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Academic entrepreneurship in South East Asia: an exploratory study of spin-offs in biotechnology from Hong Kong universities

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University research with associated spin-offs is at the heart of knowledge generation in the biotechnology industry. However, only a few studies have so far dealt with biotechnology university spin-offs in Hong Kong (HK), a latecomer in this industry. The purpose of this research is to gather information about the history and innovative status of biotechnology university spin-off companies in HK in order to understand the dynamics of this phenomenon better. This study arrived at several important conclusions about biotechnology spin-off firms in Hong Kong; specifically that the firms are relatively small in size and young, were mostly formed by university staff, and created with joint effort. In addition, these firms developed commercial products and services, are aware of intellectual property protection, are motivated to create spin-offs in order to apply knowledge to practical applications and utilize market opportunities. However, the firms also face challenges, such as difficulties in accurately estimating the market demand for their products, and technical problems in the development and production of their products. Furthermore, difficulties with financing are also an important inhibitor to success.

Keywords: academic entrepreneurship, spin-offs, university spin-offs, biotechnology industry, Hong Kong

1. Introduction

The role of universities has changed around the world during the past two decades. The existence of major research universities in regions seems to favour the advancement of knowledge-driven economies (Bramwell and Wolfe 2005; Clayman and Holbrook 2007). Universities are increasingly seen as an important driver of economic growth. In particular, universities now have a stronger mandate for promoting technology transfer to enhance a region's economic development (Leung and Mathews 2006). Universities contribute to the local economy through different channels, such as creating the pre-conditions for regional learning systems, generating technology based spin-offs, collaborating in R&D with companies, and training scientists, engineers, researchers and other graduates. Adding to these channels, universities contribute through establishing science and technology parks and incubator centres, commercializing research activities and contracting research with companies (Longhi and Keeble 2000).

The channel on which this paper focuses is the creation of a spin-off company that embodies a technology developed at a parent university. This is by no means a new phenomenon in developed countries, especially in the biotechnology industry (Zhang 2009). There is an increasing trend towards spin-off companies in Asia as well, although, only a small number of studies have so

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far dealt with biotechnology spin-offs from universities in Hong Kong, a latecomer in biotechnology. The purpose of this research is to gather information about the history and innovative status of biotechnology spin-off companies from Hong Kong universities in order to understand the dynamics and influence of this phenomenon as knowledge transfer process in biotechnology. By using a case study method, the paper analyses the local activity as an important step towards understanding the emerging biotechnology industry in latecomers. Although this study was conducted (out of necessity) on a relatively small scale, it is believed that the insights gained from this exploration into the field could prove useful for future research. Many of the issues involved have been analysed in the literature. These include university–industry technology transfer and technology transfer offices (TTO) (Poon and Chan 2007; Sharif and Baark 2008); research on the spin-off process by higher education institutions conducted by Leung and Mathews (2006); biotechnology industry in Hong Kong discussed by Poon and Liyanage (2004) and Baark (2005); and biotechnology development in Hong Kong compared to Singapore by Tsui-Auch (2000). The merit of this paper, however, lies in the fact that it combines all of these concepts, with a specific focus on university spin-offs in biotechnology.

The rest of the paper consists of three parts: in Section 2, the concept of spin-offs is defined, located in the context of academic entrepreneurship. Section 3 discusses the findings of our exploratory study on biotechnology spin-off companies in Hong Kong. The paper concludes with some lessons learnt and pointers for further research on the growing worldwide spin-off phenomenon.

2. The importance of spin-offs

Many universities have become increasingly interested in the creation of a spin-off company as an important tool for the commercialization of research results (Rasmussen and Borch 2010; Lee 2010), but it transpires that there is no universally accepted definition of a spin-off. Smilor, Gibson and Dietrich (1990, p. 64) define a spin-off company in two ways: (1) the founder was a faculty member, staff member, or student who left the university to start a company or who started the company while still affiliated with the university; and/or (2) a technology or technology-based idea developed within the university which was used to start the company. The effectiveness of this technology transfer method is typically visible in knowledge-intensive sectors such as biotechnology (Chiesa and Piccaluga 2000; Nezu 2005).

Policymakers in developed countries are encouraging universities to increase the rate of spin-off formation. The set-up of knowledge-based organizations with original ways of interacting and stimulating academic entrepreneurship is a main contributor to regional economic development (Smith and Bernardy 2000). Policies to promote university spin-offs have a long history and the results in terms of numbers of new companies created are indicative of success. In the USA, for example, in 2010 alone, 651 university-based start-up companies were launched; while a total of 3657 start-up companies were still operating in 2010 (AUTM 2010a). Other countries have followed American practice. In Canada, the total number of operational start-ups increased in number from 591 in 2009 to 632 in 2010 (AUTM 2010b). In the UK, 273 new spin-off companies were set up in 2009/2010 to exploit intellectual property originating in UK higher education institutions (HEIs). Meanwhile, the total number of university spin-off companies that had been active for three years or more grew steadily, from 746 in 2005/2006 to 969 in 2009/2010 (www.educationinvestor.co.uk).

There is an increasing trend towards spin-off companies in Asia as well (Ngan 2006). For example, Japan in 1995 created 15 university spin-offs, and in 2004 the number leapt to 195 (Kondo and Hasegawa 2007). China is also visibly successful in creating high-tech start-ups from universities and research institutes. These start-ups are especially noticeable in Beijing (Kondo

2003). The World Bank's 2001 report, *China and the Knowledge Economy* cited by Nezu (2005) confirms that Beijing University and Tsinghua University created more than 60 spin-offs each in high tech areas. Hong Kong has been involved in the creation of spin-offs for around two decades, starting in the early 1990s. However, there is a limited amount of literature dealing directly with the topic of biotechnology spin-offs from universities in Hong Kong.

3. Case studies on biotechnology university spin-offs

3.1. Research methodology

A variety of secondary sources of information enabled an understanding of the general concept of biotechnology and spin-offs. An exploratory study by means of a questionnaire survey was conducted in order to understand the performance and innovative status of biotechnology spin-offs in Hong Kong. The survey was managed in two steps. During the first stage, research was carried out to identify how many universities have a TTO, and a five-page email questionnaire was sent to the TTOs at five universities in Hong Kong, namely University of Hong Kong (UHK), Chinese University of Hong Kong (CUHK), Hong Kong University of Science and Technology (HKUST), Hong Kong Polytechnic University (PolyU) and City University (CityU). All the universities responded to the questionnaire. TTOs were requested to specify the spin-offs at the university and indicate how many of them are in the biotechnology sector. This process yielded a total of 19 biotechnology companies which seemed to fit the definition of a spin-off.

In the second stage, a nine-page questionnaire was developed specifically for the biotechnology spin-off companies. The questionnaire was emailed to those companies identified through the TTO survey; thereafter companies were telephoned and visited to administer the survey. The questionnaire covered, amongst other things, the nature and activities of the company, motivations behind the creation of the company, and the identification of the major problems faced by the company during its life. During the second stage, field research revealed that two biotechnology companies are not active anymore and three companies are not biotechnology spin-offs. It was evident that one company was not in biotechnology after the completed questionnaires were received, and two others turned out not to be biotechnology companies after the follow-up telephone calls. Two companies had the same director and commercialized and accounted for their products under one company. A further company was identified as not being a biotechnology company after more investigation. In all, our research identified 12 spin-offs related to biotechnology created by Hong Kong universities. Of these, 10 spin-offs were classified in the 'biotechnology' field and two in the 'Chinese medicine' field (Table 1). In the next section, the cases of five (41%) biotechnology spin-offs from the universities in

Table 1: Spin-offs from Hong Kong universities

Name of Institutions	No. of spin-off companies and joint ventures	Biotechnology spin-off companies and joint ventures
CityU	23	1
PolyU	18	1
HKUST	29	4
UHK	6	3
CUHK	15	3
Total	91	12

Note:¹Biotechnology including Chinese medicine.

Source: Survey carried out by the authors in 2009.

Hong Kong are explored.¹ Due to the limited number of companies, no inferences to the other population of spin-offs can be drawn from the primary data and its analysis (Perez and Sanchez 2003). Companies presented in this paper are coded as Company A, Company B, Company C, Company D and Company E.

3.2. Results

The study has highlighted the profiles of the companies; including the opportunities, obstacles and problems they faced. The survey addressed a number of key questions: what are the companies' classifications by type of activity? What are the companies' turnover and R&D budgets? Who is/are the founder(s) and where do they come from? What motivated them to create a spin-off? Do the companies collaborate with other organizations/institutions/companies? Where did university biotechnology spin-offs receive assistance from at the time of start-up? The answers are provided in detail below.

3.2.1. Definitions of a spin-off in Hong Kong

We asked participants to define their companies and used this information to analyse the companies' profiles. In this study we settled for Smilor and colleagues' (1990) simple definition² (discussed in Section 2). Our research found that in the Hong Kong context some companies clearly fitted this simple definition but some other companies were more complex and required an expanded definition: (1) the core technology and the founder(s) came from the parent university, and the founder(s) continue to work for the parent university; (2) the core technology of the company was created in the parent university, while the founder(s) were employed by, or was/were, research student(s) at the parent university; (3) the core technology of the company originated in the parent university, but the founder(s) was/were not from the parent university; and (4) the company was created by the parent university.

3.2.2. The age and size

The survey reveals that biotechnology university spin-off activities in Hong Kong have started mostly after 2000. Four companies (Company B, C, D and E) were created after 2000 with Company B, C and D being set up between 2000 and 2005. Company E was set up between 2006 and 2009. Only one company (Company A) was set up before 1990, and was also the oldest biotechnology spin-off company that this survey discovered in Hong Kong.

Firm size is measured in terms of turnover, employment and R&D spending. The survey showed that company size is relatively small (see Table 2). Turnover of three companies was under HK\$3 million; only Company A had a turnover of more than HK\$11 million. Companies created after 2000 are still in the development stage, with turnover still relatively low.

Table 2: Firm size: turnover, employment, and R&D expenditure

	Turnover (HK\$ millions)	Employees	R&D budget (HK\$ thousands)
Company A	11–50	31–50	301–500
Company B	< 3	1–5	< 150
Company C	4–10	1–5	–
Company D	< 3	1–5	1000–5000
Company E	< 3	1–5	< 150

Source: Survey carried out by the authors in 2009.

R&D expenditures are incurred in expectation of future growth in revenues. Companies in the biotechnology sector must spend capital resources on R&D in order to generate more revenues later on (Byrd 2002). In the Hong Kong case studies, the R&D budget of the companies gives insight into the working of the companies as well. It reveals that only Company D (i.e. a product-development company) had a R&D budget of more than HK\$1 million in 2008. Two of the firms had R&D budgets of under HK\$150,000. The R&D budget of Company C was not provided. The companies' size is also reflected in the number of employees. Biotechnology related companies from universities are small in Hong Kong. Only one company has more than 31 employees. Four of them have less than six employees. Despite that, our results show that all companies developed commercial products and services (Table 3). Two companies developed Chinese medicines, one focused on health care while another two developed biotechnology related products.

When the companies' activities are taken into account (Table 4), two companies (B and D) are of the product-development type. Only one company sells research results (Company E) and one company (C) is in services. One company (A) has multiple activities, i.e. combines manufacturing, service, consultancy and product-development.

Collaboration has turned out to be of the utmost importance in the organization of R&D in all knowledge-intensive industries (Valentin and Jensen 2006), especially in biotechnology. As a result of collaboration, companies could access a pool of skills, laboratory equipment and other opportunities. These companies do not normally possess all of the necessary elements to capitalize on new developments at the pace biotechnology demands. For example, a company

Table 3: Commercial products and services developed by the company

	Commercial products and services developed by the company
Company A	1. Five Chinese medicines 2. DNA vaccine/in collaboration with others
Company B	1. Gel electrophoresis unit 2. DNA fingerprinting reagent kit
Company C	1. TCM-based products and health foods
Company D	1. CardioDetect H-FABP rapid test 2. CardioCare hs-CRP & infectCheck CRP ELISA kits 3. INfectCheck NeoPT rapid test
Company E	1. Skincare lines: MELI, GENE & SABIO 2. Healthcare lines: GENECARE

Source: Survey carried out by the authors in 2009.

Table 4: Companies classification by type of activity

Type of activity	Manufacturing type	Services type	Consultancy type	Research type	Product development
Company A	O	O	O	—	O
Company B	—	—	—	—	O
Company C	—	O	—	—	—
Company D	—	—	—	—	O
Company E	—	—	—	O	—

Source: Survey carried out by the authors in 2009.

may have sufficient funding but lack the ideas and expert knowledge another company has (Byrd 2002). In the case of Hong Kong, it is evident that collaboration between spin-offs and institutions is not strong in all spin-off companies. Only Company A and D collaborated with the government and other spin-off companies, Company A, C and D collaborated with the research groups at universities and institutes. Company D is the only one that collaborated extensively with research groups at universities and institutes located in Hong Kong, China and other parts of the world (Europe). Company B and E had no collaboration at all (Table 5).

One of the most important science and technology indicators for biotechnology companies is the number of patents it creates in different categories. Patents are accepted to be evidence of a country's technological and inventive achievements (Pouris 2005). Once patented, it is expected that the company will be able to develop the intellectual property (IP) into a commercially viable product or use it to improve an existing one. Patents are also considered to be tangible assets, something the company may point to as proof that they are able to capitalize on their R&D (Byrd 2002). On this note, Byrd (2002) analysed the profile of spin-off firms³ in the biotechnology sector included in the 1999 Biotechnology Use and Development Strategy Survey. Of the 358 core biotechnology firms found in the manufacturing sector, 123 were core biotechnology spin-off firms (34%). The author also found that Canadian core biotechnology spin-offs hold a total of 1029 existing patents. Rutherford and Fulop (2006) identified five companies (as case studies) that transferred IP under licensing agreements, giving the companies worldwide rights to their respective technologies. In Hong Kong, the companies' intellectual property portfolios revealed that of the five companies, three companies have patents (Company A, D and E); two patents are worldwide, and one is a China-based patent.

3.2.3. *Who founded biotechnology spin-offs and why?*

In this section we want to paint a picture of the founders of spin-offs at Hong Kong universities in terms of their affiliation, the number of staff at inception, as well as the reasons leading to the creation of a spin-off. We begin with the founders' affiliations (Table 6).

Table 5: Companies collaborating with government organisation(s), research group(s)/institute(s) at universities and other spin-off companies

Collaborations with	Government organizations	Research groups/institutes at universities	Other spin-off companies
Company A	Yes	Yes	Yes
Company B	No	No	No
Company C	No	Yes	No
Company D	Yes	Yes	Yes
Company E	No	No	No

Source: Survey carried out by the authors in 2009.

Table 6: Founder(s)' original affiliation

Founders original activity	University	University and industry	Industry
Company A	O	—	—
Company B	O	—	—
Company C	—	O	—
Company D	O	—	O
Company E	O	—	—

Source: Survey carried out by the authors in 2009.

Table 7: Number of founder(s)

No. of founders	1	2–3	4–5	6–10
Company A	—	O	—	—
Company B	—	—	—	O
Company C	—	—	O	—
Company D	—	O	—	—
Company E	—	O	—	—

Source: Survey carried out by the authors in 2009.

The founders of the companies came mostly from academia. One company (D) was established by a group of people, some of whom were from an academic environment and some of whom were from an industrial context, whilst another company (C) was established by people who simultaneously had a position in academia and in industry. Table 7 reveals the number of company founders at inception. All the companies were created with joint effort, i.e. have more than one founder. Three were created by two to three founders, one company had four to five founders, whilst another company had between six to ten founders.

A large selection of empirical work has focused on factors that can promote the creation of academic spin-offs, including institutional support, local context features, and technology characteristics (Fini et al. 2009). However, the factors that motivate academics at university to venture into spin-off activity have only more recently been the explicit focus of empirical studies. These factors are usually framed in terms of *pull (demand-side) determinants* (such as market opportunities, applying knowledge to practical applications), and *push (supply-side or production) determinants* (such as being independent or having a profit motive) (see for example Weatherston 1995; Chiesa and Piccaluga 2000; Rasmussen 2006; Kroll 2008; Fini, Grimaldi, and Sobrero 2009; Morales-Gualdrón, Gutiérrez-Gracia, and Dobon 2009).

In addition, the literature also indicates that there is a significant variety of motivations behind setting up an academic spin-off (Muller 2010); and the motivations and aspirations cited by academic entrepreneurs for the foundation of a company are as diverse as the definitions of academic spin-offs and the nature of the activities carried out in such firms (Kroll 2008; Muller 2010). That is, if a spin-off is not strictly linked to a particular technology, it is possible that the driving force for the spin-off might be to apply academic knowledge in practice (as in providing consulting services). Understanding the set-up rationale also means taking into account the environment in which these decisions are made and implemented, i.e. ‘set-up decisions are decisions driven by human agency and taken by individuals that scan the environment for opportunities’ (Kroll 2008, p. 99). In the pre-seed phase, motivations such as opportunity recognition and organizational procedures may be accelerated. People who are mainly driven by the desire to work for themselves might have had the wish to become self-employed at the back of their mind for some time. People such as this may therefore recognize the opportunity of exploiting the skills that they acquire, methods they develop, or research they conduct (Muller 2010). Hence, spin-off decisions are to be understood as part of the interactions amongst individuals, organizations, policy measures, and the overall environment the entrepreneurs face.

When an entrepreneur decides to set up a company there are various considerations: Technological considerations will clearly be at the early stage, requiring proof of concept. On completion, a prototype will need to be developed, effectively turning knowledge into a product. The university spin-off is then faced with the issue of market uncertainty, particularly the issue as to whether the product will find acceptability in the market. Consequently, to overcome this

Table 8: Motivation behind the foundation of the spin-off company

Motivations	Average score
Apply knowledge into practical applications	4,8
Identification of market opportunities	4,6
Profit making	4,0
Complete the projects	3,4
Fully utilize existing knowledge	3,4
To be independent	3,2
Aversion for bureaucracy and low risk orientation of the research environment	2,8
Personal success	2,6
Other factors ¹	2,2

Note: 1: Not important, 2: Slightly important, 3: Neutral, 4: Important, 5: Most Important; ¹Two companies did not fill in this motivation and none of the companies explained the other factors.

Source: Survey carried out by the authors in 2009.

problem, the company has to identify the right market application for the technology and to judge the market size (Shane 2004).

Bearing in mind these insights from the literature, we asked the founders in our survey what motivated them to create spin-off companies. Respondents were asked to rate their motivations on a Likert scale ranging from 1 (not important) to 5 (most important). The results are shown in Table 8 and discussed below.

The analysis of the motivations behind the foundation of a spin-off company shows that the principal motivation is that the founder(s) wished to apply their knowledge to practical applications. This is followed by the recognition of potential market opportunities and profit making. This is not a surprising result: other studies found similar motivations. Chiesa and Piccaluga (2000), for example, in their research on Italian spin-offs, found that the majority of the founders' motivations (nearly 60%) were pull factors such as identifying market opportunities and applying their knowledge to practical applications. Jafta and Uctu (2009) found similar rankings of motivations for the Western Cape university spin-off firms in South Africa. Kondo (2004) conducted a first survey on the university spin-off companies in Japan and found that the primary motive in founding a company is to put invented technologies to practical use. Making a fortune is mentioned by only a few founders as a primary motive. Kondo and Hasegawa (2007) conducted research on the characteristics of Japanese university spin-off companies by industry, region and founder type. In their research, respondents were asked to rate their motivations in six choice areas: commercialization of developed technology, commercialization of business ideas, asset making, social contribution, own capacity development, and others. When faculty members started a spin-off their main motivation was the commercialization of technologies, followed by social contribution, and the commercialization of business ideas. This result is different in spin-offs created by the students. For them the major motivations were to commercialize business ideas, followed by social contribution, and their own capacity development. Researchers and technical staff, on the other hand, were motivated by social contributions, followed by the commercialization of business ideas. Unfortunately, our data for Hong Kong does not allow such a neat matching of founder-type to motivation rankings.

Given the importance founders assigned to market opportunities it is interesting to explore what their respective target markets were at the firms' establishment, and whether these have altered over time.

Table 9 reveals the companies' geographical target markets. Companies mainly targeted Hong Kong and mainland China during their start-up phase and their current market still remains the

Table 9: Market at foundation and at present

	Geographical market at start-up				Present markets of the spin-off companies			
	Hong Kong	China	SE Asia	Others (Europe)	Hong Kong	China	SE Asia	Others (Europe)
A	O	O	—	—	O	O	—	—
B	O	—	—	—	O	—	—	—
C	O	—	—	—	O	—	—	—
D	O	O	O	O	O	O	O	O
E	O	O	—	—	O	O	—	—

Source: Survey carried out by the authors in 2009.

same. Only Company D has focused on Hong Kong, China, other Southeast Asian countries and the international market (especially Europe) from their start-up phase up until 2009.

In all our cases, the companies developed commercial products/services (discussed in Table 3, Section 3.2.2). This illustrates that they applied their knowledge to practical effect. In terms of marketing their products, the companies had clear market objectives from their inception.

3.2.4. Funding sources

It is generally accepted that it is important to measure the financial status of biotechnology spin-off companies in order to better estimate the future growth of the sector. For our purposes, this funding source information is useful in relation to whether funding was an obstacle to spin-off formation and growth. Spin-off companies need to engage in technical and market development before selling their products or services and need finance to develop their companies. In many cases, companies cannot survive only with their own capital and must acquire finance from external sources such as business angels, venture capitalists, and government agencies (Shane 2004). In our case studies in Hong Kong, funding came mostly from personal sources, venture capital and other sources (i.e. angel funds, personal loans) (Table 10). A tiny percentage of the funding was received from international research foundations. The use of personal sources, loans and grants show that financing is a weakness in the system in Hong Kong. This is the

Table 10: Sources of funds for start-up

Percentage of total capital at start-up (%)					
Category	Companies				
	A	B	C ¹	D	E
Personal sources (include friends and relatives)	—	—	—	90	—
Governments	—	—	—	10	—
Venture capital (China-based)	—	—	—	—	100
International research foundations	1	—	—	—	—
Competitive grants	40	—	—	—	—
Other(s)					
HK Jockey Club	50	—	—	—	—
University	10	—	—	—	—
Personal loan	—	100	—	—	—
Angel funds (investors)	—	—	~45	—	—

Note: ¹Only the percentage supplied.

Source: Survey carried out by the authors in 2009.

case not only for spin-offs, but generally for biotechnology companies, as it is a relatively new sector and private venture capitalists in Hong Kong have not shown very much interest in biotechnology so far (Lindgren 2008). This view was supported by one of the participants in this survey. In the interview, the participant opined that venture capitalists in Hong Kong have not shown much interest in biotechnology because they expect investment returns in a short period, as they would when investing in information and communication technologies (ICT). Returns on investing in biotechnology are, in contrast, a long-term prospect.

3.2.5. *Obstacles to success*

The literature on biotechnology identifies three crucial elements – commonly called the ‘three pillars’ – essential to success for a biotechnology start-up company: (i) effective management; (ii) sufficient capital; and (iii) access to new technology that leads to products. All biotechnology companies face difficult managerial challenges in R&D because it is both the most expensive and the most critical aspect of bringing a product to market which requires a complex repertoire of knowledge, skills and talents, including marketing, the basics of intellectual property rights, early-stage technology finance, and knowledge of scientific, regulatory and ethical issues (Schoemaker and Schoemaker 1998; Meyers and Hurley 2008; Malazgirt 2011). The second pillar, sufficient capital, presents a struggle for most biotechnology companies because the processes involved in developing a product are costly and time-consuming (Schoemaker and Schoemaker 1998; Malazgirt 2011). Lastly, every biotechnology company, from its inception, must have a well-defined and well-articulated product focus. The company needs a clear vision to identify the avenues of its future revenue streams. For the biotechnology company it could be a single product to create the foundation for a profitable company. Once chosen, the company needs to focus on the development of its chosen product and its underlying technology (Schoemaker and Schoemaker 1998).

In order to understand the relevance and extent of these major challenges for the companies in our survey, we asked respondents to rate the obstacles they faced on a five-point Likert scale, where 1 was not important and 5 was most important. The results are illustrated in Table 11.

In the current survey, the biggest difficulties faced by biotechnology spin-off companies in Hong Kong are the estimation of market demand and technical problems in development and

Table 11: Major obstacles faced by spin-off companies

Type of problem	Average core
Estimation of the market demand	4,2
Technical problems in development and production	4,2
Funding	4,0
Relationships with the parent university	4,0
Regulatory compliance	3,8
Problems related with the position played in the parent university	3,6
Commercialization	3,5
Problems in the management of human resources	3,4
Distribution	3,0
Patenting	2,6
Problems among owners	2,2
Contractual problems	2,2
Others ¹	—

Note: 1: Not important, 2: Slightly important, 3: Neutral, 4: Important, 5: Most Important; ¹None of the companies indicated this obstacle.

Source: Survey carried out by the authors in 2009.

production, closely followed by funding and relationships with the parent university, regulatory compliance, and problems related to the role played in the parent university. Comparing our findings to other studies, it appears that this applies not only in developing countries but also in developed countries. Funding, commercialization and managerial skills, for example, seem to be a universal problem. Van Geenhuizen and Soetanto (2009) explored a case study of Delft University of Technology in the Netherlands and found that the main difficulties faced by university spin-offs are market-related (marketing knowledge, sales skills, customer base); followed by financial (cash flow, investment capital, R&D investment); and management problems (dealing with uncertainty, management). According to Van Geenhuizen and Soetanto (2009), managerial skills (e.g. market-related problems) are not surprising obstacles since spin-off firms must evolve from a non-commercial environment to become an established, profit-generating firm which implies that a new and different type of knowledge is required to be successful. Rutherford and Fulop (2006) found similar lack of expertise in Australian biotechnology start-ups. The authors stated that business awareness of science is low and scientists lack entrepreneurial skills to commercialize their research. To overcome these problems, the authors suggested training and equipping scientists with the necessary commercialization and managerial skills. Byrd (2002) found that the major problem faced by Canadian biotechnology spin-off companies was access to the capital to develop the company. Similarly, Kondo (2004) found that a major difficulty at start-up for Japanese companies was access to finance, followed by staff recruitment. Likewise, Kondo and Hasegawa (2007) found the major difficulty is recruiting R&D staff, followed by the lack of R&D funds. Chiesa and Piccaluga (2000) also found that some of the major problems Italian spin-off companies faced were funding and the commercialization of the research results. Perez and Sanchez (2003) studied 10 companies spun-out from the University of Aragon in Spain and found that the major obstacles these spin-offs confronted during their first year were the small market size and lack of financial sources. Although the rankings vary, it is evident that the top three to four obstacles elsewhere are similar to the ones listed in Table 11.

Overall, although spin-off creation from Hong Kong universities in biotechnology is a relatively new phenomenon, it seems as if the motivations for creating them, and the obstacles they face, are not significantly different from the experiences of spin-off companies elsewhere.

4. Conclusion

This paper surveyed university technology transfer offices and firms in order to gather information about the history and innovative status of biotechnology spin-off companies from universities. The aim of this study was to contribute to the understanding of this phenomenon as knowledge transfer process in Hong Kong. The paper analysed the local activity as an important step towards understanding the emerging biotechnology industry in latecomers. Based on our research, we would say that there is an increasing awareness of academic entrepreneurship in the form of creating university spin-offs in Hong Kong, but not yet for the biotechnology sector, where spin-offs are relatively few. This is actually not only for spin-offs, but generally for biotechnology, which is comparatively new, and private venture capitalists have shown little interest in biotechnology so far (Lindgren 2008).

One of the main conclusions of this study is that while the textbook definition of biotechnology spin-offs clearly fitted some companies, some others were more complex and required an expanded definition. In one case, for instance, the founders were not from the university, while in another case, the company was created by the university itself.

The study has also highlighted the profiles of the companies; opportunities and reasons for foundation, as well as obstacles and major problems faced by biotechnology spin-offs. In summary, the results suggest that biotechnology university spin-off firms in Hong Kong;

- (1) are relatively small in size and young (operating less than ten years);
- (2) operate more often in biotechnology product and process industries than services;
- (3) developed commercial products and services;
- (4) seldom collaborate with other organizations (with two exceptions);
- (5) are aware of IP protection;
- (6) are mostly formed by university staff;
- (7) are created with joint effort, i.e. have more than one founder;
- (8) are motivated to create spin-offs in order to apply knowledge to practical applications and utilize market opportunities;
- (9) experience problems with estimating the market demand, technical problems in development and production, and difficulties with financing, as the most significant inhibitors to success.

Although this study was conducted on a relatively small scale, it is believed that the insights gained from this exploration into the field could prove useful for future research. This paper contributed to the understanding of the rationale for, and the nature of, biotechnology spin-offs from Hong Kong universities. The research also generated a few interesting questions to pursue in further research, namely;

- (1) whether it would be possible to track the survival strategies and/or growth paths of these firms over time; and
- (2) related to this, examine the role that patents play in the success of these spin-offs; and finally
- (3) compare the motivations of academics who were in a position to spin-off, but did not, to better understand the pull and push factors in spin-off creation.

Notes

1. This is not an unusual phenomenon. Even in developed countries obtaining sufficient data in this relatively new branch of enquiry led researchers to use more qualitative techniques, such as case studies (Rothaermel, Agung, and Jiang 2007, p. 701).
2. Smilor and colleagues' (1990) two-dimensional definition. In the aforementioned study, the authors excluded the spin-off firms that provided consulting services. However, those types of companies were included in our research.
3. A spin-off is described as a new company created to transfer and commercialize inventions and technology developed in universities, firms or laboratories.

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