Origins and Dynamics of University Spinoffs: The case of Hong Kong

Ming Chu Leung* and John A. Mathews**

September 2010

* Ming Chu Leung
  Post-doctoral research associate
  Macquarie Graduate School of Management
  Macquarie University
  Sydney NSW 2109   Australia
  Telephone:  852 2727 9621
  Fax:  852 2727 9620
  Email  leungmingchu@gmail.com

** Professor John A. Mathews
  Eni Chair of Competitive Dynamics and Global Strategy
  LUISS Guido Carli University
  Viale Romania 32   00197 Roma   Italy
  Tel +3906 8522 5504
  Fax +3906 8522 5985
  Email jmathews@luiss.it
  Web:  http://docenti.luiss.it/mathews/
Abstract

This paper reviews the experience of Hong Kong’s university-based spin-offs and start-up enterprises established by five universities in Hong Kong over the past decade and a half. It focuses on these enterprises at both the early stage of their development and again at the later stage after they have been operating for a few years. A principal finding is that Hong Kong spin-offs and start-ups have a relatively high survival rate of 73% for the first five years of their operation. The study investigates issues identified from the literature which include the motives for university scientists in developing the enterprises and the changes in the profile of these enterprises. It compares the experience of these enterprises in Hong Kong with those found elsewhere outside the Asia-Pacific region. The paper focuses on the technology transfer processes, practices, and obstacles faced by the companies, to probe more deeply into the finding of a relatively high rate of company survival. The strength of this study and its conclusions are based on its analysis of primary data collected from the total population of research-based spin-offs and start-up companies spun off from five universities in the period of 1991 to 2004 (with some partial updating to 2008). We postulate that the pattern of spin-offs pursued by the universities of HK falls into three broad models, and that the HK experience provides a ‘natural experiment’ for their efficacy; however our conclusions as to which model seems to work best, and which is most generalizable, are necessarily cautious.

Keywords: Hong Kong; university spin-offs; technology transfer; technology transfer offices; entrepreneurship
1. **Introduction**

Universities in Hong Kong are contributing to the transformation of the global city from trade hub to innovation hub (Baark and Sharif 2006). Along with other measures, the spinning-off of enterprises initiated by university faculty is contributing to the innovation dynamism of Hong Kong. Since Hong Kong universities became active in this sphere in the 1990s, over 100 such university spin-off enterprises (USOs) have been launched, and one has achieved celebrity in Hong Kong through its public listing on the Hong Kong Stock Exchange. To date there have been few studies of the university spin-off phenomenon in Hong Kong (with some notable exceptions such as Mok, 2005, Poon and Chan, 2007, Sharif and Baark, 2008) although there has accumulated much scholarship on the experiences of universities outside the Asia-Pacific region.

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 or actively promoting new ventures that embody this technology, has come to be widely noted (Rosenberg and Nelson 1994; Mian 1997; Leydesdorff and Etzkowitz, 2001; Di Gregorio and Shane, 2003; Benneworth and David, 2005; Lerner, 2005; Mueller, 2006; Renault, 2006; Wright, et al., 2006; Mathews and Hu, 2007; Bramwell and Wolfe, 2008; Debroux, 2008; Bathelt, et al., 2010; Vincett, 2010). The literature encompasses experiences from USA (OECD 2003; AUTM FY2008; Acworth. 2008; Lehrer et al. 2009; Yusof and Jain, 2010), from Europe (Clarysse et al. 2005; Walter et al. 2005) from the UK (Franklin et al. 2001; Siegel et al. 2008; Mustar and Wright, 2010), and R&D-rich countries such as Israel (Meseri and Maital, 2001). There have also been a few experiences reported from the Asia-Pacific region (Lee and Win, 2004; Baark and Sharif 2006; Eun et al. 2006; Woolgar, 2007; Chang et al. 2009 ; Eoma and Leeb, 2010) which provide benchmarks for the HK experience.
Supported by a series of government initiatives to promote innovation in the 1990s, five universities in Hong Kong established infrastructure to support the innovative initiative of technology transfer. The City University of Hong Kong (CityU) was the first to form a Technology Transfer Office (TTO) in 1991, in the form of CityU Enterprise Ltd. Since then and especially under the impact of Hong Kong’s drive for high tech development (CIT1999; CSD 2000) other universities have become active in the field, namely Hong Kong Polytechnic University (PolyU) through its Partnership Development Office of the Institute for Enterprise; and the Hong Kong University of Science and Technology (HKUST) through its enterprise arm, HKUST Technology Development Corporation (TDC). The other two TTOs from the oldest universities in Hong Kong are Versitech of the University of Hong Kong (HKU), and Centre for Innovation and Technology (CINTEC) 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 from the other two universities in Hong Kong. Thus it is timely to subject this experience, in one of the world’s most dynamic and competitive cities and financial centres, to a review and evaluation.

In this article we offer a review of USOs originating from Hong Kong universities. We have the advantage that many of the issues involved have now been discussed in the scholarly literature, such as the knowledge flows generated (Mowery and Sampat 2006), the technology transfer process itself (Perez and Sanchez, 2003), and the various approaches adopted to the spin-off process by institutions in generating USOs as discussed by Clarysse et al. (2005), Mustar et al. (2006); Mustar and Wright (2010). We have reviewed the entrepreneurial university model (Wong, 2007; Bramwell and Wolfe, 2008; Rasmussen and Borch, 2010), and the academic entrepreneurship literature and framework as proposed by Djokovic and Souitaris (2006), Rothaermel et al. (2007); O’Shea et al. (2008). These sources provide useful frameworks for fresh reviews such as ours.

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 each has pursued. We then analyse and validate the findings using
triangulation approach including statistical tools and in-depth case studies of selected
‘flagship enterprises’ and the TTOs. We conclude by setting our findings in the wider
context of 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 Di Gregorio and Shane (2003), TLO spin-
offs are created when the licensee of a university-assigned invention creates a new
company to exploit it (Di Gregorio and Shane, 2003: 210) and the new spin-off is based
on the intellectual assets of the parent organization (Birley, 2002). USOs can contribute
positively in terms of the educational opportunities and incentives created for the
benefits of the academic scientists, the students, the graduates, and the sponsoring
universities (Becker and Gassmann, 2006); and to develop a third stream of financing in
UK (Mustar and Wright, 2010). Oakey (1994, 1995) identified USOs as one of the two
major sources of technology-based firms. 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 such as PolyU’s
spin-off, Eco-Tek (Franklin et al. 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, 2000; Fontes, 2003). Most institutions have now settled on
various kinds of arms-length vehicles for such activities, such as TTOs or 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 (Mustar et al. 2006). We prefer the term university spin-off (USO) enterprises.

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, we can specify four factors that can be expected to influence the rate and scale of formation of TLO spin-offs and their success (Di Gregorio and Shane 2003). Based on data collected on all start-ups across the US for the years 1994 to 1998, these authors found 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. This might not be the case as evidenced in this study that the USOs must overcome the obstacles of funding and capabilities to provide products or service required by the markets to survive. Our study takes the Di Gregorio and Shane (2003) approach as a starting point.

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). We build on the insights 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.

All of the universities in Hong Kong are publicly funded so there is strong guiding principle that public money cannot be used to subsidise private profits. This leads to a general approach where, in the pursuit of USOs, founders are expected to raise their own capital (at this early stage normally external venture capital funding is not available) and universities tend to set a ceiling on the amount of ‘seed money’ to be invested in the spin-off companies; in turn universities have established clear management guidelines to protect their interests in the representation in the Board of Directors of the respective USOs. For example, the HKUST has established its
Entrepreneurship Program and dedicated space to an incubation facility since 1999, while the university’s R&D Corporation manages a Venture Capital Fund to help launch USOs. The University through HKUST RDC takes a 3% share of equity in companies accepted into the Program. On the other hand, the PolyU can invest and own up to 50% of the USOs so that their performance could be subjected to public scrutiny and allow the university to influence the strategic direction taken in technology transfer process and the development of USOs. The latest development is the Independent Review Report released from PolyU in August 2010 which included recommendations to put a stop to further cash investment and avoid the university taking directorship in the USOs because of staff and public unease. Other universities have also established infrastructure to support the USOs however the guiding principle of demarcation between public and private funds applies.

In pursuit of innovation generally, the HKSAR has established an Innovation and Technology Fund (ITF) to provide funding support to projects that contribute to innovation and technology upgrading and development in industry. By June 2010 the ITF had injected over half a billion US dollars (US$578 million) into such projects. Inherent in the design of the ITF projects intended for the public good is that support will be provided for USOs activities on campuses. The recipient organization has the right to own all intellectual property (IP) arising from the project and in return is required to make available to local companies the project results through workshops, seminars, licensing or consultancy arrangements. The general principle is that all interested local companies should have equal access to the project results on equal terms (Au et al. 2001). In our interviews with the founders of the USOs -- for example Eco-Tek Holdings Ltd., MaCaPS International Ltd., Wisers Information Limited, mCommerce Online Limited, and SMILE Technologies Ltd -- all agreed that the ITF had helped them at critical formative stages to develop, to research and to patent the technology needed for the commercialization process. However, scholars such as Baark and Sharif (2006) argue that the HKSAR must move forward from the ‘outmoded innovation concepts’ based on the ‘linear paradigm’ of high technology innovation, a model that has been increasingly questioned in recent decades.
We find that the three sponsoring organizations with the largest numbers of USOs 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 with proven technology that has been licensed. The university takes a small equity position in the USOs and IP rights are transferred to the USOs in exchange for the university’s small equity stake. There is by contrast the maximalist approach, where the university actively seeks out prospective new ventures and investors, and takes an active role in driving the innovation speed (Markman et al. 2005). The university takes an equity position at a higher level than in the minimalist mode and plays a stronger role in the anticipated future growth of the enterprise.

Then there is a third approach, that in Confucian terms appropriate to this study we may call the middle way, 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 USOs to find its own strategic direction with a view to securing a relatively early exit and transferring IP rights to the company.

Our typology is 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. Thus, in this study we are concerned with the underlying resources transferred from the university (knowledge capital and its expression as IP 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 in Hong Kong with regard to USOs.
3. **University spin-offs in Hong Kong: A decade and a half of experience**

By 2007, with more than 16 years of experience behind them, Hong Kong universities had spun off at least 84 enterprises. The universities started as latecomers to entrepreneurial endeavours and to the formation of various kinds of technology transfer institutional support mechanisms (Eastham, 2003; Mok, 2005; Baark and So, 2006; Sharif and Baark, 2008). They were able to learn from the more evolved models that had been developed in Europe, the US and Japan. Just how they have learnt and what they have learnt provides the background of our study. A listing of the 84 University Spin-Off (USO) enterprises from all five universities in Hong Kong (see Table 1).

Table 1 about here

### 3.1 City University of Hong Kong (CityU)

The first mover in HK to adopt an entrepreneurial institutional process was CityU which formed the CityU Enterprises Ltd in 1991. CityU thus has 16 years of experience with spin-offs and technology transfer. By 2007 the university had launched 25 spin-off companies and has developed a series of evaluation criteria for screening ventures to assess their commercial potential. One of the more outstanding ventures created by CityU Enterprises Ltd has been TeleEye Holdings Ltd. *(TeleEye)* -- the first company to be nurtured from incubation to listing on the Growth Enterprise Market (GEM) of the Hong Kong Stock Exchange. The historic listing in May 2001 raised HK$ 23 million, giving the company a substantial capital injection. Another successful spin-off enterprise is MaCaPS International Limited, founded in 1997, and which continues to grow and successfully win contracts to install security systems at government installations such as Immigration Control at the Hong Kong Airport.

### 3.2 Hong Kong Polytechnic University (PolyU)
The next Hong Kong tertiary institution to engage in entrepreneurial activities was PolyU, through its Institute of Enterprise. The university secured its first patent in 1996, and now has more than a decade of experience in managing an IP portfolio. Its best-known spin-off is Eco-Tek Holdings (Eco-Tek), a firm which is engaged in producing innovative environmental protection products and services. When Eco-Tek was listed on the GEM index of the Hong Kong Stock Exchange in 2001, the Initial Public Offering (IPO) was sixty-times over-subscribed, representing a total value of HK$ 2 billion. The company was able to secure a government tender early in its life, enabling it to become established.

3.3 Hong Kong University of Science and Technology (HKUST)

The third in line to adopt an entrepreneurial approach was HKUST, the youngest university, being founded only in 1991. Hong Kong Supernet Ltd. was one of the first clusters of USOs incubated and launched in 1996 and was successfully spun-off and sold by the university the same year. By 2005 and by applying the ‘faculty driven’ model, HKUST had launched more than 50 enterprises – amongst them Perception Digital, founded in 1999 and since grown to employ over 250 staff with gross revenue over US$25 millions. HKUST then evolved a new ‘venture development’ model, under which the importance of a partner’s joint-venture capabilities becomes more highly valued than the simple provision of venture capital. This model is illustrated by the formation of TA Therapeutics (TAT), a joint-venture partnership with the Geron Corporation announced in March 2005 and since acquired by Geron. This was hardly a favourable outcome for HKUST.

3.4 University of Hong Kong (HKU)

Established in 1910, HKU is the oldest university in Hong Kong and is considered to be the most well funded university in the region. Formed in 1998, HKU’s wholly owned subsidiary Versitech serves to bring university IP to market and focuses on IT and biotech sectors. The original model of Versitech was to provide ‘one-stop service’ to HKU’s USOs and adopting the ‘surrogate entrepreneur’ model (Radosevich, 1995). One of the successful USOs under this arrangement was mCommerce Online
Limited, founded in 1999 by Versitech Limited and spun off from HKU in 2002. In September 2006, a new TTO reporting to the Pro-Vice-Chancellor (Research) was established to serve operations related to technology transfer, legal and liaison activities; while the commercial operations remained under Versitech which continues to operate as an independent entity reporting to its Board of Management.

3.5 Chinese University of Hong Kong (CUHK)

The CUHK is the second oldest university in Hong Kong, founded in 1963. In 1998, the university established the Research and Technology Administration Office to support R&D contracting, technology transfer, and IP rights. A more focused vehicle was then established in the form of the Centre for Innovation and Technology (CINTEC) in 1999. One of the successful CINTEC graduates is Wisers Information Limited, founded in 1999 and successfully spun-off and with the IP rights bought back from CUHK in 2002. While the total number of USOs established is small (currently three) the five-year survival rate of the first two CINTEC spin-offs is 100%.

We found that the overall five-year survival rate of the 41 enterprises studied in this paper is 73.2% -- a figure that stands, we believe, as a sound achievement compared with earlier experiences (see Table 2). We believe that this high proportion would carry over to the other firms in our sample, given the entrepreneurial disposition of Hong Kong firm founders. One of the goals of our research study was to seek to identify the possible reasons for this high survival rate of USOs in Hong Kong.

Table 2 about here

4. Study methodology and results

Our study addresses directly the full population of 84 USOs in Hong Kong covering the period 1997 to 2004 (with partial updating to 2008) giving us more robust findings than in a sample-based study. A study population of 56 enterprises was selected based on the information obtained from the TTOs of the five research
universities as some enterprises had already disappeared; they were not available for the study. According to Zhang (2009) empirical investigations on USOs are constrained by the limited availability of data. However we managed to contact a few founders of failed USOs and reasons given were unanticipated downturn in the economy during this period adversely affected the funding sources, demand overload (Clark, 1998), insufficient institutional support and underestimated the time and resources needed from inception to commercialisation of inventions. The primary data was actually collected from 22 of the firms. This was an excellent response rate given the difficulties of studying spin-offs in Hong Kong in a setting of fast-paced business and unwillingness of some founders or managers to disclose sensitive data concerning their enterprises. Our criterion for success of these USOs is the relatively limited notion of survival (at least up to 2008); we recognize that this is not a particularly insightful criterion, but we judge it to be sufficient for this preliminary study. A preliminary pilot study of the questionnaire was carried out to ensure greater accuracy and sensitivity for the Hong Kong setting. The primary data analysed was collected from case studies, questionnaire surveys and structured interviews (held in March 2002 up to June 2008) with founders or senior management staff of USOs. The triangulation research process helped us to establish, to verify and to confirm the findings. We aimed at maximize the rigour with which we conducted this research study to ensure that the findings are internally and externally validated.

We gathered primary data ourselves and analysed using statistical techniques which are the analysis of variance (ANOVA) and Factor Analysis with Varimax Rotation\(^1\) of the Statistical Package for Social Sciences (SPSS 15.0) of seven issues identified (from the literature) as being significant, and backed by in-depth eight case studies of these USOs launched between 1991 and 2004, and two TTOs.\(^2\)

The study focuses on seven basic research questions which deal with the following issues: (1) the motives for the university scientists in developing the USOs in Hong Kong; (2) the profile of the USOs in Hong Kong; (3) the modes of technology

\(^1\) Varimax rotation is a variance maximizing procedure to enable more meaningful interpretation of the data set gathered in this research study.

\(^2\) Details of the case studies can be supplied by the authors upon request.
transfer from the parent universities to the USOs; (4) the modes of technology transfer from the USOs and their links to the customers; (5) the obstacles affecting the technology transfer of the USOs; (6) the main functions performed by the USOs; and (7) the means to support the future development of USOs in Hong Kong. These seven questions are consistent with our reading of the literature on USOs and the factors involved in their success and failure. The knowledge and findings gained in this study could help to reduce the failure rate; help to build a better understanding of the spin-off process, identifying the obstacles, and improving the institutional framework to support the future development of USOs in Hong Kong. The seven factors identified, and our findings in Hong Kong, are presented as follows.

4.1 Motives for university scientists in developing USOs

The motives for university scientists in developing the USOs were complex (Stefan and Mueller, 2009). Motivation is important factor for university scientists to develop USOs, which is legally allowed since 1999/2000, in China (Kroll, 2009). According to the literature, extrinsic needs are not the primary motivator as documented by Roberts (1991) in the Chalmers Institute of Technology survey. In our Hong Kong study, four variables (namely higher need for achievement[0.7531], monetary reasons [0.8309], desire to develop second career and future employment [0.7300], and frustration with academic and university life [0.8067]) could be explained by both extrinsic and intrinsic satisfaction, and we confirmed these findings in the interviews conducted.

4.2 Profile of the USOs: originating faculty, staffing level, investment in R&D, and size of customers

The issues included whether some faculties generated more USOs than others, and whether the number of staff, the investment in R&D, and the size of customers had changed over the study period. Perez and Sanchez (2003) found the USOs invested more than 10% of turnover in R&D projects and new technologies which was higher

---

3 The bracket [ ] shows the factorial loadings of the factors after being analysed by Factor Analysis with Varimax Rotation of SPSS 15.0
than for non-USOs. We found in Hong Kong that 45.5% of the USOs belonged to the Engineering Discipline, followed by the IT, and Business Disciplines of 22 companies surveyed. The average increase in headcount was 16 from the founding year to year 2006. Table 1 shows that the total number of employee headcount increased from 133 to 493 between the measurement points from the founding year to the year 2006 represented a significant increase of 270.68%. The result indicates that one of the benefits of the USOs is to create local employment opportunities. The result is consistent and supports the belief on the positive impact of USOs (Steffensen et al. 1999) in creating jobs and taxable wealth in the local community.

On the issue of R&D intensity, we found that the percentage of R&D expenditure relative to sales was high at the founding year, with a weighted average of 58.6% but that by fiscal 2006, this ratio had fallen to 37.2%. These findings are consistent with research literature, which reveals that a common feature of USOs is a high level of research intensity exceeding 10% (Perez and Sanchez, 2003). Our results are also consistent with the literature finding that USOs initially focused on large size customers (Perez and Sanchez, 2003) but that their future development depends on their ability to customize their products and services to meet the market needs (von Hippel, 1988).

Table 3 about here

4.3 **Mode of technology transfer from parent universities to USOs**

The dynamics of technology flow, as generated by different technology transfer mechanisms from the parent universities to USOs and thence to their customers (discussed in the next section) are considered important in this research. There are some empirical studies conducted on this theme (Perez and Sanchez, 2003; Link and Siegel, 2005). For example, Dahlstrand (1997) found that after an initial ten-year period, research-based start-ups grew significantly faster than non-research-based start-ups. Strong identification with the university is beneficial to the USOs (Roberts, 1991; Harmon et al. 1997; Dahlstrand, 1997; Zhang 2009; Bonardo, et al. 2010) and can
facilitate faster innovation rates (MacPherson, 1998). Most Japanese USOs keep close relationships with their original university especially in technological issues (Tsukuba Daigaku, 2004) and the new ventures are established faster when there has been high-level technology transfer and the founders have sustained access to university infrastructure (Muller 2010). In our HK study we found that 86.4% of the founders of USOs surveyed had strong identification with the respective university as their parent organization. The modes of technology transfer from the parent universities to the USOs were different between the founding year and the fiscal year 2006. At the initial stage, the technology and skill transfer process could be categorized into ‘hard’ with emphasis on product and service development, and ‘soft’ with emphasis on management of human capital. University scientists lack management expertise (Samsom and Gurdon 1993) even they are experts in their respective field so training in management is important to assist the founders of USOs to operate. Our results indicate that after the USOs operated for a few years and managed to build on its core competence, the modes of technology transfer have changed and could be classified into two main types namely the product-oriented and service-oriented technology transfer process. Our result is consistent with the literature on the development of the spin-offs (Clarysse et al. 2001) that when the USOs progressed to the second or ‘aware’ phase, consulting has increased in its important under service-oriented technology transfer with a factorial loading of 0.96 in year 2006 as shown in Table 3.1.

4.4 Mode of technology transfer from USOs and their links to customers

After a few years in operation, the mode of technology transfer from the university to USOs tend to change as they start as a one-product company and evolve into a customer-driven technology company featuring product and service innovation (von Hippel, 1988; Chiesa and Piccaluga, 2000; Mustar et al. 2006). The success of USOs depends on their resources and capabilities in managing the different phases of spin-offs development (Penrose, 1959; Clarysse et al. 2005). When compared to counterparts in the West, the Chinese universities in China (for example Fudan University and Shanghai Jiaotong University) are less active in utilizing market
mechanisms of technology transfer such as licensing and technology sales. This could be attributed to the weak domestic demands for innovative products and services, and less developed local innovation environment (Wu, 2010). In order to enhance their sustainability and competitive advantage, the start-ups tend to develop closer partnership relationships with customers; hence the technology employed tended to evolve towards market orientation from its initial product orientation (Roberts, 1990; Perez and Sanchez, 2003; Tijssen, 2006). Our results are consistent with the literature that the strategic approach of USOs shifted from technology-driven (at the earlier inception stage) to market-driven in the later stage in order to reduce the chance of market failure as shown in Table 3.2 (Olofsson. 1987; Roberts, 1990; Perez and Sanchez, 2003).

4.5 Obstacles affecting technology transfer of the USOs

The obstacles faced by USOs in transferring technology are widely documented in the literature. According to Samsom and Gurdon (1993), the learning curve involved in the transformation of university scientists into business venturers could be very steep. Business and management skills are important for university scientists in managing their start-ups (Siegel et al. 2003; Lockett and Wright, 2005; Sanchez, 2010). Apart from managerial skills, Milton-Smith (2001); Perez and Sanchez (2003); Swamidass and Vulasa (2009) identified other resource constraints such as small market size and lack of finance capital to be the main obstacles to the USOs during the founding year. Harmon et al. (1997) found lack of long-term commitment on the part of the university scientists to be a major obstacle. Other resource constraints faced by start-ups include insufficient funding to develop the technologies further (Feldman and Klofsten, 2000; Wright et al. 2006; Decter et al. 2007). Gras, et al. 2008, identified three types of support measures namely financial, non-financial and infrastructure, which can help USOs to overcome obstacles. Based on the analysis of the obstacles of technology transfer of the USOs at the founding year, in our study as shown in Table 3.3 the variables involved could be explained by three underlying factors -- resource constraints, entrepreneurship and business skills, and technology risk management. Our results support the findings of Perez and Sanchez, 2003; Geenhuizen and Soetanto, 2009;
Salvador 2010 that resource constraints were the main obstacles to start-ups during their founding year. Our results are consistent with the literature that business and management skills are important for start-ups launched by university scientists (Siegel et al. 2003; Tsukuba Daigaku, 2004; Lockett and Wright, 2005; Salvador 2010).

4.6 Main functions performed by USOs

Entrepreneurial networking by the founders and the management of USOs are found to positively influence the firms’ performance (Hansen, 1995; Raffa, 1996). We found in our study that the analysis of the main function performed by the USOs in their founding year related to variables which could be explained by two underlying factors — namely the technology outsourcing and channel development factor, and the value-added services to customers – described the main functions performed by the start-ups at the founding year. After the USOs operated for a few years, our result showed the main functions were channel development and supporting services, and value-added services to customers as shown in Table 3.4. The same findings were confirmed in our case studies and interviews with the founders of USOs. The ability and capability for the USOs to meet customers’ demands are critical for their survival.

4.7 Means to further develop USOs in Hong Kong

Finally, we examined the institutional setting in Hong Kong that frames the entrepreneurial initiatives taken by university faculty. The means to develop USOs are well documented in the literature. Scholars have suggested ways to facilitate further development of start-ups including flexibility in academic terms of employment (Harmon et al. 1997), focused policy on commercialization (Salvador, 2010; Yang and Chang, 2010), better rewards system to track the performance and achievement of university scientists (Goldfarb and Henrekson, 2003), and availability of skilled TTOs staff to manage the commercialisation process (Gras, et al. 2008). Our findings as shown in Table 3.5 are consistent with the literature in that the external environment should facilitate the efforts by university scientists to focus on developing their USOs.
5. **Discussion and concluding remarks**

Our findings are consistent with much of the literature on university spin-offs (e.g. Bozeman, 2000; Di Gregorio and Shane, 2003; Clarysse et al. 2005; Lockett and Wright, 2005). The strength of this exploratory study and its conclusions are based on its analysis of primary data collected from the total population of research-based spin-offs and start-up companies spun off from five universities in the period of 1991 to 2004 (with some partial updating to 2008). We are aware of the limitation of our approach as we have used survival of the firm as the basic indicator of success, rather than some more nuanced factor such as accrued value. In our defence, we would point out that the development of university spin-off companies are relatively new in Hong Kong and survival of these companies are critical to reflect their technological capabilities in leveraging the commercializing process in the face of fierce competitive business environment of the global markets and with only minimal institutional support from the HKSAR when compared with developed countries like in US, UK, and Taiwan.

The institutional environment in Hong Kong has not been particularly supportive of USOs, in that there are no regulations relating specifically to this phenomenon. Our finding is that the few spin-off enterprises that have survived have done so through their own efforts, and those of their launching TTOs, rather than through any favourable government regulations or statutes – with the exception of some government letting of contracts, as in the cases of Eco-Tek and mCoMo and government venture capital assistance as in the case of MaCaPS.

It is worth remarking that this is an exploratory study on the origins and the dynamics of research-based spin-offs and start-ups designed to generate insights into the phenomenon developed among the five universities in Hong Kong over the past decade and a half. Hong Kong is one of the most crowded and a vibrant international financial centre of the world, and thus it is no surprise that the universities established there should see spinning-off of firms as one of their activities. Our study has highlighted the major issues faced by newly founded firms as well as by the different technology transfer vehicles established by the leading public universities. As latecomers to these
technology transfer and spin-off venture activities, the Hong Kong universities have much to learn from the rest of the world, but also something to teach.

The total number of spin-offs from Hong Kong tertiary institutions over a decade and a half numbers more than 100 viable enterprises, which certainly stands comparison with comparable experiences elsewhere in the world. We found that the five-year survival rate of Hong Kong spin-off firms attained 73 percent, which is superior to most experiences elsewhere, indicating that the competitive environment in Hong Kong is favourable to spin-offs, academic entrepreneurs’ higher opportunity costs and technology advantage (Zhang, 2009), or that the tertiary institutions are managing the spin-off process particularly well. Against this we have to set the fact that there have been only two IPOs in the decade and a half of experience (TeleEye and Eco-Tek) and only one Main Board listing, of TeleEye. This is not a particularly successful outcome for the time and energy that went into the process.

In terms of the ‘natural experiment’ that has been staged by different tertiary institutions pursuing different strategies in spinning-off activities, it is clear that the Poly U approach with its dedicated TTO (the PolyU Development Organization), has fashioned a viable and replicable business model. However this is likely to change under the impact of the latest Independent Review Report published in July 2010 (IRP 2010), which included recommendations to put a stop to further cash investment and avoid taking board positions in the USOs because of staff and public unease. The oldest of the Hong Kong institutions, the CityU with its TTO dating back to 1991, has also fashioned a credible model, and been responsible for the successful spin-off, TeleEye. The HKUST with its risk-reduction strategy does not seem to have chalked up many successes as yet, and some notable failures, such as the TTA story. By contrast, the minimalist approach of the HKU and CUHK does not appear to have borne much fruit to date. Hence we can make only cautious conclusions as to which of the HK ‘models’ of university spin-off enterprises is working best.

This is an initial exploratory survey of the spin-off phenomenon in Hong Kong, and could be followed up by more elaborated studies in future. We see the phenomenon
of university-based start-ups as constituting an important element in future entrepreneurship studies.

Acknowledgements

The authors wish to acknowledge the support and valuable input of the senior management of TTOs, and the founders/ senior management of the university spinoffs. An earlier version of the paper was presented at the 2006 Annual Conference of the Technology Transfer Society. All remaining errors and omissions are entirely our own.

References


Baark, E., Sharif, N., 2006. From trade hub to innovation hub: the role of Hong Kong’s innovation system in linking China to global markets. Innovation: Management, Policy and Practice, vol. 8 no.1/2, 193-209


McQueen, D., Wallmark, J., 1982. Spinoff companies from Chalmers University of Technology. Technovation 1, 305-15.


Samsom, K.J. and Gurdon, M.A. 1993. University scientists as entrepreneurs: a special case of technology transfer and high-tech venturing, Technovation, 13, 263-71


### Table 1  List of University Research-based Spin-offs and Start-ups in Hong Kong as at 2007

**CityU Enterprise Associated Companies**

<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Nature of Business/Academic Dept.(s)</th>
<th>Founding Year (FY)</th>
<th>No. of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CityU Research Company*</td>
<td>To support research and spin-off companies</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>CityCom Technology Limited*</td>
<td>Telecommunications</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>City Facility Management Consultancy Limited*</td>
<td>Property and facility management</td>
<td>1994</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>MaCaPS International Limited*</td>
<td>Smart-card security systems</td>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>CitySoft (Hong Kong) Limited*</td>
<td>E-commerce</td>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Digital Content Development Corporation Limited*</td>
<td>Digital content products</td>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Signal Communications Limited* (Listed on the Growth Enterprise Market on 8 May 2001 under the holding company TeleEye Holdings Limited)</td>
<td>Closed-Circuit TV systems</td>
<td>1994</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>LangComp Company Limited**</td>
<td>Computer-assisted language learning/ Dept. of Chinese, Translation and Linguistics</td>
<td>1997 FY (2) Yr. 2006 (11)</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>BonVision Technology (Hong Kong) Limited*</td>
<td>Software technology</td>
<td>1998</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Yantai Integrity Technologies Company Limited*</td>
<td>Wireless communications</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>DynaCity Technology (HK) Limited**</td>
<td>Advanced motion controller/driver products./Dept. of Engineering</td>
<td>2003 FY (5) Yr. 2006 (10)</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Synergicorp Limited*</td>
<td>Intelligent business activity monitoring software</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
<td>Products/Services</td>
<td>Year</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>CMA-CityU Centre for Entrepreneurial Development Co. Ltd. #</td>
<td>Professional consultancy and training for Small and Medium Enterprises</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>CityUOS Ltd. #</td>
<td>Installation of building automation systems</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Shenzhen Goldradio Communication Co. Ltd.*</td>
<td>Telecoms and mobile wireless communications</td>
<td>2002</td>
<td></td>
</tr>
</tbody>
</table>

**The Hong Kong University of Science & Technology Spin-off Companies**

1. Hong Kong Supernet Ltd.* ISP 1993
3. SAR1.com * (previously IMPAS Co. Ltd) Micro payments by Internet 2000

**Start-up Companies**

5. Perception Digital Ltd.** Chipsets / Dept. of Electrical & Electronic Engineering 1999 FY (2) Yr. 2006 (50)
7. Pharmaco Genetics Ltd.** Medical products / Dept. of Biochemistry 1997 FY (8) Yr. 2006 (10)
8. Googol Technology (HK) Ltd.* Motion Control products 1999
9. Integra Antennas Ltd.* Mobile communications devices 1999
10. iSILK.com Ltd.* Voice recognition 1999
11. Soft Objects (HK) Ltd.** 3D simulation and virtual fitting products / Dept. of Mechanical Engineering 1999 FY (7) Yr. 2006 (0) Inactive
12. Tim EDPlatform Ltd.* (was EDPlatform Ltd.) Information management systems for schools 2000
13. eED Vision Ltd.* On-line interactive training courses 2000
15. Micro Web Ltd.** IT and Internet services for Small and Medium Enterprises / Dept. of Information & Communication Technology 2000 FY (3) Yr. 2006 (7)
<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Industry/Unit</th>
<th>Establishment Year</th>
<th>Fiscal Year</th>
<th>Yr. 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>SinoCDN Ltd.*</td>
<td>CDN technology / Dept. Of Computer Science; and Dept. of Electrical &amp; Electronic Engineering</td>
<td>2000</td>
<td>FY (13)</td>
<td>Yr. 2006 (25)</td>
</tr>
<tr>
<td>19.</td>
<td>e-Aid Media Ltd.*</td>
<td>Multi-media news/ HKUST Business School</td>
<td>2001</td>
<td>FY (1)</td>
<td>Yr. 2006 (0) Inactive</td>
</tr>
<tr>
<td>20.</td>
<td>Integrated Microdisplays Ltd.*</td>
<td>Display products</td>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>PenCalc Technology Ltd.*</td>
<td>Pen-based handwriting recognition products</td>
<td>2001</td>
<td>FY (2)</td>
<td>Yr. 2006 (2)</td>
</tr>
<tr>
<td>22.</td>
<td>TBCAD Technology Ltd.*</td>
<td>Web-based solutions for building structures</td>
<td>2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Bio-Click Technologies Ltd.*</td>
<td>Biotechnology</td>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>R &amp; C Biogenius Ltd.</td>
<td>Biotechnology</td>
<td>2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Artenano Company Ltd.</td>
<td>Environmental Nano materials</td>
<td>2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Advanced Packaging Technologies Ltd.*</td>
<td>New materials and technology solutions</td>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>LiteMagic (HK) Ltd.*</td>
<td>Innovative LED lighting systems</td>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>Analog Power Ltd.*</td>
<td>Application-specific solutions for power management</td>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td>Blue Solve Ltd.*</td>
<td>Wireless communication and power management ICs.</td>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>MoFinity Ltd.*</td>
<td>Wireless application solution provider</td>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>Velda Ltd.*</td>
<td>Telecoms and mobile communications</td>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34.</td>
<td>Workout New Media Ltd.*</td>
<td>Digital entertainment solutions and service provider</td>
<td>2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.</td>
<td>Creative Forex Ltd.</td>
<td>Trading on foreign exchange markets using software solution integration</td>
<td>2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36.</td>
<td>Fustec Company Ltd.</td>
<td>Software solution integration</td>
<td>2004</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hong Kong Polytechnic University Spin-off Companies**

<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Industry/Unit</th>
<th>Establishment Year</th>
<th>Fiscal Year</th>
<th>Yr. 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Eco-Tek Holdings Ltd.*</td>
<td>Environmental hydraulic filters / Dept. of Engineering</td>
<td>1999</td>
<td>FY (2)</td>
<td>Yr. 2006 (35)</td>
</tr>
<tr>
<td>2.</td>
<td>SMILE Technologies Ltd.*</td>
<td>Multimedia Integrated Learning System / Dept. of Building and Real Estate</td>
<td>2000</td>
<td>FY (8)</td>
<td>Yr. 2006 (20)</td>
</tr>
<tr>
<td>3.</td>
<td>Sun Wah-PearL Linux Limited**</td>
<td>Linux training programmes / Dept. of Information Technology</td>
<td>2001</td>
<td>FY (10)</td>
<td>Yr. 2006 (15)</td>
</tr>
</tbody>
</table>
1. mCommerce Online Limited**
   Mobile technology GPRS / Dept. of Electrical & Electronic Engineering
   2002
   Yr. 2006 (10)

2. -Security Solutions Limited*
   Public key encryption
   2000

3. Hantak Ortho-Technology Limited #
   Biomedical
   2000

4. Hong Kong DNA Limited #
   Biotechnical
   2001

5. Enzymes Technology Limited #
   New materials & technology
   2001

6. Jenesis Computing Limited #
   Applied e-security solutions
   2003

7. Power ELab Limited #
   Power converter technology and service technology
   2003

8. Hong Kong Poultry (Kamei Chicken) Development Limited #
   Development of Poultry products
   2003

9. HongPharm Limited #
   Chinese herbal dietary products
   2002

The University of Hong Kong Spin-off Companies

1. Wise Information Ltd.**
   Electronic news / Dept. of Engineering
   1998
   Yr. 2006 (220)

2. DINASTech(HK) Limited**
   Scalable video-on-demand solution / Dept. of Engineering
   2001
   Yr. 2006 (10)

3. PhotoRite #
   IT solution integration
   2003

Source: the authors’ research

* The population of the research-based start-ups surveyed in this Hong Kong study collected from the period covering 1991 to 2004.

** The research-based start-ups responded to the Hong Kong study.
Company identified as spin-off only after the study was completed. The yellow colour highlighted the spin-offs and start-up enterprises surveyed in this Hong Kong study managed to survive the first five years of operation.
Table 2  Survival Rate of Research-based Spin-offs and Start-ups, by University

<table>
<thead>
<tr>
<th>University</th>
<th>No. of Questionnaire Sent</th>
<th>No. of Enterprises Survived*</th>
<th>Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>City University of Hong Kong (CityU)</td>
<td>22</td>
<td>14</td>
<td>63.6%</td>
</tr>
<tr>
<td>Chinese University of Hong Kong (CUHK)</td>
<td>2</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>The University of Hong Kong (HKU)</td>
<td>2</td>
<td>1</td>
<td>50%</td>
</tr>
<tr>
<td>Hong Kong University of Science and Technology (HKUST)</td>
<td>22</td>
<td>16</td>
<td>72.7%</td>
</tr>
<tr>
<td>The Hong Kong Polytechnic University (PolyU)</td>
<td>8</td>
<td>8</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56</strong></td>
<td><strong>41</strong></td>
<td><strong>73.2%</strong></td>
</tr>
</tbody>
</table>

Source: the authors’ research

* These enterprises studied survived the first five years of operation counting from the founding year.
Table 3 Summary Results of the Study

3.1 Modes of Technology Transfer from the Parent
Universities to the Research-based Spin-offs and Start-ups

Founding Year

<table>
<thead>
<tr>
<th>&quot;Hard&quot; Technology &amp; Skills Transfer Process</th>
<th>&quot;Soft&quot; Technology &amp; Skills Transfer Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation in product development (0.9278)</td>
<td>Training in management (0.8963)</td>
</tr>
<tr>
<td>Cooperation in research (0.8851)</td>
<td></td>
</tr>
<tr>
<td>Sales or purchase of products / services (0.6941)</td>
<td></td>
</tr>
</tbody>
</table>

Year 2006

<table>
<thead>
<tr>
<th>Product-oriented Technology Transfer Process</th>
<th>Service-oriented Technology Transfer Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales or purchase of products / services (0.8771)</td>
<td>Consulting (0.9583)</td>
</tr>
<tr>
<td>Cooperation in product development (0.8684)</td>
<td>Patenting and licensing (0.9320)</td>
</tr>
<tr>
<td>Subcontract product development (0.7085)</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Modes of Technology Transfer from the Research-based
Spin-offs and Start-ups and their Links to Customers

Founding Year

<table>
<thead>
<tr>
<th>&quot;Existing&quot; Technology &amp; Skills Transfer Process</th>
<th>&quot;New&quot; Technology &amp; Skills Transfer Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patenting and Licensing (0.9509)</td>
<td>Subcontract product development (0.9303)</td>
</tr>
<tr>
<td>Cooperation in research (0.9075)</td>
<td>Consulting (0.8747)</td>
</tr>
<tr>
<td>Transfer of people (0.8444)</td>
<td>Cooperation in product development (0.6450)</td>
</tr>
</tbody>
</table>

Year 2006

<table>
<thead>
<tr>
<th>New Product and Technology Development Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training in Management (0.9353)</td>
</tr>
<tr>
<td>Patenting and Licensing (0.8599)</td>
</tr>
<tr>
<td>Cooperation in product development (0.8429)</td>
</tr>
<tr>
<td>Cooperation in research (0.7478)</td>
</tr>
<tr>
<td>Consulting (0.5599)</td>
</tr>
</tbody>
</table>

4 The bracket ( ) shows the factorial loadings of the factors after being analysed by Factor Analysis with Varimax Rotation of SPSS 15.0
### 3.3 Obstacles affecting the Technology Transfer of the Research-based Spin-offs and Start-ups

#### Founding Year

<table>
<thead>
<tr>
<th>Resources Constraints</th>
<th>Entrepreneurship and Business Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small market size (0.8730)</td>
<td>Lack of entrepreneurship skills (0.9111)</td>
</tr>
<tr>
<td>Lack of time to develop technology further (0.7247)</td>
<td>Lack of business and managerial skills (0.8222)</td>
</tr>
<tr>
<td>Lack of trust among partners (0.7112)</td>
<td>Lengthy and complicated patent and licensing issues (0.7596)</td>
</tr>
<tr>
<td>Lack of funding support from government (0.7106)</td>
<td>Lack of best business practices (0.7150)</td>
</tr>
<tr>
<td>Lack of customers/clientele (0.6671)</td>
<td></td>
</tr>
<tr>
<td>Lack of information about potential business partners (0.5807)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of innovation clusters/networks to facilitate technology transfer (0.8438)</td>
</tr>
<tr>
<td>Lack of financial resources/funding (0.7503)</td>
</tr>
<tr>
<td>The technology is perceived as being too risky (0.6388)</td>
</tr>
</tbody>
</table>

#### Year 2006

<table>
<thead>
<tr>
<th>Resources Constraints</th>
<th>Business Routines and Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of customers/clientele (0.8538)</td>
<td>Lack of time to develop the technology further (0.8271)</td>
</tr>
<tr>
<td>Small market size (0.8477)</td>
<td>Lack of innovation clusters/networks to facilitate technology transfer (0.8127)</td>
</tr>
<tr>
<td>Lack of information about potential business partners (0.6254)</td>
<td></td>
</tr>
<tr>
<td>Lack of best business practices (0.5768)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology Risk Management</th>
<th>Institutional Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lengthy and complicated patent and licensing issues (0.8520)</td>
<td>Lack of marketing information (0.8433)</td>
</tr>
<tr>
<td>The technology is perceived as being too risky (0.7995)</td>
<td>Lack of funding support from government (0.8029)</td>
</tr>
</tbody>
</table>
### 3.4 Main Functions Performed by the Research-based Spin-offs and Start-ups

#### Founding Year

<table>
<thead>
<tr>
<th>Technology Outsourcing and Channel Development</th>
<th>Value-added Services to Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of test / maintenance services (0.9460)</td>
<td>Increase customers’ distribution or management efficiency (0.9812)</td>
</tr>
<tr>
<td>Increase customers’ operation efficiency with consulting (0.8705)</td>
<td>Provision of maintenance services (0.8552)</td>
</tr>
<tr>
<td>Marketing and distribution channel (0.7836)</td>
<td></td>
</tr>
</tbody>
</table>

#### Year 2006

<table>
<thead>
<tr>
<th>Channel Development and Supporting Services</th>
<th>Value-added Services to Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing and distribution channel (0.9242)</td>
<td>Increase customers’ distribution or management efficiency (0.9234)</td>
</tr>
<tr>
<td>Provision of test / maintenance services (0.8286)</td>
<td>Increase customers’ operation efficiency with consulting (0.8483)</td>
</tr>
<tr>
<td>Increase customers’ operation efficiency with products (-0.7158)</td>
<td>Provision of maintenance services (0.6378)</td>
</tr>
</tbody>
</table>

### 3.5 Means to Further Develop the Research-based Spin-offs and Start-ups

<table>
<thead>
<tr>
<th>Universities</th>
<th>CityU</th>
<th>CUHK</th>
<th>HKU</th>
<th>HKUST</th>
<th>PolyU</th>
<th>Wt. Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Government funding &amp; infrastructure support</td>
<td>4.7</td>
<td>4.0</td>
<td>4.0</td>
<td>4.7</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>2 Set up a centralized body to support the start-ups</td>
<td>3.3</td>
<td>3.0</td>
<td>1.0</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>3 Flexibility in academic terms of employment to support the development of start-ups</td>
<td>3.7</td>
<td>3.5</td>
<td>4.0</td>
<td>2.5</td>
<td>3.1</td>
<td>3.0</td>
</tr>
<tr>
<td>4 Longer incubation period more than 3 years</td>
<td>2.7</td>
<td>1.0</td>
<td>3.0</td>
<td>4.3</td>
<td>1.5</td>
<td>2.7</td>
</tr>
<tr>
<td>5 Structured training and network to support academics on managing the start-ups</td>
<td>4.0</td>
<td>5.0</td>
<td>1.0</td>
<td>3.2</td>
<td>2.0</td>
<td>2.9</td>
</tr>
<tr>
<td>6 Active support from the stakeholders: universities and industries</td>
<td>4.0</td>
<td>4.5</td>
<td>4.0</td>
<td>3.8</td>
<td>4.3</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Source: the authors’ research