perspectives as firms need to consider the structural and the Schumpeterian elements against their internal characteristics when formulating and implementing their strategies.

CONCEPTUAL FRAMEWORK, STUDY CONSTRUCTS AND THEIR OPERATIONALIZATION

In the following paragraph, we propose the strategies most likely to be adopted by the BioNexus firms in support of their survival and growth, and discuss their measures in brief. In regard to the Biotechnology Innovation strategy, its implementation is measured in terms of 1) types of innovation, and 2) types of market served. In regard to firm creation strategy, the two variables used to measure its operation are 1) location of firms, and 2) form or design of organization

Biotechnology Innovation Strategy

The classification of innovation strategy into type of biotech innovation and type of market served is based on theories of innovation and the three perspectives on firm competition, which are the industrial organization (I/O), resource-based (RBV), and Schumpeterian (SS).

Type of Biotechnology Innovation

The types of innovation are related to the output that biotechnology firms offer to their potential customers. Innovation theories suggest classifying innovation

according to types of innovation based on sectors because of the distinctive features across sectors (Malerba, 2002). In this paper, we utilize the sectoral biotechnology innovation categorization based the one prepared by the Malaysian Biotechnology Corporation (BiotechCorp) (2009b), which include agriculture, healthcare or industrial. *Agriculture-biotechnology* is the use of biotechnology to turn agricultural produce into food and agricultural-based products. It also indicates the use of biotechnology in any of the value chain of herbal production, from seedling up to harvesting, packaging, and distribution points. Animal biotechnology, including those involving marine and fresh water organisms, is also classified under agriculture-biotechnology. *Healthcare-biotechnology* refers to the application of biotechnology to produce medicine and health-care products. This includes new diagnosis and diagnostic tools, therapies, and medicine. *Industrial-biotechnology* involves the utilization of biotechnology to manage the natural environment, including the development of new energy sources and other new products that help protect the environment from rapid degradation (BiotechCorp, 2009b).

When deciding on which type of innovation to produce or offer, the decisions made by BioNexus firms can be influenced by its external factors (availability of raw materials, regulatory requirements, market needs etc.), which means that the decision is affected by an externally-driven situation (the I/O perspective). Industrial organization perspective describes customers as a sector in its discussion on environmental elements. According to this perspective, the types of innovation demanded by customers have an influence on how a strategy is devised by management. Therefore based on this deduction, the variable ‘sector’ or ‘type of innovation’ is included into the study as it can influence the type of innovation strategy utilized by the BioNexus firms.

The firms’ decision can also be based on the availability of their internal resources (technical expertise, availability of equipment, financial strength etc.), while having the ability to operate within a selected innovation category points to the entrepreneurial capability of their managers. These capabilities indicate innovation as an internally-driven action (the RBV perspective). In parallel, having the ability to operate within a selected innovation category indicate the adoption of both the SS and RBV perspectives by managers and leaders of the BioNexus firms.

Data on types of innovation were gathered from the BiotechCorp internal reports. However, while the categorization is based on companies’ core innovation, it is possible that some companies are involved in more than one type of innovation (BiotechCorp, 2010a). Another categorization of biotechnology innovation is based on whether a firm’s innovation is a product or a service, or both.

Type of Market Served

Type of market is categorized into local and foreign, or both. Using this variable, we can determine if an innovation produced by a firm is meant for domestic customers or exclusively for foreign customers, or both, as this reflects the extent of the firm's value chain operation and its innovation strategy.

The type of market chosen by a firm can be influenced by external issues (customers' requests, rivals' actions, government's regulations etc.) and so it is an externally-driven decision (the I/O perspective); on the other hand, if the decision is influenced mainly by the firm's internal situation (shareholders' request, output capacity issue etc.), it is an internally-driven action (the RBV perspective). Having the ability to be positioned in a more competitive international market, which requires innovative strategizing and relevant resources, indicates the adoption of both the SS and RBV perspectives by managers and leaders of the BioNexus firms.

Firm Creation Strategy

Location of a Firm

Location of a firm refers to the proximity of a firm to its suppliers and other relevant companies/agencies (Hall and Bagchi-Sen, 2002; Porter, 1998). This study examines the location of BioNexus firms by classifying them into regions to enable the analysis of the agglomeration and clustering of the BioNexus firms.

Selecting a business location can be an externally driven issue; for example, a firm might choose its business location by imitating the decision made by its rival (the I/O perspective). It can also be an internally-focused matter when the decision is based on the firm's own operational needs and innovative decisions (the RBV and the SS perspectives), such as locating close to its suppliers in order to gain effective and efficient access to the resources of its suppliers.

Form or Design of Organization

In the I/O perspective, a firm's structure is influenced mainly by its external situation, while in the RBV and the SS perspective, a firm's structure is built around the efficient and effective use of its resources. By analyzing its form or design, we are able to determine the influential factors and the types of resources that a biotechnology firm can access efficiently and effectively.

In this study, form or design is measured using three variables: a) Listed or non-listed (which points to whether a firm is a public or privately owned, which

also indicates the financial resources of the firm, whether it is obtained from the public or others); b) Group or independent (which indicates if a firm is a part of a conglomerate or a single independent firm and if the resources of the firm are provided by its parent/system companies or mainly gathered from its external environment); and c) Existence of alliances or collaborations (which indicates the level of support a firm receives from universities, research institutes or other commercial entities).

RESEARCH METHODOLOGY

We employed the content analysis methodology, an empirical technique that can be used to analyze numerous volumes of textual data with the aim of gaining an in-depth understanding of a phenomenon (Krippendorff, 2004; Krippendorff and Bock, 2008; Duriau, Reger and Pfarrer, 2007; Stemler, 2001). This method is effective when the objective of a study involves improving the understanding of existing constructs or the discovery of new constructs. It is also appropriate when published information are available and when access to primary data is not convenient (Duriau, Reger and Pfarrer, 2007; Stemler, 2001), which was the case with our study. Most agencies and biotechnology companies do not give open access to primary data through formal organizational channel.

Based on Krippendorff (1980), Stemler outlines six questions that need to be addressed when using the methodology of content analysis. Five of the questions are: “1) *What data are analyzed?* 2) *How are they defined?* 3) *What is the population from which the data is obtained?* 4) *What are the contexts that are relevant to the data being analyzed?* and 5) *What are the boundaries of analysis?*” The last question will be described at the end in this section. Addressing these questions will help ensure a study to have high reliability and validity. (A similar content analysis research design has been adopted in many earlier studies including those related to biotechnology industry (for example, Khairul Akmaliah, Hasmiah & Mohd Fuaad, 2011) as well as telecommunications industry (for example, Mohd Fuaad & Khairul Akmaliah, 2010). For these earlier researches, the content analysis research design generates understanding of the research phenomena while also allow new constructs and relationships to emerge from the empirical data).

In fulfilling the first five requirements of Krippendorff-Stemler’s, the types of data we collected were pre-defined in the proposed conceptual framework. The data gathered for our study include those available in the public domain, as well as direct communications with the companies. The study was limited to 92 firms that had been granted the BioNexus status by BiotechCorp as of December 2008 (BiotechCorp, 2010a). The data was gathered in four stages, which began in December 2008 and

ended in June 2010. This effort involved compiling the list of companies from BiotechCorp, and gathering and analyzing data from published sources and direct communications with the BioNexus firms when necessary. Appendix 1 gives a detailed description of the four major steps in the data gathering process.

The data generated through the four steps were then analyzed and categorized. Verification procedure was not necessary during analysis since all data were “factual”, and not perceptual records (which could be the main reason for ambiguity in data classification or improper data coding). By selecting factual data, the research avoids the challenges associated with data instability due to interpretation issues, while also making it possible to reproduce the findings of the study (Stemler, 2001).

With the types of data to be collected being pre-defined (as discussed in the conceptual framework section), the content analysis methodology allowed us to establish important elements of innovation and firm creation strategies and generate emergent variables. Finally, we tackled the last issue in the use of the content analysis methodology, i.e., “*what is the target of inference?*” (Stemler, 2001). This was done through corroborating the emergent elements and constructs, as well as their relationships with broader theories of firm growth, which enabled verification of the emergent conceptualization and strengthened the internal validity of the study.

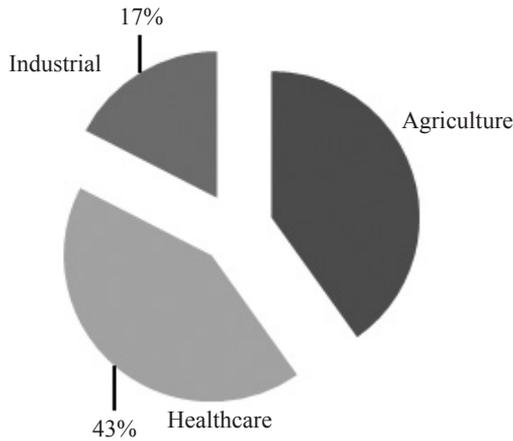
FINDINGS

This section presents the findings, based on the objectives of the study: biotechnology innovation strategy and firm creation strategy.

Biotechnology Innovation Strategy

Types of Innovation

Types of innovation according to sector: Figure 1 shows that, of the 92 BioNexus companies, 43% of the innovations is in the healthcare sector while the agriculture sector makes 40 per cent of the biotechnology innovations. Seventeen per cent of the innovations is made in the industrial technology sector.



Source: BiotechCorp 2010a

Figure 1 Core innovation categories of BioNexus firms

Type of innovation according to product or service: Table 1 shows the companies’ core innovation and types of company output. The output of the 92 BioNexus firms can be categorized into: a) Exclusively products (59 firms or 64%), b) Exclusively services (23 firms or 25%), and c) A combination of both products and services (10 firms or 11%). Products are defined as tangible outputs while services range from contract research to contract manufacturing services. An example of a company that provides a combination of product and service is Bioalpha International which produces health formulation and extracts as well as provides contract manufacturing and product registration services to other companies.

Table 1 Core innovation and categories of output

Core innovation	Type of company output			Total
	Products	Services	Products and services	
Agriculture	29	3	5	37 (40%)
Healthcare	19	16	4	39 (43%)
Industrial	11	4	1	16 (17%)
Total	59 (64%)	23 (25%)	10 (11%)	92 (100%)

Table 2 provides information on the production value chain of the 59 companies involved exclusively in the manufacture of products. All 59 companies are involved in research and development. This is perhaps due to the effort to meet

the requirements for the BioNexus status which, among others, require a strong R&D capability. The agriculture sector has the most number of firms involved in producing exclusively products, while R&D, manufacturing, and distribution are the most common production value chain activities performed by these 59 BioNexus companies.

Table 2 Production value chain (for firms involved exclusively in manufacturing products) and their core innovations

Value chain	Core innovation			Total
	Agriculture	Healthcare	Industrial	
Exclusively R&D	2	1	0	3
R&D, production and trading*	3	3	2	8
R&D, production and distribution*	12	7	6	25
R&D and production	10	6	3	19
R&D, production and investment holding	1	1	0	2
R&D, production, trading and investment holding*	1	0	0	1
R&D, prototyping, production and trading*	0	1	0	1
Total	29	19	11	59

Notes: *Trading refers to the firm’s involvement in overseas’ market while distribution indicates exclusively local sale and marketing.

For firms that are involved exclusively in providing service (23 firms), the types of services they provided appear to be very diverse and range from one or two specialized services to a full-range of services. An example of a specialized service company is Green World Genetics Sdn Bhd which offers contract research and farming services for seed breeding. An example of a firm providing a full-range service is StemLife Berhad, which offers a comprehensive service of stem cell banking, consultancy, and services. Each service company has its own unique innovation, although the categories of services that they offer can be similar. For example, although many companies are involved in contract research, the types of services they provided are diverse. A case in point is the contract research provided by CellSafe International Sdn Bhd for stem cells of umbilical cord and peripheral blood. These services are completely different from the ones provided by another stem cell company, Stempeutics Research Malaysia Sdn Bhd, which focus on bone marrow derived mesenchymal stem cells.

The value chain of the ten firms involved in both products and services is also diverse, with each having its own unique innovation activities. For example, for Bioalpha International's products, the processes include formulation and extraction, while activities for its services consist of contract manufacturing and product registration. In contrast, InQPharm's value chain includes developing its own brand of healthcare products and providing clinical contract research and manufacturing services.

Type of Market Served

In regard to the types of market in which their products are sold, of the 92 firms, 30% operate exclusively in the local market and 70% of the firms have presence in foreign markets. The number of international ventures is likely to be higher if the measures also include the activities performed by the BioNexus firms to support their parent or sister companies' internationalization efforts.

Strategy for Firm Creation

Location of Firms

Table 3 shows that 70% of the firms (64 firms) are located in the Klang Valley. This region is an area of 30 by 50 square kilometers with Malaysia's capital of Kuala Lumpur in its center. The location of the remaining 30% BioNexus companies is equally spread in the North, South, West, and East Malaysian regions. When these regional locations were analyzed against the firms' core innovation (Column A vs. Column B), the healthcare and industrial sectors are found to be located mainly in Klang Valley area, while the agriculture sector is more spread out throughout the country.

Form/Design of Organization

Listed or non-listed: Table 4 shows the classifications of the 92 BioNexus companies according to the type of company (public-listed or privately-owned) and their core innovation categories. As shown in the table, private limited companies dominate the biotechnology market, i.e. 98% of the analyzed firms, while the remaining 2% are public-listed companies. Table 4 shows that there are two exchanges in Malaysia: the Main Market and the ACE Market. Two public BioNexus companies are listed in the ACE Market; StemLife Berhad is listed under the Trading/Services sector and Malaysian Genomics Resource Centre Berhad is listed under the Technology sector.

Table 3 Core innovation and firm location

Core innovation	Column B			Total		
	Region					
	Klang Valley	North	South		West	East Malaysia
Agriculture	22	2	4	5	4	37
Healthcare	30	3	1	3	2	39
Industrial	12	1	1	1	1	16
Total	64 (70%)	6 (7%)	6 (7%)	9 (9.5%)	7 (7.5%)	92

Table 4 Type of BioNexus company and core innovation categories

Type of company	Sector categories in Bursa Malaysia	Core innovation categories			Total	
		Healthcare	Agriculture	Industrial		
		Public companies	Main Market ACE Market	- Trading/Services Technology		0 1 1
Private Companies		-	37	37	90 (98%)	
Total			39 (43%)	37 (40%)	16 (17%)	92 (100%)

Part of a Group of Firms/Private Independent Companies: Of the 92 companies, 44 (47%) are private independent companies while 48 companies (53%) are members of a group of firms. Each of the 48 companies is either a subsidiary company (48%), a parent company (6%), a sister company (6%) or both a subsidiary/sister firm (40%).

Table 5 Core innovation and group of firms/independent firm

Group/Independent categories	Core innovation	Total
Part of a group of firms	Agriculture	21
	Healthcare	20
	Industrial	7
Total		48 (53%)
Private independent firms	Agriculture	16
	Healthcare	19
	Industrial	9
Total		44 (47%)

Table 5 shows the total number of companies that belong to group of firms and are purely independent companies based on their core innovation. As shown in Table 5, there is very little difference between the group or independent categories and the types of core innovation. The 48 companies that are classified as group of firms are related to 82 companies. Therefore, the mean for the number of family members for the group of firms is 2.7 firms (48 BioNexus firms plus their 82 related companies divided by 48).

Of the 48 BioNexus companies that are owned by a group of firms, 25 are either public-listed firms themselves (two firms) or have relations with other public-listed companies (23 firms, including three with international public-listed companies), while the remaining 23 firms belong to private-held group of firms.

Within the public-listed companies' group, the two public-listed BioNexus companies are StemLife Berhad, which is a parent company to its member firms, and Malaysian Genomics Resource Centre Berhad, which is a subsidiary to one of its two family members. Of the 23 BioNexus companies that are related to public-listed companies, 21 have public-listed companies as their parents, while the remaining two are associated to public-listed companies through public-listed ownership of their parents. Seventeen of the 23 companies' core innovations are connected to their public-listed family members' core businesses, with all 17 either directly serving their parent companies (15 firms) or the parent companies of their parents' (2 firms) core businesses. For example, the core activity of ACGT Sdn Bhd

is to support the business operation of its parent company, Genting Plantation Sdn Bhd, in plantation activities. Two other companies, Carotech Bio-Vites Sdn Bhd and Hovid Research Sdn Bhd, conduct R&D to help with the commercialization of their group's oil palm-based products. Therefore, these BioNexus companies form an important part of their groups' value chain. For the remaining six companies, their activities are not directly aligned with their public-listed parent companies' businesses; two of these firms are diversification cases, while four are "investments of unrelated business" to their parent firms' operations. The diversification cases are a) GranuLab, the parent company of which is Sindora Berhad, a conglomerate that is involved in the shipping business, and b) KL Biotech Manufacturing, a subsidiary of Malaysia Steel Berhad, the core business of which is steel production. For the investment companies, their parents are investment holding companies, and their core businesses are not aligned with or directly related to the biotechnology industry.

In the second group, which comprises of 23 BioNexus companies that belong to a group of firms related to private limited firms, their relationship with their families of firms can be classified as follows: a) a BioNexus company that acts as a partner in the value chain of a group of firms, in which it directly supports the group of firms' product or services value chain. For example, in the case of Furley Bioextracts Sdn Bhd, its sister company, Furley Marketing, provides the distribution service to the company. In another case, Holista Biotech Sdn Bhd acts as the parent company to two other firms, i.e. Alterni, the group's product direct marketing subsidiary, and Tropical Botanics, the group's R&D unit; b) a BioNexus company that operates as a separate company with its own distinguished products and customers. For example, Generti Biosystems handles the commercialization of InfoValley's digital autopsy system while its sister company, i-Gene, manages the development of its medical kits family of products. Therefore, for companies that are belonged to a group of firms, their relationships with other group members can be in the form of directly supporting or complementing their parent/family core businesses, or serving as a diversifying unit or an investment arm of their parent firm.

When we examined the date the BioNexus companies were established, the results showed that there is little difference in the mean time of their incorporation between the groups that are belonged to or affiliated with public-listed companies and those which are private independent companies. The mean establishment year for 25 BioNexus firms which are related to public-listed company is 5.24 years, while the mean establishment year for 23 BioNexus firms which are related to private firms is 5.43 years. However, the mean year of establishment for 44 BioNexus private independent firms is 3.52 years. The mean age for companies that are belonged to group of firms is higher, which implies that the development of the group of firms happens over time. When we examined the mean age of the

oldest member of the family in the public-listed and privately-held group of firms, the result shows that the mean age of former is 29.16 years, while the latter is 10.58. This indicates that perhaps time is a factor in influencing the types of firm established, either public-listed or private.

Alliances or Collaborations: All 48 BioNexus companies that are part of a group of firms have collaborative relationships with research institutes and private companies. For example, Holista Biotech Sdn Bhd and InfoValley conduct joint research with local and international organizations, research institutes, and universities. Holista Biotech has links with many research-based organizations as well as related biotechnology services which provide research, manufacturing, and marketing support to the company. While most of the firm's manufacturing partners are locals, many of its research partners are foreign institutions or companies (Adriana, Khairul Akmaliah, & Mohd Fuaad, 2010). InfoValley group of companies has also established networks with R&D institutes in Europe (Khairul Akmaliah & Mohd Fuaad, 2008).

In addition, all 44 privately-owned independent BioNexus firms have collaborative relationships with local and international research institutes and other private companies, mainly in research. For example, Orchid Life's product was the result of a research initiated by UPM using the university's facilities and grant in collaboration with Genetwister Technology of Netherland.

DISCUSSION

In general the Malaysian biotechnology industry has a supportive institutional context for its development. Among the incentives provided to this industry are incentive for research and development, human capital development, financial infrastructure, and regulatory development. Since the implementation of the biotechnology policy in 2005, the number of BioNexus companies has been increasing. Between 2006 and 2007, there were 42 companies; this number increased to 92 by December 2008, 126 in September 2009, and 173 in October 2010 (BiotechCorp, 12 October 2010; BiotechCorp, 2010b). All companies which have been awarded with the BiotechCorp BioNexus status are companies involved in leading-edge biotechnology. These companies encompass new independent firms as well as subsidiaries of large firms.

Based on the types of innovation developed by these BioNexus firms, a high percentage is in agriculture-biotechnology sector. This high number is to be expected since Malaysia is rich in agricultural diversity and the country's core economic focus in agriculture prior to the industrialization policy introduced in mid-1970s.

Given these situations, there are many agriculture-based companies in Malaysia. Therefore, the availability of supplies (i.e. external factors) is the main reason for a large number of agriculture-based biotechnology companies being established in Malaysia. Nevertheless, given the high-technology nature of the biotechnology innovation, internal capabilities are still needed to take advantage of the available resources. Given the novelty of the industries in Malaysia, we can assume that the involvement of the companies in the industrial and healthcare industries is not mainly influenced by these external factors.

Although these companies are grouped into specific sectors of agriculture, healthcare, and industry, the products and services offered are diverse and the activities performed in these sectors are product manufacturing or service, or both. In addition, while companies in the product category are involved in research and development, production or distribution or a combination of them, the activities of companies within the services appear to be very diverse. This indicates that each industry member has its own innovation, and many of them have a unique value chain. This is not surprising as having an innovative product or process is one important pre-condition in obtaining the BioNexus status. Therefore these companies are often not in direct competition with one another. Moreover, as incentives are only given to companies with unique innovations, they are encouraged to generate more innovations within the industry.

In regard to the type of market served by these firms, most of the companies serve foreign markets. This indicates high internationalization initiatives and their readiness to enter foreign market. It seems that internationalization is pursued to meet the global demand for biotechnology products and services, to develop their markets, and perhaps also to overcome the challenges relating to underdeveloped domestic biotechnology markets. This indicates that the decision on the type of market among the BioNexus companies is driven by both internal and external considerations.

Most healthcare and industrial firms are clustered in the Klang Valley area. This shows that the Klang Valley offers benefits, particularly for the healthcare business. The benefits are in forms of close proximity to highly-skilled workers, suppliers, and customers. Thus, it seems that the decision to location is more influenced by external factors (i.e. customers' needs and suppliers' availability). For agricultural-based biotechnology companies, most productions are conducted at or near the locations of agriculture estates, farms, or cultivation areas. This means that close proximity to ingredient-supplying sites is also an enabler for firms to develop their agriculture biotechnology business. Therefore, for this group of firms, their locational decision is mainly internally-driven (i.e. production requirements).

In regard to public-listed versus privately-owned companies, two are listed on the ACE Market and another ninety are privately-held firms. The two public-listed companies belong to a sector category known as Trading/Services and Technology, respectively. Neither the main board nor ACE has a specific sector for biotechnology. The low number of public-listed biotechnology firms and the absence of the biotechnology sector in these exchanges highlight the embryonic state of the Malaysian biotechnology industry.

Half of the BioNexus companies are part of a group of firms, while the other half is independent private companies. Among companies that are members of groups of firms, 48% are either subsidiaries or associated companies of large public-listed companies while the remaining 52% have relations with private-limited companies. All these suggest the importance of “groupings” among these companies. For members of a group of firms, their relationships with other firms in the group can be in the form of direct supporters to or complementary partners in the parent/sister company’s businesses. Both indicate high reciprocal relationships between them. Companies that belong to groups of firms can also be diversified business units of their parent companies. Therefore, a highly reciprocal relationship exists between a biotechnology firm’s core innovation and the business of its parent company; the biotechnology firm serves as an important resource to its group, and in turn the parent or sister companies serve as readied customers, important source of fund and know-how, or important partners in the value chain or a combination of these. In this regard, companies that belong to a group are either direct supporters to or are complementary partners in their family of firms. These findings indicate that the formation and groupings of the company is a resourced-based decision.

In regard to the age of the firms, on average, only companies that are more than five years old and/or listed companies operate a family of subsidiaries. This incremental development of the group of firms indicates that time is a crucial factor in the development of biotechnology businesses. Therefore, for these BioNexus firms, time or age of firm determines the form/design for the firm’s creation; in other words, time or age and organization form/design are interlinked. This indicates that the time and age of firm is related to availability of resources of the firm.

Moreover, the setting up of biotechnology subsidiaries or sister-units by the public-listed and grouped-private companies appears to be a strategy which supports the rapid development of their group biotechnology products or services portfolio. Alternatively, for some large companies, which are in unrelated industries, such as steel and shipping, setting up or diversifying in biotechnology businesses in recent years indicate that they are following the worldwide trend of investing into biotechnology business.

The fact that all BioNexus companies have external collaborations implies that collaboration with others is a critical strategy for innovation and firm development. Many of them have established research collaborations with public-funded universities. Perhaps this strategy is adopted to facilitate their research, as all BioNexus firms that are involved in biotechnology products are R&D-intensive companies. Collaborations provide important resources and so for these firms, the ability to establish collaboration is crucial. For groups of firms, collaborative relationship seems to supplement the advantage of “groupings”. On the other hand, for independent private firms, collaborations help overcome the limitation of “newness” (which includes lack of resources and established networks) while buying time for internalization (the time taken to develop into a group of firms).

For a new company, initially, lack of technical expertise persuades them to collaborate more. However, once the company aged and survived the business, they have more “internalized” resources, and be able to vertically integrate, through establishing subsidiaries and buying related companies.

In summary, entering international markets, locating close to resources, operating under a group of firms and having external collaborations/alliances are some of the strategies implemented by the biotechnology firms to support their growth.

CONCLUSIONS

The Malaysian biotechnology industry has received extensive government support in innovation and firm development. The government’s policy that requires firms to have an innovative product or process as one of the preconditions before being granted the BioNexus status not only promotes unique innovation amongst industry members but also in a way limits direct competition among them. In this regard, an environment that is suitable for cutting-edge innovation and promotes the development of unique innovations among the biotechnology businesses also helps reduce direct competition within the industry. This shows that industry contextual variables act as enablers of innovation and firm creation in the emerging biotechnology industry. Moreover, the findings also indicate these firms’ ability to exploit institutional opportunities and thus, on the whole, their innovativeness reflects the I/O (understanding their industry structure) and the SS perspective (ability to exploit their environment) of the entrepreneur-managers of these companies.

Further analysis of the data shows the importance of resources of the firm in influencing strategies in innovation and firm creation amongst this group

of firms. Organizing family of firms, collaborations, selection of location, and internationalization are some of the companies' responses in designing strategies for the growth and development of their firms. These strategies, in turn, are influenced by the age and size of companies. These findings, which reflect the influence of the availability of internal resources of the firm, in the entrepreneur-managers' responses, can be explained by the RBV theories and the Schumpeterian view. Taken together, these managerial responses can be explained by the three generic perspectives of strategy and competition, which are I/O, RBV, and Schumpeterian; resources being the key aspect of firm innovation and development indicate more emphasis on the RBV (availability of resources) and Schumpeterian (ability to be resourceful in recognizing and exploiting business opportunities).

The capability to exploit new opportunities being a precondition for developing and benefiting from a supportive environment indicate the need for the biotechnology firms to have market structural knowledge and capabilities to leverage on their situation. This points to the function of managerial capability and experiences not only in identifying what competitors are doing, but also in continuously gathering overall institutional intelligence in the effort to seek new opportunities provided by government-supported programs, as well as those in the greater environmental contexts.

Theoretically, the managerial actions or responses of firms are driven mainly by their management experiences, which comprise entrepreneurial cognition and affective factors as well as other related capabilities, including accumulated managerial knowledge as well as important technological and organizational resources (Baron, 2004; 2008; Ward, 2004). Management experience, a theorization of managerial capabilities developed by Edith Penrose, is a central concept in explaining managerial ability to design strategy for their firms' growth (Penrose, 1959; Kor & Mahoney, 2004). The conceptualization of managerial response and experience in this study, which built upon Penrose's management experiences, affirms the Schumpeterian view and its proponents' perspectives, which emphasize on entrepreneurial capability as a prerequisite for innovation and firm development (Hagedoorn, 1996). It can be expected that the need for managerial experience is higher in emerging economies given the underdeveloped nature of both the institutions and the supplier and customer groups.

Based on these findings, entrepreneurs-managers gain insights on the important constructs that can improve their responses to institutional factors and challenges, while policy makers can use the knowledge to institute necessary policy intervention that are in line with industry development objectives.

APPENDIX 1

The data collection analysis process in this study involved the following four major steps:

Step	Activities
Step 1	<p>Gather the list of Malaysian Companies with the BioNexus status from BiotechCorp Internal Report</p> <p>As of December 2008, BiotechCorp listed the number of the BioNexus companies according to their core innovation, i.e. agriculture, healthcare or industrial (BiotechCorp, 2010a).</p>
Step 2	<p>Analyze Companies' Information Based on Predetermined Study Constructs</p> <p>The profile of BioNexus companies gathered in Step 1 was analyzed based on the constructs that were predefined in this study. We scrutinized the content of the following sources:</p> <ol style="list-style-type: none"> a) Company website; b) Profiles of the companies' obtained from the BiotechCorp database (BiotechCorp, 2010a) and BiotechCorp official website (www.biotechcorp.com.my); c) Description of the nature of business of each company obtained from Companies Commission of Malaysia, which is the registrar of companies; d) Companies' information from other sources on the Internet, including their parent and/or sister companies' website, to establish the companies' <i>activities</i> and <i>products/services</i> and to determine the <i>types and value chain of biotechnology product/service innovation, and types of markets and customers</i>. This is also to verify whether the companies have a parent and sister companies with businesses related to biotechnology; e) Profiles of the companies obtained from the BioMalaysia website. This website provided a list and profile of exhibitors in BioMalaysia 2008, which includes biotechnology companies with BioNexus status. f) Profile of BioNexus companies obtained from BiotechCorp internal database. g) Companies' information obtained from the Bursa Malaysia's website (http://www.bursamalaysia.com) and company annual report for public-listed companies. This website provided information on companies listed on its two boards: the Main Board and the ACE Market. (As of mid-2009, there are only two markets in Bursa Malaysia, with the Main and the Second Boards merged as the Main Market while the MESDAQ Market, which is an exchange platform for technology-based and high growth companies, evolved into the ACE Market, which is an alternative market for emerging companies. Information on international stock exchanges was also viewed where applicable). h) MATRADE and MIDA websites, which provided the list of firms that were involved in international markets. Both these agencies are supporting agencies for Malaysian firms' internationalization efforts.

Step 3 Gather Information from Other Sources in the Public Domain (if necessary)

In this step, any relevant data that could not be obtained in Step 2 was supplemented with other sources of information available in the public domain.

Step 4 Gather Information through Telephone Interview (if necessary)

If the required information could not be obtained via Step 3, the information was gathered through telephone inquiries from the respective BioNexus firms.

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