

Origins and dynamics of university spinoff enterprises in Hong Kong

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Abstract

This exploratory paper reviews the past fifteen years Hong Kong's university-based spin-off experience and studied those RBSOs (research-based spin-offs) established by five universities in Hong Kong, namely the City University of Hong Kong, the Hong Kong Polytechnic University, the Hong Kong University of Science and Technology, the University of Hong Kong, and the Chinese University of Hong Kong. Important issues related to the motivation, the technology transfer process and practices, the strategies of the TTOs (technology transfer offices) in technology transfer and commercializing universities intellectual assets, the obstacles and means to facilitate future development of RBSOs are addressed. Using data from companies spun off from five universities in the period of 1997 to 2004, and case studies of flagship spinoff enterprises including the TeleEye Holdings Ltd., Eco-Tek Holdings Ltd., Perception Digital, MaCaps International Ltd. and the TA Therapeutics Ltd. in order to provide insights of these successful spin-off companies. We conclude by drawing some lessons based on the Hong Kong experience that are probably generalizable to other latecomer jurisdictions with aspirations to become players in the growing worldwide spin-off phenomenon.

1. Introduction

Universities all around the world are coming to view themselves not just as advanced training institutions which transmit knowledge from professors to students, but also as generators of knowledge that has widespread wealth-creation potential. Under this rubric, the phenomenon of universities promoting the transfer of technology to enhance a region's economic development (BankBoston 1997; Steffensen et al 1999; Shane 2004; Siegel et al 2004), or actively promoting new ventures that embody this technology, has come to be widely noted (Radosevich 1995; Mian 1997; Leydesdorff and Etzkowitz 2001; Bower 2003; DiGregorio and Shane 2003; Lerner 2005; Link and Siegel 2005; Mathews et al 2006; Renault 2006). The literature encompasses experiences from USA (OECD 2001, AUTM FY2004), Europe (Walter, Auer and Ritter 2005; Clarysse et al 2005), and the UK (Franklin, Wright and Lockett 2001) as well as from R&D-rich countries such as Israel (Meseri and Maital 2001).

There have been some famous TLO (Technology Licensing office) start-ups in the US, such as Genentech in biotechnology (from Stanford), Cirrus Logic in semiconductors, Cisco in routers and Lycos in Internet search engines. Stanford sold its stake in Google in 2005, netting US\$336 million for the university. But there have been some not-so-famous disasters as well, as in the case of Boston University's investment in a biotech start-up in the early 1990s where the university ended up investing up to US\$90 million in a venture that went nowhere, despite an Initial Public Offering, so that the university's equity stake was in the end worth only US\$4 million. These and many more such stories show that the entrepreneurial pathway may be strewn with good intentions but also with many traps (Lerner 2005).

So the issues involved in universities becoming sponsors and promoters of new ventures -- over and above promoting technology transfer through licensing and contracted research -- are complex, demanding and (not least) controversial. Those jurisdictions that come later to the process have the benefit of learning from prior experiences in the field; they can enjoy a 'latecomer advantage' in learning to tune their institutions and policies according to earlier experiences (Gerschenkron 1962). The Hong Kong SAR of China is one such 'latecomer' jurisdiction, and therefore an attractive location in which to promote, and study, the phenomenon.

Hong Kong entered this field in the early 1990s, and has now had 15 years of experience with university-based spin-offs, dating from the formation of the first TLO by the City University of Hong Kong, in the form of CityU Enterprise Ltd. Since then especially after the drive from the HKSAR, two other universities have become active in the field, namely the Hong Kong Polytechnic University, through the Partnership Development Office (PDO) of the Institute for Enterprise, and the Hong Kong University of Science and Technology (HKUST) through its enterprise arm, HKUST Technology Development Corporation. This institution has also very recently founded a new vehicle in the form of the HKUST Biotechnology Research Corporation. The other two TLOs from the oldest and the most established universities in Hong Kong are Versitech of the University of Hong Kong (HKU) and CINTEC (Centre for Innovation and Technology) established by the Faculty of Engineering of the Chinese University of Hong Kong (CUHK). In the past decade and a half, over 100 new ventures have been launched by the

first three universities, as well as sporadic launches at the other two universities in HK. Thus we feel it is timely to subject this experience of a decade and a half, in one of the world's most dynamic and competitive cities and financial centres, to a review and evaluation.

In this article we offer what is probably the first comprehensive review of Hong Kong's spin-off experience. We have the advantage that many of the issues involved have now been discussed in the scholarly literature, such as the knowledge flows generated (Siegel et al 2004), the technology transfer process itself (Perez and Sanchez 2003), and the various approaches adopted to the spin-off process by institutions in generating research-based spin-offs (RBSOs) as discussed by Mustar et al (2006) or Clarysse et al (2005). In the sections that follow, we first discuss the general spin-off phenomenon and what has been learnt from experiences in the USA and Europe, and then narrate the experience of the universities in Hong Kong, noting the differences in strategy adopted. This leads to a nice 'natural experiment' since all five institutions have been acting in the same environment under the same conditions, but with different outcomes according to the strategies pursued. We then analyze the experience through the results of a survey instrument as well as through selected case studies of 'flagship enterprises' that have proven to be particularly successful. We conclude by drawing some lessons based on the Hong Kong experience that are probably generalizable to other latecomer jurisdictions with aspirations to become players in the spin-off phenomenon.

2. The spinoff phenomenon

Some universities routinely transfer technology through the formation of new firms (like MIT) while others favour licensing (like Columbia). There are wide divergences in propensity to form spin-offs between universities: Stanford, for example, is adept at creating start-ups, while Duke, with comparable sponsored research funding, generates few. In the definition offered by DiGregorio and Shane (2003), TLO spin-offs are created when the licensee of a university-assigned invention creates a new company to exploit it (2003: 210) and the new spin-off is based on the intellectual assets of the parent organization (Birley 2002). This is in contrast to the case where the university licenses the know-how to an established firm, or where the technology is developed by an external investor without the university as an institution having any share in the returns. Oahey (1995) identified university spin-offs as one of the two major sources of technology-based firms and, unlike the case of corporate spin-offs, it encourages the transfer of technology from the university to the wider economy. On the whole, Hong Kong universities have been active in promoting 'academic entrepreneurs' rather than in seeking out third-party investors for university-generated technology – with some important exceptions (e.g. PolyU's Eco-Tek) (Franklin, Wright and Lockett 2001).

The spin-off process is recognised as the most important mechanism of technology transfer between academic institutions and industry (Carayannis et al. 1998; Chiesa and Piccaluga 1998; Fontes 2003). Most institutions have now settled on various kinds of arms-length vehicles for such activities, such as Technology Transfer Offices (TTOs) or Technology Licensing Offices (TLOs) or Technology Development Corporations (TDCs) all of which are owned and operated by the university. The resulting ventures are termed in the literature 'spin-out ventures' or 'spin-off ventures' or research-based spin-offs

(RBSOs) (Mustar et al 2006). In this article we settle on the terminology of spin-off ventures launched by university owned and operated TLOs.

The success or failure of university initiated new firms has been studied at both the macro level and the micro level. At the macro level, DiGregorio and Shane (2003) identify four factors that can be expected to influence the rate and scale of formation of TLO spin-offs and their success. These are (1) whether the university is located in an area rich in start-up resources such as venture capital; (2) the extent to which the university conducts industry-funded research; (3) the degree of intellectual eminence of the universities involved; and (4) the policies adopted by the universities, particularly in regard to protection of IPRs and human resource management policies (e.g. the degree of liberality in allowing faculty to own intellectual property). Overall, on a panel of data collected on all start-ups across the US for the years 1994 to 1998, they find that universities' intellectual eminence and licensing policies have a significant impact on TLO start-up activity, while availability of venture capital and the commercial orientation of research exert little impact. These were shown to be powerful determinants of the success or failure of start-up activity. Our study of the process of spin-off formation from universities in HK takes the DiGregorio and Shane (2003) approach as a starting point, in that we too utilize the data on spin-offs provided by university TLOs.

At the micro level, there are also factors such as the innovation clusters and networks that connect the faculty members concerned, their entrepreneurial orientation, and the wider support structures that can be appealed to in the process of incubating a new venture. Grandi and Grimaldi (2005) focus on the organizational processes through which successful university-initiated start-up firms are created and supported, based on a sample of 42 university-based start-ups in Italy. Building on the insight generated by Thursby et al (2001) namely that the majority of academic inventions commercialized through spin-offs are at an early stage of development when they are licensed and that continued inventor involvement in the commercialization process is key to its success, they sought to measure the effect of these characteristics by studying the creation of new ventures where academic staff are involved in both the invention and the commercialization phase.

Like us, the findings of Grandi and Grimaldi support the hypothesis that the outward orientation of the academics involved in starting new ventures is just as important to their likely success as is the quality of their technology and the originality of their idea – a finding which we also take as a benchmark for our study. Our study confirms the entrepreneurial needs are the key motivator of founders of RBSOs in HK. Another way of expressing this is to make the observation that spin-off venture performance is likely to be positively affected by the network capability (NC) of the founder(s) and their entrepreneurial orientation (EO) (Walter, Auer and Ritter 2005). The founder of Perception Digital (as mentioned in section 5) has demonstrated strong entrepreneurial drive, as realized through his business networks in HK and in USA, complemented by sustainable relations with faculty members and the TTO staff of HKUST.

Clarysse et al (2001) identified three different entrepreneurial environments that exist in Europe which seem to follow a linear learning path evolving from an “unaware” environment to an “aware” and finally to a “supportive” environment. Our HK study supports this perspective, in that we find the RBSOs carried out low-technology activities which are typical of an “unaware” environment at the founding year; after the RBSOs

developed into the “aware” environment at later year consulting increased in intensity, as shown in part 5 of Table 3.

Clarysse et al (2005) further distinguish between three organizational modes at the level of the parent organization in launching spin-off ventures – the “low selective” mode; the “supportive model”; and the “incubator model”. We build on this typology in our study, where we identify three kinds of institutional support structures for spinoff enterprises. But we do not follow Clarisse et al in their terminology again because we find mixtures of all three of their categories in the approaches followed in HK.

We find that the three sponsoring organizations with the largest numbers of RBSOs in Hong Kong, namely the CityU, the PolyU, and the HKUST, have adopted different degrees of support and commitment to the commercialization of enterprises started through their sponsorship. This creates a fascinating ‘natural experiment’ in the same location under the same set of external conditions, both economic and legislative.

There is first the minimalist approach where the university offers administrative support to academic staff who wish to form an enterprise, where the technology has been proven to be ‘market-ready’ through some tests, usually that it has already been successfully licensed. In this mode, the university takes a small equity position in the new company and takes a seat on the Board in order to protect its interests – with a view to exiting at the first available opportunity. In this model the university plays less active role in the future growth and prospects of the company.

There is by contrast the maximalist approach, where the university actively seeks out prospective new ventures and investors, and takes an active role in directing the strategy of the newly-formed enterprise and drive to increase the innovation speed (Markman et al 2005). Again the university takes an equity position in the newly formed venture (usually at a higher level than in the minimalist mode) and its representatives on the Board take an active interest in the strategic direction to be taken by the firm. In this model, the university plays a strong role in the anticipated future growth of the enterprise.

There is a third approach, that in Confucian terms appropriate to this study we may call the ‘doctrine of the mean’ that sees the university playing an active role in the launch of the enterprise, actively seeking out investors or even, in the optimal case, a joint venture partner. Thereafter the university adopts a passive role, allowing the newly-formed venture to find its own strategic direction, and maintaining a seat on the Board merely to protect its interests, again with a view to securing an early exit.

Our typology is thus intuitively plausible and readily checked against the policies of the actual institutions of higher education in Hong Kong – as well as against those of institutions globally. Whereas the review by Mustar et al (2006) identifies three perspectives in the literature – what they call the resource-based perspective, the business model perspective and the institutional perspective – we seek to transcend these categories in our own review of the HK experience, incorporating elements from all three perspectives in our study. Thus we are concerned with the underlying resources transferred from the university (knowledge capital and its expression as intellectual property rights) as well as financial resources; with the business models pursued by the firms and the growth strategies adopted; and with the patterns of institutional links and the

efficacy and efficiency of the procedures adopted by the Higher Education Institutions (HEIs) in Hong Kong with regard to spinning-off new enterprises.

3. University spin-offs in Hong Kong: A decade and a half of experience

Hong Kong universities started as latecomers to entrepreneurial endeavours and to the formation of various kinds of technology transfer institutional support mechanisms (Eastham 2003). They were therefore able to learn from the more evolved models that had been developed in Europe, the US and Japan. As of 2006, the Spinoff Enterprise of all five universities in Hong Kong is listed in Table 1.

City University of Hong Kong

The first mover in HK (when it was still under British control) to adopt an entrepreneurial institutional process and formed the CityU Enterprises Ltd in 1991. CityU thus has 15 years of experience with spin-offs and technology transfer. By 2006 the university has experience to launch 25 spin-off companies.

CityU has well developed procedures for screening technologies for their commercial potential, usually by requiring that they first secure some commercial licensing before they can be considered for seeding as an enterprise. The most outstanding graduate of CityU has been TeleEye (TeleEye Holdings Ltd.), the first company to be nurtured from incubation to listing on the GEM (Growth Enterprise Market) of the HK Stock Exchange in May 2001 (a listing that raised \$23 million).

Hong Kong Polytechnic University

The next HK institution to engage in entrepreneurial activities was PolyU, through its enterprise arm, the PolyU Enterprise. PolyU secured its first patent in 1996 – and thus has 10 years experience in managing an IP portfolio. The best known of the PolyU spin-off enterprises is Eco-Tek (Eco-Tek Holdings Limited), which has evolved to become a fully-fledged and independent firm primarily engaged in innovative environmental protection products and ancillary services with a listing on the GEM of the HK Stock Exchange on 5 December 2001 and recorded a subscription rate of over 60 times of the offer size, representing a total order book of about HK\$2 billion. The critical success factor of Eco-Tek was the strong committed involvement of the PDO led by the Head together with the academic inventor and the technical team managed to work successfully with the outside investor, Dr. Lily Chiang and her management team to launch this RBSO and able to commercialise the PolyU proprietary technology.

Hong Kong University of Science and Technology

The third in line to adopt an entrepreneurial approach was HKUST which is the newest university in Hong Kong established in 1991. It first sets up its administrative structure, in the form of the HKUST R&D Corporation Limited in 1993 and manages HK \$10 million Venture Capital Fund initially to support start-up companies; and launched a full-fledged Entrepreneurship Program in July 1999. Hong Kong Supernet Ltd. was one of the first clusters of companies incubated in 1996 and was successfully spun-off and

sold by the university the same year. By 2006, the “Faculty Driven” model for the R&D and technology transfer of HKUST launched approximately 50 enterprises, of which 7 had become classified formally as ‘spin-offs’ – meaning that they were now functioning independently of their connection with HKUST. One of the most successful of these ‘spin-offs’ is Perception Digital, as well as new joint ventures such as TA Therapeutics (both described in section 5).

As of 2006 the university’s spin-off policies were evolving to a new model where venture capital input would not be seen as so important and much more emphasis would be placed by the HKUST R&D Corporation on lining up proven successful joint venture commercial partners for the RBSOs – as in the case of TA Therapeutics Ltd. discussed below.

University of Hong Kong

Established in 1910, HKU is the oldest, the most elitist and probably the richest in terms of resources and networks with the top governmental officials being the home-grown graduates of the university. Its research excellence has positioned it as the most successful university in Hong Kong in terms of securing competitive research funding from the Research Grants Council (RGC). Versitech Limited is the wholly owned subsidiary of HKU and is the technology transfer and commercial arm of the university, established in 1998, and focuses on the region's R&D strengths in IT and biotechnology.

Chinese University of Hong Kong

The CUHK is the second oldest university in Hong Kong, with a founding date of 1963 after amalgamated 3 different colleges. In 1998, the university established a Research and Technology Administration Office (RTAO) to support R&D contracting, technology transfer, IP rights and database management. A more focused vehicle has been established in the form of CINTEC (Centre for Innovation and Technology), formerly known as the INL (Information Networking Laboratories), which was established in January 1999 under the auspice of the Faculty of Engineering. It takes on an advisory and infrastructural support role for the Faculty R&D projects with good business potential to develop them into RBSOs. Even with limited number of spinoff enterprises (currently numbering three), and its low-profile approach, the five-year survival rate of the first two CINTEC spin-offs is 100%.

In terms of our typology of spin-off administrative processes and support structures, we would classify the experiences in the first decade as follows. All five institutions with an entrepreneurial orientation started out with the minimalist approach, while offering a degree of Incubator support. While CityU, HKU and CUHK have stayed more or less in that mode, we have found that PolyU has moved to something approaching a maximalist mode, while HKUST has evolved to the third, the ‘mean’ approach of offering more support at the beginning through arranging joint ventures and then leaving the venture to find its own strategic direction.

In this sense, changes in external environment and resources endowments (Baldini et al., 2006), the acceptance of entrepreneurial university (Etzkowitz et al., 2000), we agree with Mok’s comment that “a culture of academic entrepreneurship is emerging among Hong Kong’s universities” (Mok 2005: 545,). Intellectually eminent universities

generate more start-up companies (Link and Scott 2005) but our study revealed that the two most established universities, namely the HKU and the CUHK have adopted a largely laissez-faire approach to spin-offs. The strategic direction of different universities in HK adopted in supporting and developing the RBSOs and the results over the past decade constitute interesting findings of this study.

The wider institutional support for the entrepreneurial activities on the part of HK Higher Education Institutions (HEIs) is considerable – ranging from the major funding body, the UGC (University Grants Council) to technology promotion agencies such as the Hong Kong Productivity Council and the newly formed HK Science and Technology Park is viewed as the logical place where newly fledged incubates are expected to locate. The institutional environment was enhanced by the formation of the Innovation and Technology Fund (ITF) and the Applied Science and Technology Research Institute (ASTRI), both of which were recommended by the Innovation and Technology Commission established under the HKSAR (Hong Kong Special Administrative Region) first Chief Executive, Mr Tung Chee-hwa. The ITF was designed to finance mid-stream and downstream R&D projects undertaken by universities and industry support organisations, while ASTRI was established in 2001 to capture the promise of technological advances for HK through applied research.¹ Thus one would expect Hong Kong to be a favourable location for the spin-off phenomenon, and to be able to utilize its latecomer status effectively. This level of support is reflected in the relatively high survival rate of 78.57% for the first five years for the RBSOs in our study.

4. Quantitative and Qualitative Assessment

Our population of spin-offs is 56, collected for the period covering 1997 to 2004. The primary data analysed was collected from questionnaire surveys and structural interviews held in March 2002 to December 2005 with founders or senior management staff of companies span off from different universities in Hong Kong. Enterprises that had already disappeared were thus not available for study. The basic data from the companies that responded covering activity, founding year, and number of employees, are shown in Table 2. Our study has shown not all the RBSOs can survive in spite of incubation support from the respective universities; those RBSOs set up with IT enabling technologies are badly affected by the economic downturn because of the dot.com bubble. In this study, we use factor analysis to identify the principal issues faced by entrepreneurs and their firms as they navigate the spin-off process.² This result of factor analysis reveals the underlying dimensions and issues related to the motivation, technology transfer process and practices, its relationship with network and subsequent business development, the obstacles and the means to improve RBSOs in future is shown in Table 3. The list of spin-offs was gathered from visits to the commercialization arms of all five universities.³

¹ The late Professor Tien Chang-lin, Chairman of the Commission, was confident that proposals in the report would increase Hong Kong's competitiveness as a high tech centre like Silicon Valley and relative to that of Singapore and Taiwan (referred in CIT1999 and CSD2000)

² We employ Factor Analysis with Oblique Rotation, using the SPSS 13.0 (Statistical Package for Social Sciences)

³ We received 22 valid responses from the population of firms (marked with an asterisk) listed in Table 1, giving a response rate of 39.29%. Given that this is the first such exercise reported from HK, we judge this to be a realistic response rate and one that can be used to generate useful insights.

Motivation

The acid test of the founders is the survival and the sustainability of the RBSOs in a competitive global business environment and the performance of university scientists are not just measured by the number of referred journals published. Dubinskas (1988) found that in science, it is accepted that the quest of knowledge is valued over the pursuit of profits or capital gain and is in contrast with business objectives are more focussed with short planning horizon and monetary values.

In addition, the academic terms of employment in HK are not as flexible when compared with MIT in facilitating the development of RBSOs (Shane 2004). Samsom and Gurdon (1993) conducted an intensive study of scientists in the Canadian-US study and found that less than one-third of the scientists were able to combine the ongoing relationship with their institution with off-campus venturing activities. Finally, most of them had to sever their affiliations with academia. We find the same scenario in our HK study. Normally, the university scientists are allowed to spend one-day per week to pursue “outside work” activities which is not sufficient considering the heavy workload of academics nowadays. Reasons being all the universities in Hong Kong are publicly funded so administrators in universities are very careful to avoid any possibility of cross-subsidy and conflict of interests which can easily lead to scandals in the local press and affect negatively the corporate image of the said university. Successful RBSOs founders like Professor Cliff Chan of the TeleEye Holdings Ltd., and Dr. Jack Lau of the Perception Digital (mentioned below) decided to leave the academic position in the university and made a long term commitment to pursue the businesses on a full-time basis.

To understand the motivation of founders in initiating the RBSOs (Shane 2004), our factor analysis has shown the significantly high entrepreneurial needs followed by high need for achievement, as shown in part 1 of Table 3. Structured interviews conducted with the academics founders also confirmed that high entrepreneurial needs and intrinsic needs are the primary contributing factors of starting the RBSOs. Our study supports the findings that extrinsic needs are not the primary motivator, as documented in the Chalmers Institute of Technology surveyed (McQueen and Wallmark 1982). Financial gain is secondary consideration and the primary motive is to satisfy intrinsic needs (Siegel et al 2003). Our study agrees with Dahlstrand (1997) that entrepreneur’s motive is important but we do not support freedom to explore new ideas was more common than to test one’s entrepreneurial ability. The negative score related to optimism is possibly attributed to poor economic outlook in HK during this study period.

Rate of Growth

The RBSOs have started with unique resources and competitive advantages in exclusive technology licenses (Rothaermel and Thursby 2005) hence one would expect the rate of growth is faster than for other SMEs. Oakey (1994) studies show that rapid or even moderately rapid organic growth is not perceived as a feasible way to develop the hi-tech companies and this reinforces. For those companies studied, the number of employees increased by 12 persons by universities and by 13 persons by sectors in year 2004 when compared with the founding year as shown in part 2 of Table 3.

Empirical studies including sectoral analysis presented in part 2 of Table 3 are meaningful as there are differences between sectors (Fontana, 2006). In this HK study, the main sectors are engineering, IT, telecommunication, environmental, biochemistry and Chinese medicine. At the date of founding, the percentage of resources allocated to R&D was high, in the order of 80%, but it reduced to 57% in year 2004. The variance shown the percentage of R&D in relation to revenue reduced by 16.2% by universities and by 23% by sectors in year 2004 when compared with the founding year. The largest reduction was found in the IT and telecom related sectors as they were badly affected by the dot.com bubble. We find the RBSOs committed more R&D resources in developing the core technologies at the initial stage of spin-off formation. For example, in Perception Digital case (mentioned in section 5), it took the company four years to commercialise and launch the first product. Early investment and long term commitment of resources before immediate returns are very important as shown in part 6 of Table 3. Difficulties in managing the spin-offs and the obstacles they face including small market size, and lack of financial resources identified also complicated the situation, and can lead to spin-offs failure.

As the RBSOs developed, the customer profile shifted from the initial large size to medium size customers whereas the small size customers reminded with little change, the reason being the small size customers might not be able to afford the advanced technology at a premium price. As shown in the Eco-Tek case (mentioned in section 5), the company successfully won substantial government contract of HK\$ 26 million from the EPD (Environmental Protection Department) so it put the company in a strong position to grow. Another example is MaCaps case (also mentioned in section 5), which can survive in spite of the investors pulled out the funds after the company was set up. The company continued to develop its products and successfully won the tender from the HKSAR to install the security systems required at all government installations such as the Immigration Department at the HK Chek Lap Kok Airport. These large customers helped the RBSOs survived at the initial and probably the most challenging stage of its development.

Modes of technology transfer from universities to RBSOs

The dynamics of technology flow generated by different technology transfer mechanisms from the university to RBSOs and then to their customers are important in our understanding of hi-tech innovation systems but there are few empirical studies conducted (Porter, 1985, 1991; Perez and Sanchez 2003; Link and Siegel 2005; Rothaermel and Thursby 2005). Roberts (1991) demonstrated the importance of the universities as parent organization to transfer the technology to RBSOs. Harmon et al. (1997) believed the technology transfer from the university can contribute indirectly the development and the high growth of RBSOs. Dahlstand (1997) found after an initial ten-year period, the RBSOs were growing significantly faster than the non-spin-offs even no significant difference in the inventiveness was found between these two groups. RBSOs normally start as a one-product company and will evolve into a customer-driven technology company with product and service innovation (von Hippie 1988; Chiesa and Piccaluga 2000; Mustar et al 2006), and manage its resources and capabilities in creating wealth at different phase of spin-offs development (Penrose, 1959; Barney et al., 2001; Brush et al., 2001; Clarysse et al., 2005). The flagship spinoff enterprises like TeleEye also started with one remote sensing product using the proprietary digital signal processing technology but

quickly developed its products for different applications including remote surveillance, and traffic control.

As mentioned in section 2, and data shown in part 3 of Table 3, our study supports Clarysse et al (2001) findings of the “unaware” environment whereby the technology and skill transfer from universities to RBSOs tends to be “hard” (referred as low-technology activities); and “soft” technology and skills transfer with the objective of generating immediate revenue for its survival at the founding year. Universities scientists lack management expertise (Samsom and Gurdon 1993) so training in management and transfer of people are important to assist the RBSOs to operate at the founding year.

Our study also supports Clarysse findings that when the RBSOs progress to the second phase namely the “aware” environment and consulting is the main activities. In year 2004, the mode of technology transfer from universities to RBSOs shifted to product-oriented; service-oriented; resource-oriented; and management training. The RBSOs have gradually evolved into the second phase of spin-offs development and build on its core competences. Our study also shows that management training has become increasingly important in later year to equip the university scientists the right management skills in managing RBSOs.

Mode of technology transfer from RBSOs to customers

After a few years, the spin-offs have built up their clients’ base, and the dependency on the university and the technology flow from the parent universities is reduced. Market-oriented technology is developed to replace product-oriented technology in order to increase the sustainability and competitive advantage of the RBSOs (Roberts 1990; Shah 1990; Perez and Sanchez 2003). Entrepreneurial networking of the founders and the management of RBSOs can positively influence firm performance (Covin and Slevin 1991; Zahra 1993; Hansen 1995; Human and Provan 1997).

Our study as shown in part 4 of Table 3, at the founding year, there are two types of technology and skills transfer from RBSOs to customers: “soft” (including training in management); and “hard” (including sales or purchase of products and services). It echoes the findings of the above section that the RBSOs need to market its products and services to the customers to generate immediate revenues for survival. Subsequently, the technology transfer shifted to new product and technology development for the customers; and enhancement of existing technology for the benefits of the customers. Partnership with customers and provide technology solution for the customers are the competitive advantages of RBSOs. Our study found that the importance of consulting increased from founding year to year 2004 in both modes of technology transfer from universities to RBSOs and then to customers (in part 3 and 4 of Table 3). RBSOs need to invest more resources including knowledge capital to establish and maintain closer network and relationship with customers; otherwise the business will not survive.

Main functions performed by RBSOs

Our study as shown in part 5 of Table 3, at the founding year, the main functions performed by RBSOs are basically revenue generating for survival. There are 3 main functions including technology outsourcing and channel development, value-added services to customers and product enhancement. The factor analysis has shown the

provision of test / maintenance services is very high. This can be explained that the customers can rely on the technical expertise and can gain access to expensive capital testing equipments or laboratories of the universities through the RBSOs by charging customers the market price as we are not suggesting the universities are cross-subsidy the spin-offs business activities. The RBSOs can capitalize their expertise to bring value-added services to the customer by improving their distribution and management efficiency. In addition, the RBSOs also engaged in product enhancement initiatives to increase customer operation efficiency with products at the founding year.

At year 2004, the main functions shifted to channel development and supporting services including marketing and distribution channel whereas the increase in customer operation efficiency with products decreased. It is explainable as the RBSOs have built up its core technology hence their customers have rely less on the products itself to improve its efficiency. RBSOs also provided value-added services to customers through consulting which increased in importance from founding year to year 2004. This can show increased credibility and confidence of the RBSOs performance perceived by the customers.

Obstacles affecting technology transfer of the RBSOs

The obstacles of RBSOs technology transfer are widely documented in the literature and will be addressed below. In our study, we find three main obstacles: entrepreneurship and business skills, partnership and networking, and long term commitment in the founding year. In year 2004, there are four main obstacles: technology risk management, long term commitment and synergy, business routines and networks, and resources constraints; as listed in part 6 of Table 3.

Entrepreneurship and business skills are perceived as one of the obstacles in the founding year. One of the primary motivators for the academics to initiate the RBSOs is to satisfy entrepreneurial needs as highlighted in the first part of Table 3, so the parent organization and TTOs should provide full support to the RBSOs in overcoming this obstacle. The learning curve and the transformation of university scientists to business ventures can be very steep according to Samsom and Gurdon (1993).

Business routines and networks is being identified as one of the four obstacles in year 2004, the founders of the RBSOs have to build their management capabilities, including best business practices, in order to manage the companies effectively. We support Siegel et al (2003a) and Lockett and Wright (2005) viewpoint that business and management skills are important for RBSOs university scientists.

The HK study identifies partnership and networking as the major obstacles in the founding year. Perez and Sanchez (2003) identified small size of market, and lack of financial resources was the main obstacles to RBSOs during the founding year. The issue of resources constraints should not be ignored as lack of financial resources and funding is critical in year 2004. We support Nishizawa (2003) findings that insufficient funding sources affect negatively the start-up ventures in Japan. Lambrecht and Teich (1976) argue that barriers can be reduced by means of alliance and partnership building and Vohora et al. (2004) suggests access to resources and capabilities in different phases of development are critical for RBSOs to overcome the obstacles.

Harmon et al (1997) found lack of long term commitment of the university scientists and all inventors studied were not committed full-time in the development of their respective RBSOs. In our study, we find the situation has worsened as lack of trust among partners increased from 0.87 in the founding year to 0.95 in year 2004. Consequently, lack of trust compounded by difficult business environment like small market size in the founding year will create obstacles for the RBSOs to grow. To overcome these obstacles, McDonald and Gieser (1987) recommended the facilitate process in building respect and trust, open communication and mutual interdependence among partners. Renault (2006) stresses the importance of institutional transformation and alignment including re-design the rewards and incentives to promote RBSOs, to create trust, and minimise any conflict of commitment between the university and the RBSOs.

Our study identifies technology risk management was an obstacle in year 2004 as lengthy and complicated patent and licensing issues (the score has not decreased when compared with the founding year), and the technology is perceived as too risky which could inhibit the development of RBSOs. Siegel et al (2004) point out that the management of intellectual property itself is in an embryonic stage of development. Universities have limited budgets for filing patents and if universities decide to seek global patent protection, the cost, the procedure and the time involved could be expensive and lengthy. The RBSOs must be equipped with the right skills to manage the technology risk effectively.

Rothaermel and Thursby (2005) show timely graduation from the incubator and improve incubator firms' absorptive capacity to effectively transform university knowledge into firm-level competitive advantages are indicators that RSBOs have surpassed its obstacles.

Means to further develop RBSOs in Hong Kong

Means to further develop RBSOs is well documented in the literature including flexibility in academic terms of employment (Harmon et al 1997), create a commercially entrepreneurial culture (Clarke 1998), establish high-tech clusters and networks (Saxenian 1994), improve the financial support and enhance the business skills (Siegel et al 2003a; Siegel et al 2004) and to develop commercial infrastructure to support spin-offs (O'Shea et al 2005). TTOs can provide a buffer against possible conflict between the commercialization and the research and teaching activities (Debackere and Veugelers 2005), and equip with boundary spanning skills (Siegel et al 2003) to interact among the stakeholders namely universities, the university scientists and the business community. Thursby and Kemp (2002) believed the benefits of building trust among academics towards TTOs can lead to increase in potential technology disclosure.

Our study as shown in part 7 of Table 3 confirms that institutional transformation and alignment are key variables. Business development capabilities and routines of the universities are significant determinants of differences in spin-out activity between universities (DiGregorio and Shane 2003; Clarysse et al. 2005; Lockett and Wright 2005). Bozeman (2000) suggests aligning the reward system in university to encourage the founders of RBSOs. In addition, the RBSOs must have strong support in resources, relationship and routines to equip them with structured training and network, and a centralized body to support RBSOs. Storey and Tether (1998) viewed that RBSOs as a

means of technology transfer is crucial to the long term development of an economy and need to be supported. In our study, longer incubation period of more than 3 years is not considered as an important factor. The role and characteristics of complementary institutions and mechanisms to facilitate successful technology transfer activities to take place, for example financial markets and intellectual property systems, need to be aligned with the universities (OECD 2003).

We now flesh out these overall quantitative and qualitative findings with some case studies of successful spin-off enterprises from all three of the active universities, starting from the oldest and best established spin-offs to the most recent.

5. Case studies of flagship spinoff enterprises

5.1 TeleEye Holdings Ltd (CityU)

The TeleEye group is the oldest and best known of the Hong Kong university spin-off enterprises, founded by CityU in 1994 with a group of engineering faculty led by Professor Cliff Chan. It has since developed a wide range of innovative remote sensing systems that make use of the group's proprietary digital signal processing technology. TeleEye Holdings Ltd was launched on the GEM of the HK Stock Exchange in May 2001 and has established offices in Japan, Singapore, UK, China, Croatia and Philippines.

It took TeleEye 7 years from founding to IPO and demonstrated founder's strong entrepreneurial commitment and company's market-orientated strategies as TeleEye had only one single product initially then the company is effective in expanding its product range and services to capitalise the market demands locally and internationally, build the business routines and network, and expand the channel distribution network worldwide. In spite of the marginal loss (approximately \$75,000) at the 2005/06 third quarterly result, TeleEye should be able to sustain its business in future because of the recent economic upturn and the company is led by a seasoned university-scientists equipped with strong entrepreneurship drive and skills.

5.2 Eco-Tek Holdings Ltd (spinoff from PolyU)

Eco-Tek Holdings Ltd, founded in 1999, equipped with technology developed at PolyU with the unfailing support from the PDO and the university, and the entrepreneurial driving seat taken by an outside investor, Dr Lily Chiang. The group received the New SME Silver Award from the HK Productivity Council in recognition of its being one of the outstanding small or medium-sized enterprises in HK. Mr. Pao, the Managing Director, believed Eco-Tek success is due to its ability to capitalise the imminent market demand from the EPD with the available technology and commitment from the PDO of PolyU, so the company managed to win the government tender value over HK\$24 million and able to supply directly to the customers at the retail stations. The company does not face the same level of obstacles as other RBSOs because of availability of funding, strong entrepreneurial drive, long term commitment and trust between the PolyU and the partners. Mr. Pao served over 30 years in the Chen Hsong Group which was established by Dr. Chiang Chen who is Dr. Lily Cheung's father, in 1958. The Chen Hsong Group is the world's largest manufacturers of injection moulding machines capturing 10 per cent of the

world's market share. Although Dr Lily Chiang left the company over two years ago, the company still manage to grow because of its lean and effective operations in HK and China with strong support from the PDO at the Board level and the committed staff of the company.

5.3 Perception Digital (spin-off from HKUST)

Perception Digital, founded in 1999, is a successful spin-off company from HKUST. The core activity of Perception Digital is the production of chipsets for various kinds of digital storage, including HDD and flash memory, on an MP3 platform design. The company was founded by three professors in 1999: Dr. Jack Lau, Dr. C Y Tsui and Professor Roger Cheng. These founders secured two US patents in the early years. Now, the company has developed many new products and obtained over 10 patents. Dr. Jack Lau is the Chairman of Perception Digital and left the academic position of the university to run the business on a full-time since 2005 whereas the other two professors are still working in the university and serve the company at the board level.

Dr. Lau's strong business mindset, his international networks and extensive experience are critical to the company's survival. The company struggled in its first four years to develop its technologies until the first product was successfully launched in 2002. This is a common experience with start-up companies. Long term commitment and trust among partners are critical as resources are committed over a prolonged period before revenue is obtained. Dr. Lau's international business network, entrepreneurship and management skills and close relationship with customers are key success factors to help his company to grow and develop innovate new chipsets products to fit the customers' requirement. The company has grown to 200 staff and the gross revenue has increased from HK\$140 million in 2004 to HK\$200 million in 2005 with over HK\$200 million projected for 2006. One of the strategic directions of the company is to produce products ahead of their competitors and aim for an IPO within the next few years.

5.4 MaCaPS International Ltd (CityU spinoff)

The business of MaCaPS is smart-card systems, and was founded in 1997 by a CityU professor, Dr L.M. Cheng, initially as a magnetic card company, and secured external investment – but as the global market switched from magnetic card technology to smart card technology, the investor pulled out the funds and left the company stranded. This was a lesson dearly bought. The company then re-established itself, this time with funding of HK\$14 million from the HK Technology Fund, and align with a new focus on smart-card technology.

The company is still under the control of the original founding professor, Dr Cheng, who maintains a dual role as principal of the company and a professor at CityU. The company has successfully bid for leading security systems at government installations such as Immigration Control at HK Airport, where its fingerprint-based ID cards have speeded up immigration procedures from China. The company is poised to make its mark in the global security systems market worth an estimated US\$3 billion in 2004. It aims for an IPO within the next few years.

The key success factor of the company is its ability to product new smart card products utilising smart card technology fit for the customers ahead of their competitors in spite of the sudden financial difficulties. As mentioned earlier, the RBSOs have started with unique resources and competitive advantages in exclusive technology licenses.

Provided the founders and university scientists can capitalize this unique resources and competitive edge and can overcome the inherent obstacles of RBSOs, the future development of these RBSOs companies is promising.

5.5 TA Therapeutics Ltd (HKUST joint venture)

TA Therapeutics is a new joint venture that is wholly owned 50:50 by the Geron Corporation in the US and HKUST through its newly created Biotechnology Research Corporation (BRC), itself established through HK\$175 million donation from the Hong Kong Jockey Club (the original source of the funds to establish HKUST in the first place). The JV builds on a long-term research partnership between Geron, which is a NASDAQ-listed Californian biotechnology company with an advanced telomerase technology platform, and HKUST researchers that have an interest in finding anti-ageing properties in Chinese traditional medicines. These collaborative research activities have identified two such traditional medicines and their properties, which have been isolated and synthesized and now brought to the point where analogs of the active ingredients can be developed that demonstrate even greater efficacy. The TA Therapeutics JV will put the two identified compounds into preclinical development and, in due course, into clinical trials.

This is potentially one of the largest and most significant of the university-related spin-offs to come out of Hong Kong. The striking feature from the perspective of this study is the advanced character of the IP aspects of the deal, and the attention paid by the university to structuring the venture in such a way that maximizes its chances of success and overcome obstacles, for example the technology risk management (including the perception of risky technology and lengthy licensing procedures) and resources constraints (including lack of financial resources and funding, and marketing information) faced by most RBSOs. A reputable and international proven JV partner can overcome the resources constraints and gain access to potential high grown markets for the RBSOs.

6. Concluding remarks

Our study indicates that the HK spin-off phenomenon stands scrutiny with the experiences recorded elsewhere, in the USA, Europe and in countries such as Israel. The overall five-year survival rate of 78.57% of the 56 enterprises studied in this paper is again a sound achievement

Based on our study and the experience of HK spin-offs over the past 15 years, we would list six features of a university spin-offs program as being established beyond doubt. We offer this list of six points as an alternative to those provided for the case of the US by Lerner (2005).

1. The only projects to be backed should be those emanating from the university.

The universities have strong applied research capabilities and RBSOs plays a catalysing role in the technology and knowledge transfer processes of the innovation networks. The HK experience indicates that the university's venture capital enterprises should not be viewed as general investment vehicles, thus competing with financial institutions generally, but exclusively as technology transfer vehicles from the university.

2. Academic entrepreneurs should be guaranteed some equity stake in their ventures.

If the university seeks to hold a large equity position itself in a spin-off venture, then this simply kills the entrepreneurial spirit that the whole scheme of spin-offs is supposed to promote. High entrepreneurship and achievement needs are the primary motivator of founders of RBSOs in our study so institutional framework alignment is needed to allow flexibility within the academic terms of employment to facilitate the growth of RBSOs in creating economic gains and development for the benefits of the university stakeholders including the students and the community at large.

3. The university should provide every assistance to help get the venture started, particularly in linking the academic entrepreneur with potential investors – but not necessarily provide cash.

The experience with university-controlled cash investment funds is mixed, and the university can play a role in assisting new ventures in so many other ways; besides, the academic entrepreneur has to feel cash hunger in order to succeed. On the other hand, joint ventures with leading players are sometimes fuelled if the university can put up some cash. Universities should support the RBSOs so the academic entrepreneurs are equipped with the right business, management, entrepreneur, financial and marketing skills to run the companies effectively and efficiently. Even lack of financial funding is considered as one of the major obstacles, provided the RBSOs can continue developing its core technology, build strong partnership relationship with customers, acquire business routines and networks, overcome issues related to technology risk management and committed long term for the success of the RBSOs, all these are important ingredient to fuel the future success of these hi-tech companies.

4. The university should maintain a seat on the Board for as long as it holds an interest in the venture – but should not seek to intervene in the strategic direction being taken.

The university is entitled to a seat on the Board for as long as the company makes any public attribution of its link to the institution, simply in order to protect its good name and reputation. The venture has to learn to fly with its own wings. Eventually, the RBSOs need to leave the parent institution to fend for themselves, face the challenges of the real business world and to earn its success like any corporate enterprises.

5. The university should exit as soon as convenient, to leave the firm to find its own way in the world of international business.

An equity stake and an exit strategy should enable the university to remove itself from the affairs of the company once it is established, as well as give some prospect of the university actually earning a return on its investment. However, the university should provide a platform to facilitate the new RBSOs to learn the critical success factors from the spin-out companies.

6. The institutional framework should be aligned to support the development of the RBSOs in HK.

Our study reveals that flexibility in academic terms of employment, active support from the universities and the TTOs for new venture formation, changes in the reward system to reflect outstanding performance in commercialising technology, and

increased government funding support to assist the RBSOs at different phases of their development, would be beneficial to the technology transfer and commercializing in HK.

This is an exploratory study on the origins and the dynamics of university spin-off companies in Hong Kong. We see it as generating insights into the development of RBSOs in HK over the past 15 years in one of the most crowded and vibrant international financial centre of the world. The study has highlighted the major issues faced by newly founded firms as well as the technology transfer vehicles established by the leading public universities. As a latecomer to these technology transfer and spin-off venture activities, the HK universities have much to learn from the rest of the world, but also something to teach.

(8644 words excluding abstract, tables and references)

Table 1 List of University Spin-off Companies

<i>CityU Enterprise Associated Companies</i>				
No.	Company Name	Nature of Business	Founding Year	Relation with the University
1.	CityU Research Company*	To support research and spin-off companies	1997	Wholly-owned subsidiary
2.	CityCom Technology Limited*	Telecommunications	1997	Subsidiary Companies
3.	Plasma Technology Limited*	Plasma immersion ion implantation (PIII)	1998	
4.	Genetel Pharmaceuticals Limited*	Genomics-based diagnostic and therapeutic products	2000	Associated Company
5.	City Facility Management Consultancy Limited*	Property and facility management	1994	
6.	MaCaPS International Limited*	Smart-card security systems	1997	
7.	CitySoft (Hong Kong) Limited*	E-commerce	1998	
8.	Digital Content Development Corporation Limited*	Digital content products	1999	
9.	SoftEnable Technology Limited*	Multimedia and workflow management software products	2000	
10.	Bioactive Technologies Limited*	Herbal medicines	2000	
11.	CITINet Systems Limited*	Electronic business systems	2000	
12.	e.Energy Technology Limited*	E-electronic lighting products	2000	
13.	Signal Communications Limited*	Closed-Circuit TV systems	1994	
14.	LangComp Company Limited*	Computer-assisted language learning	1997	Investment
15.	Warren Health Technologies Limited*	Health related technology products	1998	
16.	BonVision Technology (Hong Kong) Limited*	Software technology	1998	
17.	Yantai Integrity Technologies Company Limited*	Wireless communications	2001	
18.	DynaCity Technology (HK) Limited*	Advanced motion controller/driver products.	2003	
19.	Synergicorp Limited*	Intelligent business activity monitoring software	NA	
20.	HiGain-HiTech (HK) Co Ltd. *	Telecommunication antennas and accessories	2003	
21.	CitCon Ltd.*	New materials synthetic lightweight expanded clay and technology solutions	2001	
22.	Newstart (HK) Ltd.	Energy saving products	2004	
23.	CMA-CityU Centre for Entrepreneurial Development Co. Ltd.	Professional consultancy and training for Small and Medium Enterprises (SMEs).	NA	

24.	CityUOS Ltd	Installation of building automation systems	NA	
25.	Shenzhen Goldradio Communication Co. Ltd.*	Telecoms and mobile wireless communications	2002	
<i>The Hong Kong University of Science & Technology Spin-off and Start-up Companies</i>				
1.	Hong Kong Supernet Ltd.*	ISP	1996	Spin-off Company
2.	Asia Vision Technology Ltd.*	Computerized visual recognition technology	1997	
3.	SAR1.com * (previously IMPAS Co. Ltd)	Micropayments by internet	2000	
4.	Veridata Ltd.*	Automated transcription system for court	2000	
5.	Acron International Technology Ltd.*	Environmental and energy management for intelligent buildings	1995	Start-up Company
6.	Pharmaco Genetics Ltd.*	Medical products	1997	
7.	Googol Technology (HK) Ltd.*	Motion Control products	1999	
8.	Integra Antennas Ltd.*	Mobile communications devices	1999	
9.	iSILK.com Ltd.*	Voice recognition	1999	
10.	Perception Digital Ltd.*	Home office products	1999	
11.	Soft Objects (HK) Ltd.*	3D simulation and virtual fitting products	1999	
12.	Tim EDPlatform Ltd.* (was EDPlatform Ltd.)	Information management systems for schools	2000	
13.	eED Vision Ltd.*	On-line interactive training courses	2000	
14.	Global Customization Services Ltd.*	Customize products for internet used	2000	
15.	Micro Web Ltd.*	IT and internet services for SMEs	2000	
16.	Radica Systems Ltd.*	e-sales and e-commerce products	2000	
17.	SinoCDN Ltd.*	CDN technology	2000	
18.	Weniwen Technologies Ltd.*	Voice recognition products	2000	
19.	eAid Media Ltd.*	Multi-media news	2001	
20.	Integrated Microdisplays Ltd.*	Display products	2001	
21.	PenCale Technology Ltd.*	Pen-based handwriting recognition products	2001	
22.	TBCAD Technology Ltd.*	Web-based solutions for building structures	2001	
23.	Bio-Click Technologies Ltd.	Biotechnology	NA	
24.	R & C Biogenius Ltd.	Biotechnology	2005	
25.	Artenano Company Ltd.	Environment nano materials	NA	
26.	Earth-Link Technology Enterprises Ltd.	Environment global scrap tire solution	2000	
27.	Advanced Packaging Technologies Ltd.	New materials and technology solutions	NA	
28.	Brilliant Concept Technologies Ltd.	New materials and technology solutions	NA	

29.	LiteMagic (HK) Ltd.	Innovative LED lighting systems	2003	
30.	Analog Power Ltd.	Application-specific solutions for power management	2002	Start-up companies
31.	Blue Solve Ltd.	Wireless communication and power management ICs.	2002	
32.	MoFinity Ltd.	Wireless application solution provider	2003	
33.	Velda Ltd.	Telecoms and mobile communications	NA	
34.	Workiout New Media Ltd.	Digital entertainment solutions and service provider	2004	
35.	Creative Forex Ltd.	Trading on foreign exchange markets using software solution integration	NA	
36.	Fustec Company Ltd.	Software solution integration	NA	
<i>Hong Kong Polytechnic University spin-off companies</i>				
1.	Eco-Tek Holdings Ltd.*	Environmental hydraulic filters	1999	Spin-off company
2.	Smile Technologies Ltd.*	Multimedia Integration Learning System	2000	
3.	Sun Wah-PearL Linux Limited*	Linux training programmes	2001	
4.	Acumen Environmental Engineering & Technologies Co. Ltd.*	Environmental assessment	2002	
5.	ECL Technology Company Limited*	Optical products and technology	2002	
6.	PolyU TCM Research Institute Ltd.*	Traditional Chinese medicine	2003	
7.	Innover Home Ltd.*	Innovative metal furniture systems	2002	
8.	InnoVech International Ltd.*	Design, development, manufacturing and marketing of petrol and electric 4-wheel driven light vehicles	2003	
9.	Nano-Sports Technologies Ltd.	Development of nano-technologies for clothing application	2004	
10.	Institute for Leadership & Potential Development (Hong Kong) Limited	Experiential learning programmes for education and corporate markets.	2001	
11.	Xi'an Tongli Technology Enterprise Ltd.	Provision of executive training and consultancy	2001	
<i>University of Hong Kong spin-off companies</i>				
1.	mCommerce Online Limited*	Mobile technology GPRS	1998	Spin-off company
2.	i-Security Solutions Limited*	Public key encryption	2000	
3.	Hantak Ortho-Technology Limited	Biomedical	NA	
4.	Hong Kong DNA Limited	Biotechnical	NA	
5.	Enzymes Technology Limited	New materials & technology	NA	
6.	Jenesis Computing Limited	Applied e-security solutions	2002	

7.	Power ELab Limited	Power converter technology and service technology	2004	
8.	Hong Kong Poultry (Kamei Chicken) Development Limited	Development of Poultry products	NA	
9.	HongPharm Limited	Chinese herbal dietary products	NA	
<i>Chinese University of Hong Kong spin-off companies</i>				
1.	Wisers Information Ltd.*	Electronic news	1998	Spin-off company
2.	DINASTech(HK) Limited*	Scalable video-on-demand solution	2001	
3.	PhotoRite	IT solution integration	2003	

* The population of the RBSOs surveyed in this HK study collected from the period covering 1997 to 2004.

Table 2 RBSOs from the Universities in Hong Kong

No.	Company Name	University	Academic Dept.(s)	Business Sector	Founding Year (FY)	No. of employees (FY)	Operational Status as at 2006
1.	LangComp Company	CityU	Chinese, Translation / Linguistics	IT	1997	2	Active
2.	e.Energy Technology	CityU	Electrical & Electronic Eng	Environment	2001	8	Active
3.	DynaCity Technology (HK) Ltd.	CityU	Engineering	Electronics	2003	5	Active
4.	DINASTech (HK) Ltd.	CUHK	Engineering	IT	2001	6	Active
5.	Wisers Information Ltd.	CUHK	Engineering	IT	1998	10	Active
6.	mCommerce Online Ltd.	HKU	Electrical & Electronic Eng.	IT	2002	5	Active
7.	Perception Digital Ltd.	HKUST	Electrical & Electronic Eng.	Electronics	1999	10	Active
8.	Soft Objects (HK) Ltd.	HKUST	Mechanical Eng.	Computer-Aided Design	1999	7	Inactive
9.	SinoCDN Ltd.	HKUST	Computer Science, and EE Eng.	IT and Telecom	2000	13	Active
10.	Micro Web	HKUST	ICT	IT	2000	3	Active
11.	Acron International Technology Ltd.	HKUST	Mechanical Eng.	Energy saving	2000	4	Active
12.	Pharmaco Genetics Ltd.	HKUST	Biochemistry	Biochemistry	2000	8	Active
13.	PenCalc Technology	HKUST	ICT	IT	2001	2	Active
14.	e.Aid Media Ltd.	HKUST	Business	Interactive Media	2001	1	Inactive
15.	Eco-Tek Holdings Ltd.	PolyU	Engineering	Energy/ environmental	1999	2	Active
16.	Smile Technologies Ltd.	PolyU	IT	Multimedia Integration Learning System	2000	8	Active
17.	Sun Wah – Pearl Linux Limited	PolyU	IT	Linex training programmes	2001	10	Active
18.	ECL Technology Company Limited	PolyU	Industrial Systems and Engineering Dept.	Optical lenses and products	2002	10	Active

19.	Innover Home Limited	PolyU	School of Design	Innovative metal furniture systems	2002	6	Active
20.	Acumen Environmental Engineering & Technologies Co. Ltd.	PolyU	Civil and Structural Engineering	Environmental assessment	2002	5	Active
21.	InnoVech International Ltd.	PolyU	School of Design and Partnership Development Office	Petrol and electric 4-wheel driven light vehicles	2003	12	Active
22.	PolyU TCM Research Institute Ltd.	PolyU	NA	Chinese Medicine	2003	4	Active

Table 3 Findings of the Factor Analysis

Part 1 Academic Motivation to Establish the RBSOs

Extrinsic factors	Intrinsic factors
Optimism (-0.93)	High need for achievement (0.94)
To develop second career and future employment (0.92)	Freedom to explore new ideas (0.87)
Monetary reasons (0.90)	
Frustration with academic and university life (0.86)	
Entrepreneurial needs	
To satisfy entrepreneurial needs (0.98)	

Part 2 Change in Company and Customer Profile

	Founding Year		Year 2004		Variance	
	By Universities	By Sectors	By Universities	By Sectors	By Universities	By Sectors
No. of staff	5.5	5.3	17.8	18.6	+ 12.3	+13.3
R & D /Revenue	57.3%	80%	41.1%	57%	- 16.2%	-23%
Large size customers	35.6%	50%	29.5%	40%	- 6.1%	-10%
Medium size customers	30.1%	25%	34.6%	38%	+ 4.5%	+13%
Small size customers	34.3%	25%	35.2%	23%	+ 0.9%	-2%

Part 3 Mode of technology transfer from universities to RBSOs

Founding Year

"Hard" Technology & Skills Transfer	"Soft" Technology & Skills Transfer
Sales or purchase of products / services (0.86)	Consulting (0.74)
Subcontract product development (0.82)	Training in management (0.66)
Cooperation in research (0.82)	Transfer of people (0.61)

Year 2004

Product-oriented Technology Transfer	Service-oriented Technology Transfer
Cooperation in product development (0.94)	Consulting (0.96)
Subcontract product development (0.87)	Patenting and licensing (0.94)
Sales or purchase of products / services (0.74)	
Resource-oriented Technology Transfer	Management Training
Transfer of people (0.95)	Training in management (0.97)
Sales or purchase of products / services (-0.56)	

Part 4 Modes of technology transfer from RBSOs to customers

Founding Year

"Soft" Technology & Skills Transfer	"Hard" Technology & Skills Transfer
Training in management (0.97)	Sales or purchase of products / services (0.86)
Patenting and licensing (0.97)	Subcontract product development (0.86)
Transfer of people (0.82)	Consulting (0.67)

Year 2004

New Product and Technology Development	Enhancement of Existing Technology
Training in management (0.91)	Consulting (0.87)
Cooperation in product development (0.91)	Transfer of people (0.75)
Patenting and licensing (0.90)	Subcontract product development (0.69)
Cooperation in research (0.78)	Sales or purchase of products / services (0.64)

Part 5 Main functions performed by RBSOs

Founding Year

Technology Outsourcing and Channel Development	Value-added Services to Customers
Provision of test / maintenance services (0.93)	Increase customers distribution or management efficiency (0.89)
Marketing and distribution channel (0.86)	Increase customers operation efficiency with consulting (0.72)
Provision of R&D outsourcing services (0.80)	Provision of maintenance services (0.61)
Product Enhancement	
Increase customer operation efficiency with products (0.93)	

Year 2004

Channel Development and Supporting Services	Value-added Services to Customers
Marketing and distribution channel (0.94)	Increase customers operation efficiency with consulting (0.93)
Increase customer operation efficiency with products (-0.82)	Provision of R&D outsourcing services (-0.87)
Provision of maintenance services (0.77)	Increase customers distribution or management efficiency (0.81)
Provision of test / maintenance services (0.69)	

Part 6 Obstacles affecting Technology Transfer of the RBSOs

Founding Year

Entrepreneurship and Business Skills	Partnership and Networking
Lengthy and complicated patent and licensing issues (0.94)	Lack of innovation clusters/ networks (0.90)
Lack of best business practices (0.79)	lack of potential business partners information (0.72)
Lack of entrepreneurial skills (0.78)	Lack of financial resources and funding (0.72)
	Lack of marketing information (0.71)
Long Term Commitment	
Lack of trust among partners (0.87)	
Lack of time to develop technology further (0.72)	
Small market size (0.70)	

Year 2004

Technology Risk Management	Long Term Commitment and Synergy
Lengthy and complicated patent and licensing issues (0.94)	Lack of trust among partners (0.95)
The technology is perceived as too risky (0.79)	Lack of potential business partners information (0.83)
Business Routines and Networks	Resources Constraints
Lack of best business practices (0.92)	Lack of financial resources and funding (0.73)
Small market size (0.76)	Lack of marketing information (0.72)
Lack of innovation clusters/ networks (0.55)	

Part 7 Means to further develop RBSOs in Hong Kong

Institutional Transformation and Alignment	Resources, Relationship and Routine Support
Active support from universities and industries (0.96)	Structured training & network to support RBSOs (0.89)
Flexibility in academic terms of employment (0.94)	Set up a centralized body to support RBSOs (0.89)
Government funding and infrastructure support (0.94)	Longer incubation period more than 3 years (-0.78)

References

- AUTM 2004. *Licensing Survey FY 2004: A survey summary of technology licensing (and related) performance for U.S. academic and nonprofit institutions and technology investment firms.* Northbrook, Illinois, Association of University Technology Managers.
- Baldini, N., Grimaldi, R., Sobrero, M. 2006. Institutional changes and the commercialization of academic knowledge: A study of Italian universities' patenting activities between 1965 and 2002, *Research Policy*, 35: 518-532
- BankBoston, 1997, *MIT: The Impact of Innovation*, Boston: BankBoston.
- Barney, J., Wright, M., Ketchen, D., 2001. The resource based view: ten years after 1991. *Journal of Management*, 27 (6): 625-642
- Birley, S (2002). Universities, academics and spinout companies: lessons from Imperial. *International Journal of Entrepreneurial Education*. 1(1): 1-21
- Bozeman, B. 2000. Technology transfer and public policy: a review of research and theory. *Research Policy*, 29: 627-655
- Brush, C.G., Greene, P.G., Hart, M.M., 2001. From initial idea to unique advantage: the entrepreneurial challenge of constructing a resource base. *Academy of Management Executive*, 15 (1): 64-78.
- Bower, D. 2003. Business model fashion and the academic spinout firm, *R&D Management*, 33 (2): 97-105.
- Carayannis, E.G., et al, 1998. High-technology spin-offs from government R&D laboratories and research universities. *Technovation*, 18(1) : 1-11
- Clarke, B. R., 1998. *Creating Entrepreneurial Universities; Organizational Pathways of Transformation*. IAU Press, New York
- Chiesa, V., Piccaluga, A. 1998. Transforming rather than transferring scientific and technological knowledge – the contribution of academic 'spin out' companies: the Italian way. In R. Oakey and W. Daring (ed). *New technology-based firms in the 1990s*. vol. V. London, Paul Chapman: 15-31.
- Chiesa, V., Piccaluga, A. 2000. Exploitation and diffusion of public research: the general framework and the case of academic spin-off companies, *R&D Management*, 30, 329-340
- Clarysse, B., Heirman, Ans., Degroof, J.J. 2001. An institutional and resource-based explanation of growth patterns of research-based spin-offs in Europe. OECD 2001. *STI Review 26*, Special issue on fostering high-tech spin-offs: a public strategy for innovation.
- Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. 2005. Spinning-out new ventures: A typology of incubation strategies from European research institutions, *Journal of Business Venturing*, 20 (2): 183-216.
- CIT 1999. Commission on Innovation and Technology, *Second and Final Report*, Hong Kong SAR..
- CSD 2000. Commission on Strategic Development, *"Bringing the Vision to Life"* on Hong Kong's Long-Term Development Needs and Goals, Hong Kong SAR.
- Covin, J.G. and Slevin, D.P., 1991. A conceptual model of entrepreneurship and firm behaviour. *Entrepreneurship Theory and Practice*, fall, 7-25
- Dahlstrand, A.L. 1997. Growth and inventiveness in technology-based-spin-off firms. *Research Policy*, 26: 331-344

- Debackere, K. and Veugelers, R. 2005. The role of academic technology transfer organizations in improving industry science links. *Research Policy*, 34: 321-342.
- DiGregorio, D. and Shane, S. 2003. Why do some universities generate more startups than others? *Research Policy*, 32: 209-227.
- Dubinskas, F.A. 1988. Janus organizations: scientists and managers in genetic engineering firm. In: F.A. Dubinskas (ed.) *Making time, ethnographies of high-technology organizations*. Temple University Press, Philadelphia.
- Eastham, T.R., 2003. Entrepreneurship in Hong Kong, *Tech Monitor*, May-June, 36-41
- Etzkowitz, H., Wester. W., Gebhardt, C., Cantisano Terra, B.R., 2000. The future of the university and the University of the Future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, 29: 313-330
- Fontana, R., Geuna, A., Matt, M. 2006. Factors affecting university-industry R&D projects: The importance of searching, screening and signalling. *Research Policy*, 35: 309-323
- Fontes, M. 2003. A closer look at the process of transformation of scientific and technological knowledge as conducted by academic spin-offs. In R. Oakey and W. Durning and S. Kauser (ed). *New technology-based firms in the new millennium*. vol. II. Amsterdam, Pergamon.
- Franklin, S.J., Wright, M. and Lockett, A. 2001. Academic and surrogate entrepreneurs in university spin-out companies. *Journal of Technology Transfer*, 26: 127-141.
- Gerschenkron, A. 1962. *The Latecomer in History*. Cambridge, MA: The Belknap Press at Harvard University Press.
- Grandi, A. and Grimaldi, R. 2005. Academics' organizational characteristics and the generation of successful business ideas. *Journal of Business Venturing*, 20: 821-845.
- Hansen, E.L. 1995. Entrepreneurial network and new organization growth. *Entrepreneurship: Theory and Practice*, vol. 19: 55-82
- Harmon, B., Ardishvili, A., Cardozo, R., Elder, T., Leuthold, J., Parshall, J., Raghian, M., Smith, D. 1997, Mapping the university technology transfer process. *Journal of Business Venturing*, 12: 423-434.
- Human, S.E., Provan, K.G. 1997. An emergent theory of structure and outcomes in small-firm strategic manufacturing networks. *Academy of Management Journal*. Vol.40: 368-403
- Lambrecht, W.H., Teich, A.H. 1976. Technology transfer as a problem in interorganizational relationship. *Administration and Society*, 8(1):29-54
- Lerner, J. 2005. The university and the start-up: Lessons from the past two decades. *Journal of Technology Transfer*, 30 (1/2): 49-56.
- Leydesdorff, L. and Etzkowitz, H. 2001. The transformation of university-industry-government relations. *Electronic Journal of Sociology*, 5 (4): 1-17.
- Link, A.N. and Scott, J.T. 2005. Opening the ivory tower's door: An analysis of the determinants of the formation of U.S. university spin-off companies. *Research Policy*, 34: 1106-1112.
- Link, A.N. and Siegel, D.S. 2005. University-based technology initiatives: Quantitative and qualitative evidence. *Research Policy*, 34: 253-257.
- Lockett, A., Wright, M. 2005, Resources, capabilities, risk capital and the creation of university spin-out companies. *Research Policy*, 34: 1043-1057
- Mian, S.A. 1997. Assessing and managing the university technology business incubator: an integrative framework. *Journal of Business Venturing*. 12:251-285

- Markman, G.D., Gianiodis, P.T., Phan, P.H., Balkin, D.B. 2005, Innovation Speed: Transferring university technology to market. *Research Policy*, 34: 1058-1075
- Mathews, J.A. and Hu, M.-C. 2006. Enhancing the role of universities in building national innovative capacity in East Asia: The case of Taiwan, *World Development* (forthcoming).
- McDonald, D.W., Geiger, S.M. 1987. Making cooperative research relationship work. *Research Management* 30 (4):38-41
- McQueen, D. and Wallmark, J 1982, Spinoff companies from Chalmers University of Technology. *Technovation*, 1, 305-15
- Meseri, O. and Maital, S. 2001. A survey analysis of university-technology transfer in Israel: Evaluation of projects and determinants of success, *Journal of Technology Transfer*, 26: 115-126.
- Mok, K.H. 2005. Fostering entrepreneurship: Changing role of government and higher education governance in Hong Kong, *Research Policy*, 34: 537-554.
- Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N. 2006. Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35: 289-308.
- Nishizawa, A., 2003 Current situation of venture finance for university spin-off companies in Japan, *Systems and Policies for the Global Learning Economy*. The University of Texas of Austin.
- Oakey, R. 1994. *New Technology-based Firms in the 1990s*. Paul Chapman, London.
- Oakey, R. 1995. *High-technology new firms: variable barriers to growth*. Paul Chapman, London.
- OECD 2001. STI Review 26, Special issue on fostering high-tech spin-offs: a public strategy for innovation.
- OECD 2003. *Turning science into business, patenting and licensing at public research organizations*. OECD publications, Paris.
- O'Shea, R.P., Allen, T.J., Chevalier, A. and Roche, F. 2005. Entrepreneurial orientation, technology transfer and spinoff performance at U.S. universities. *Research Policy*, 34: 994-1009.
- Penrose, E.T. 1959. *The theory of growth of the firm*. Oxford. Blackwell
- Perez, M.P. and Sanchez, A.M. 2003. The development of university spin-offs: early dynamics of technology transfer and networking, *Technovation* 23, 823-831
- Porter, M., 1985. *Competitive Advantage: Creating and sustaining superior performance*. New York, Free Press.
- Porter, M., 1991. Towards a dynamic theory of strategy. *Strategic Management Journal*, vol. 12, 95-117
- Renault, C.S. 2006. Academic capitalism and university incentives for faculty entrepreneurship. *Journal of Technology Transfer*, 31: 227-239.
- Roberts, E., 1990. Evolving toward product and market orientation: the early years of technology-based firms. *Journal of Product and Innovation Management* 7 (4): 274-287
- Roberts, E., 1991. *Entrepreneurs in high technology: lessons from MIT and beyond*. Oxford University Press. New York.
- Radosevich, R. 1995. A model for entrepreneurial spin-offs from public technology sources. *International Journal of Technology Management*, Vol. 10, Nos. 7/8: 879-893.

- Rothaermel, F.T. and Thursby, M. 2005. University-incubator firm knowledge flows: assessing their impact on incubator firm performance. *Research Policy*, 34: 305-320.
- Samsom, K.J. and Gurdon, M.A. 1993. University scientists as entrepreneurs: a special case of technology transfer and high-tech venturing. *Technovation*, 13:2 63-71
- Shane, S. 2004. *Academic Entrepreneurship*. Edward Elgar
- Shah, W., 1990. An empirical analysis of organizational strategies by entrepreneurial high-technology firms. *Strategic Management Journal*, vol. 11: 129-139.
- Saxenian, A., 1994. *Regional Advantage: Culture and competition in Silicon Valley and Route 128*. Harvard University Press, Cambridge, MA.
- Siegel, D.S., Waldman, D. and Link, A. 2003. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. *Research Policy*, 32: 27-48.
- Siegel, D.S., Waldman, D. and Link, A. 2003a. Improving the effectiveness of commercial knowledge transfers from universities to firms. *Journal of High Technology Management Research*, 14, 111-133.
- Siegel, D.S., Waldman, D., Atwater, L., Link, A.N. 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. *Journal of Engineering and Technology Management*. 21: 115-142
- Steffensen, M., Rogers, E.M. and Speakman, K. 1999. Spin-offs from research centres of a research university. *Journal of Business Venturing*, 15: 93-111.
- Storey, D.J., Tether, B.S., 1998. Public policy measures to support new technology-based firms in the European Union. *Research Policy*, 26: 1037-1057
- Thursby, J.C., Jensen, R. and Thursby, M.C. 2001. Objectives, characteristics and outcomes of university licensing: A survey of major U.S. universities. *Journal of Technology Transfer*, 26: 59-72.
- Thursby, J., Kemp, S., 2002. Growth and productive efficiency of university intellectual property licensing, *Research Policy*, 31: 109-124
- Vohora, A., Wright, M., Lockett, A., 2004, Critical junctures in the growth in university high-tech spinout companies. *Research Policy*, 33: 147-175.
- von Hippie, E., 1988. *The Source of Innovation*, New York, Oxford University Press
- Walter, A., Auer, M. and Ritter, T. 2005. The impact of network capabilities and entrepreneurial orientation on university spin-off performance, *Journal of Business Venturing*, 21 (4): 541-567..
- Wright, M., Lockett, A., Clarysse, B. and Binks, M. 2006. University spin-out companies and venture capital *Research Policy*, 35: 481-501.
- Zahra, S.A. 1993. Environment, corporate entrepreneurship and financial performance, a taxonomic approach. *Journal of Business Venturing*, 8: 319-340