

INTRODUCTION

In this chapter we explore a new role for the university, one in which it contributes directly to the economic well being of the society in which it operates, contributing social and economic value not only indirectly, through training and knowledge generation, but also more directly by creating new avenues into the private sector. Here, in partnership with business interests, the university supports the application and exploitation of knowledge by lending its capabilities (including technology) to the creation of new market-ready products and services.

Hong Kong, where the higher education sector adapted in the 1990s to the former colony's new status as a Special Administrative Region of China, has witnessed its own version of this transformation. Hong Kong's higher education sector accounted for 80% of its total R&D expenditure in 2000, indicating the central importance of universities in Hong Kong's innovation system (Hong Kong Census and Statistics Department, 2007). Even the 2003 figure of 56% is high compared with R&D spending in other advanced economies, where the figure is roughly 17%.

In common with other newly industrializing economies (NIEs) in Asia—notably Singapore—Hong Kong shows signs of developing a knowledge-based strategy for economic growth. Ever since the former Chief Executive, Tung Chee-Hwa, spelled out this strategy in 1998 and 1999 policy addresses, policymakers have been trying to effect a transition in Hong Kong's economy, replacing a one-dimensional service-based economy with one that relies on innovation as a critical economic driver. As the economy depends more and more on the innovation system to fuel growth, the commercialization of intellectual capital to create value and jobs for Hong Kong industries must play a key role.

In this paper we offer a case study that assesses how the Hong Kong University of Science and Technology (HKUST), the youngest research-based university in Hong Kong, has adapted to this new role against the backdrop of the rapidly globalizing knowledge economy.

CONCEPTUAL FRAMEWORK

The trends in university orientation that we have observed in Hong Kong have assumed global dimensions. Etzkowitz, Webster, Gebhart, and Terra (2000) argue that there is a worldwide movement among universities to adopt a more complex entrepreneurial model, one that stresses the commercialization of knowledge and the fueling of private enterprise in local and regional economies. Referring to the widely held belief that university research feeds economic growth like the magic seed from 'Jack's beanstalk', Miner et al. (2000) argue that entrepreneurial firms also drive economic growth like magic seeds. If universities are to play the role we have described as incubators of entrepreneurial resources in a vigorous and thriving innovation system, they will need to operate increasingly within the Triple Helix model of innovation-driven economic growth, in which they work closely in complex, interactive relationships with government agencies and private enterprise.

Wong et al. (2007) offer three reasons that the imperative requiring universities to shift from their traditional model to the new entrepreneurial model is expected to be even more urgent in a global market that includes such Asian NIEs as Singapore. We note, however, that only one of the reasons they offer applies to the Hong Kong situation, where they argue that

the shift toward a knowledge-based economy, rather than one based on low-wage and low factor cost advantages, requires a significant increase in the indigenous capabilities of local enterprises to create and commercialize new knowledge, not just using knowledge imported from advanced countries.

However, many of the local private enterprises that had developed in the earlier industrialization phases still tend to be laggards, rather than leaders, in engaging in technology development and innovation activities. Consequently, compared to their more technologically mature counterparts in the advanced

economies, local industries in NIEs often have less experience, and lower capability, to commercialize knowledge generated from local universities (Wong et al. 2007, p. 942).

As a result of the Asian Financial Crisis of 1997, economic reforms in mainland China, and China's admission into the World Trade Organization, Hong Kong's heavy reliance on its traditional capacity as a trading center can no longer sustain its economy. Long accustomed to relatively stable levels of robust growth, Hong Kong found itself in the late 1990s facing quarter upon quarter of negative growth, deflation, and mushrooming unemployment. These developments spurred the Hong Kong government to participate actively, even urgently, in the transformation of Hong Kong's economic and innovation system so that it could create a new role for itself as well as a new engine for economic growth. In his inaugural policy address to the public on 8 October 1997 Tung said, 'My aim is to make Hong Kong an innovation centre. We . . . need to do more to stimulate the exchange of ideas between our university researchers, our businessmen and industrialists, and our customers, so as to drive forward innovation and turn technological development into commercial products' (Tung 1997).

Yet Hong Kong has been poorly positioned to leverage Triple Helix-style interactions in modernizing its innovation system. Private enterprises in Hong Kong lack the capacity for and consequently have hardly demanded rapid or extensive commercialization of university knowledge. The changing economic landscape in Hong Kong, which has been and continues to be reshaped by rapid growth in Mainland China, has pressured industry and the government on several levels, making it difficult to harness Triple Helix interactions. A recent paper by Mok (2005) utilized the Triple Helix concept to examine policy changes related to entrepreneurship and university spin-off firms in Hong Kong. Mok observes increasing movement on the part of government in facilitating entrepreneurial

linkages between universities and industry. This is encouraging because if Hong Kong's universities can play their part in a Triple Helix scenario they can serve as nodes in regional, national, and even global systems. Global links with other major centers of learning can only enhance their capacity to generate and distribute innovative ideas and products.

These possibilities add to the urgency with which universities in Hong Kong must take on an entrepreneurial role, perhaps more so than universities in advanced economies, if they are to overcome the less favorable preconditions with which they contend and also optimize the potential advantage of increasing integration with Mainland China. Universities in Hong Kong may for instance need to be more proactive in commercializing their inventions through spinoffs rather than relying on private enterprises to license them because of the latter's weakness in this respect.

We also believe that Hong Kong's universities should expand the focus on entrepreneurial culture beyond the role of technology commercialization emphasized by Etzkowitz et al. (2000) and Wong et al. (2007). The 'entrepreneurial university' model must take seed in sweeping curriculum reform, injecting university teaching with a stronger entrepreneurial dimension. In other words, the university's core function of teaching must be enlisted across multiple subject areas in the effort to re-orient academic culture.

A 2004 study of entrepreneurship in Hong Kong reflects the reluctance of Hong Kong's relatively well educated population to embrace entrepreneurship. New firms rely primarily on existing technology to avoid the risk of technology innovation (GEM, 2004). Defined as the percentage of the population that is engaged in starting new companies, entrepreneurship in Hong Kong was found to be a meager three percent compared with a more 'normal' level of about eight percent in emerging and developed economies. That figure applies to all new companies, not just entrepreneurs engaged in high technology (GEM, 2004: 1). The latest report on entrepreneurship in Hong Kong (GEM, 2007) indicates some increase in the

propensity to engage in early-stage entrepreneurial ventures, with levels of engagement in new startups that are similar to those found in the US. The GEM report nevertheless emphasizes that the weakness in R&D commitment and a relative lack of creativity in Hong Kong's educational system disadvantages local entrepreneurs. Greater China's increasingly competitive environment, in which there are fewer traditional jobs or opportunities to profit from speculative activities, requires universities in Hong Kong to urgently foster a more entrepreneurial mindset in students. Students must learn not only how to use new technologies but more importantly how to generate them for immediate commercialization.

OVERVIEW OF THE TERTIARY EDUCATION SECTOR IN HONG KONG, THE HKUST, AND THE SHIFT TOWARD AN ENTREPRENEURIAL UNIVERSITY MODEL

Background to the Tertiary Education Sector in Hong Kong

The Education Bureau (EDB) is responsible for government policies pertaining to tertiary education, employment, and human resource development. In this capacity it also oversees academic research policy, technical education, and industrial training. The EDB determines and applies the government's funding for university education and research with the assistance of the University Grants Committee (UGC) and the Research Grants Council (RGC). The UGC is an advisory committee responsible to the government for the development and funding needs of higher education institutions. The RGC advises the government through the UGC on the research needs of such institutions.

Universities provide the education and research that lays the foundation for the science and technology base of Hong Kong's economy. Presently, by feeding the human capital base with technologically savvy personnel and conducting academic and contract research, universities constitute the single most important element in

Hong Kong's innovation system. As Table 6.1 shows, over the period spanning 1995–2001, higher education R&D (HERD) has constituted well over half of total R&D expenditures, focusing mainly on basic research while also conducting some applied research. Most of the R&D expenditure in the higher education sector from 1998 to 2002 was devoted to the physical sciences (between 23% and 25%), engineering and technology (between 22% and 23%), and medicine, dentistry, and health, with (between 18% and 19%), with the arts and humanities and social sciences each showing a ten per cent share.

By 2007 however business expenditure on R&D almost equaled that of higher education, so the proportion of R&D expenditure constituted by the higher education sector had fallen to 49%. Government R&D had in addition doubled over the 1995–2007 period and several public technology support organizations, such as the Science Park, Cyberport, and the Applied Science and Technology Research Institute (ASTRI), were established.

Tables and Figures

Table 6.1: R&D Expenditure by Performing Sector, as a Percentage of GDP 1995–2007

<i>Year/ Sector</i>	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<i>BERD</i>	0.11% ^(a)	0.13% ^(a)	0.10% ^(a)	0.12% ^(a)	0.11% ^(a)	0.08% ^(a)	0.16% ^(a)	0.20% ^(a)	0.29% ^(a)	0.36% ^(c)	0.41% ^(c)	0.43% ^(c)	0.37% ^(c)
<i>HERD</i>	0.24% ^(a)	0.25% ^(a)	0.27% ^(a)	0.30% ^(a)	0.34% ^(a)	0.38% ^(a)	0.37% ^(a)	0.38% ^(a)	0.39% ^(a)	0.36% ^(c)	0.37% ^(c)	0.37% ^(c)	0.38% ^(c)
<i>GOVER D</i>	0.01% ^(b)	0.01% ^(b)	0.01% ^(b)	0.01% ^(a)	0.01% ^(a)	0.01% ^(a)	0.01% ^(a)	0.02% ^(a)	0.02% ^(a)	0.02% ^(c)	0.02% ^(c)	0.02% ^(c)	0.02% ^(c)
<i>Total (GERD)</i>	0.36%	0.39%	0.38%	0.43% ^(a)	0.46% ^(a)	0.47% ^(a)	0.55% ^(a)	0.59% ^(a)	0.69% ^(a)	0.74% ^(c)	0.80% ^(c)	0.82% ^(c)	0.77% ^(c)

Abbreviations and Notes:

BERD: Business Expenditure on Research and Development

HERD: Higher Education Expenditure on Research and Development

GOVERD: Government Expenditure on Research and Development

GERD: Gross Domestic Expenditure on Research and Development

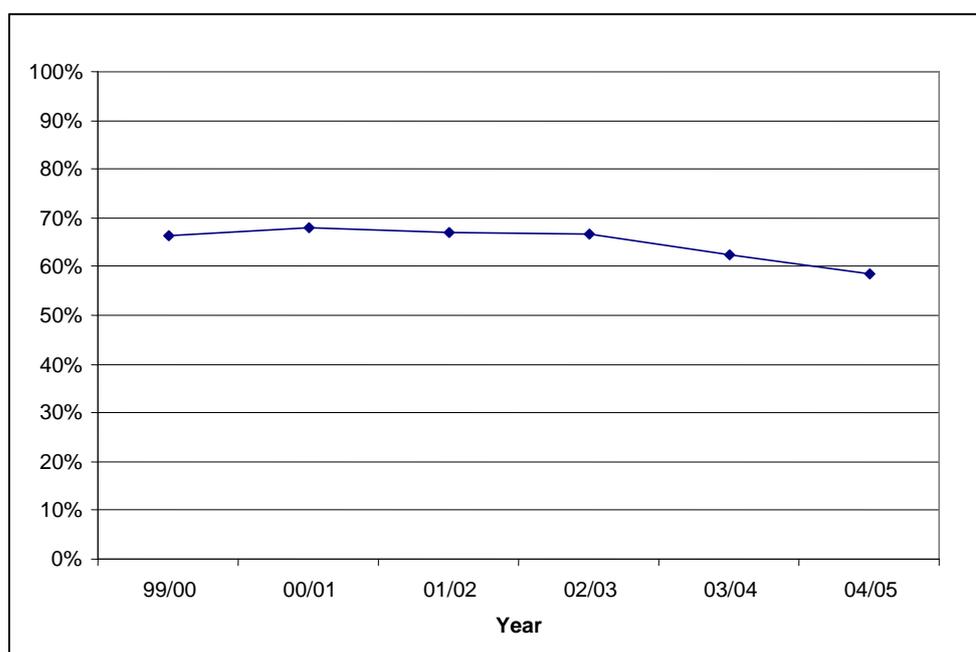
(a) Figures in respect of BERD (from 1995 to 2003), HERD (from 1995 to 2003), and GOVERD (from 1998 to 2003) are extracted from the publication 'Hong Kong as a Knowledge-based Economy: A Statistical Perspective, 2005 Edition', C&SD, HKSAR.

(b) Figures in respect of GOVERD from 1995 to 1997 are estimates based on 1998 and onward figures.

(c) Figures in respect of BERD, HERD, and GOVERD for 2004 to 2007 are extracted from Table 2 of the feature article, "Statistics on Research and Development of Hong Kong, 2003 – 2007," in the May 2009 issue of the *Hong Kong Monthly Digest of Statistics* published by C&SD, HKSAR. The figures are subject to revision.

Until recently over 65% of the total income of the eight UGC-funded universities came from government subventions (see Figure 6.1). This figure has dropped steadily from 2003/2004 onwards, suggesting that the government is shrinking its role in subsidizing the higher education sector.

Figure 6.1: Total Government Subventions as a Percentage of Total Income (aggregated for all eight UGC-funded institutions)



Source and Notes:

Annual Reports of the University of Hong Kong, Chinese University of Hong Kong, Hong Kong University of Science and Technology, Hong Kong Polytechnic University, City University, Hong Kong Baptist University, Lingnan University, and Hong Kong Institute of Education, from 2000 to 2006 (for the 1999-2000 academic year, income-related figures for Hong Kong Institute of Education and Lingnan University were not available; for the 2000-2001 academic year, income-related figures for Lingnan University were not available).

With eleven degree-granting organizations—eight of which are funded by the University Grants Committee (UGC)—Hong Kong is now in a position to provide 14,500 first-year, first-degree places to approximately 18% of the 17- to 20-year-olds in the population. One-third of these students eventually graduate with degrees in science and technology, contributing directly to the development of higher value-added activities in Hong Kong. Many of the remaining two-thirds, who graduate with degrees outside of science and technology, also contribute to the local innovation system insofar as they provide the knowledge and expertise needed to apply or use scientific ideas and technological products. These UGC-funded organizations offer a total of more than 45,000 degree places. Tertiary education accounted for approximately one-third of the government expenditure on education in 2004-05, which in turn was around 4% of GDP.ⁱ

The oldest of the eight UGC-funded universities, Hong Kong University (HKU) and Chinese University of Hong Kong (CUHK), have the longest traditions of serving Hong Kong. They are pioneers in medicinal research, for example, being closely affiliated with Queen Mary and Prince of Wales Hospitals, respectively. In spite of its comparatively young age, HKUST has developed a healthy reputation, albeit within a much narrower range of specializations than HKU and CUHK: HKUST offers degrees and conducts research only in science, engineering, business, and humanities and social science. Considered together, these three universities have developed strong

engineering schools and are the leading actors in engineering research in Hong Kong. During the latest (2006-2007) allocation of RGC Competitive Earmarked Research Grants (CERG) for engineering projects, HKU was awarded 47 projects amounting to around HK\$22 million, CUHK was awarded 48 projects amounting to HK\$25 million, and HKUST was awarded 78 projects amounting to more than HK\$42 million.ⁱⁱ

Of the remaining universities in Hong Kong, only Hong Kong Polytechnic University (HKPU) and City University receive substantial engineering and technology research funding, with HKPU having won 93 CERG projects in the engineering field amounting to HK\$42 million, and City U winning 53 CERG projects amounting to almost HK\$30 million.

Citing cooperation between universities and industry as an explicitly defined objective, the government-administered University-Industry Collaboration Program (UICP)—one of the four Innovation and Technology Fund (ITF) programs—aims to stimulate private sector interest in R&D by leveraging the knowledge and resources of universities. As of 30 September 2009, there were 182 projects approved under the UICP with a total funding amount of HK\$198.6 million (see Table 6.2). UICP support is given as a grant, subject to a cash contribution by the company amounting to no less than 50% of the project cost. While no independent evaluation has yet been carried out to assess the effectiveness of this program, Table 6.2 shows that the majority of projects under the UICP fall into the information technology area (45 projects with a total funding amount of HK\$49.7 million), biotechnology (24 projects with a total funding amount of HK\$38.4 million) and electrical and electronics (37 projects with a total funding amount of HK\$31.6 million).

Table 6.2: Distribution of Approved Projects under the UICP Program as of 30 September 2009

Technology Area	Number of Projects	HK\$ millions
Information Technology	45	49.7
Electrical and Electronics	37	31.6
Manufacturing Technology	37	22.3
Biotechnology	24	38.4
Chinese Medicine	15	26.9
Materials Science	14	7.5
Environmental Technology	9	20.7
Nanotechnology	1	1.5
Total	182	198.6

Source:

ITF website: <http://www.itf.gov.hk> accessed on 9 Nov 2009.

Overview of HKUST within Hong Kong's Tertiary Education Sector

The formation of HKUST marked a historical milestone in the development of Hong Kong's innovation system. When the HKUST project was first conceived in September 1986, it was envisioned as a world-class research university in certain key areas (science, engineering, business and management, and social science) that would serve the swiftly changing human resource needs of Hong Kong as it transitioned into an increasingly service-oriented economy. Founded in 1991, HKUST is the youngest research-based university in Hong Kong, with a total student enrolment of 9000, two-thirds of whom are undergraduates (see Table 6.3 for some relevant statistics).

Table 6.3: Profile of HKUST

Indicator	2000-2001	2006-2007
Undergraduate students enrolled	5,578	5,772
Graduate students enrolled	1,754	3,228
Graduate students as % of total students enrolment	23.92%	35.87%
Percentage of foreign students studying at HKUST^(a)	7.00%	18.63%
Total research funding amount (HK\$ million)^(b)	309.8	306.5
Percentage of research sponsored by industry	19.34%	17.13%
Total number of research projects funded^(c)	484	551
Percentage of research projects sponsored by industry	15%	15%

partners^(d)		
Number of research publications^(e)	NA	764
Percentage of research publications in refereed journals^(e)	NA	46.8%
Cumulative Patents filed^(f)	146	509
Cumulative Patents granted^(f)	36	138
Cumulative patents granted by USPTO	34	94

Notes:

^(a) University Grants Committee (2002) Facts and Figures. Hong Kong: University Grants Committee, Hong Kong

^(b) Office of Contract & Grant Administration (2008) Funding Statistics: Research Funding, Hong Kong University of Science & Technology, <http://www.ogca.ust.hk>.

^(c) HKUST facts and figures, http://www.ust.hk/eng/images/about/pdf/hkust_facts_and_figures.pdf (p.2).

^(d) There are no formal statistics available to ascertain this figure, but rather it is an educated estimate from HKUST's (Acting) Vice President of R&D, which has also been corroborated by HKUST's Director of Technology Transfer, Winter 2007/2008.

^(e) Research Output by Institution and Research Output Category, 2004/05 to 2005/06 (2005-2006 figures).

^(f) Information as of 31 January 2008 provided by the Technology Transfer Center, HKUST.

The table shows that more than 17% of the research carried out at HKUST during the 2006-07 academic year was funded by industry. This is a relatively high proportion of total research funding, almost as high as the share of industry-funded research at MIT. Moreover, in terms of patenting activity HKUST enjoyed a lead over other Hong Kong universities during the 1990s and is still among the most prolific in terms of USPTO patents granted per year. Despite being the newest and most poorly funded of this group of three universities, HKUST compares equally to its two counterparts in terms of spinoffs and patents granted. As of 31 January 2008, HKUST holds a portfolio of 382 patents (including pending patent applications) of which 43% have been commercialized by various means such as contract research and licensing. This compares fairly well for example with the approximately 400 patents applications at HKU, of which approximately 10% have been licensed (data supplied during an interview with the Director of HKU's Technology Transfer Office

(TTO), Dr. Paul Cheung, 10 Jan 08). Indeed no other local university contributes value to Hong Kong’s science and technology base as singularly as does HKUST—the only tertiary education institution devoted to and heavily focused on science and technology training.

Table 6.4 provides a summary profile of HKUST up to the 2005-06 financial year. With an annual R&D budget of about HK\$661 million HKUST alone constitutes about 6% of total R&D spending in Hong Kong.

Table 6.4: HKUST’s Share of Hong Kong’s R&D Expenditures 1999–2005

Year	Total HK R&D Expenditure^(a) (HK\$ million)	Higher Education R&D Expenditure^(a) (HK\$ million)	Total HKUST R&D Expenditure (HK\$ million)^(b)	HKUST R&D Expenditure as % of Higher Education R&D Expenditure
1999	5,885.40	4,316.90	567.73	13.15%
2000	6,218.40	4,989.20	574.97	11.52%
2001	7,087.30	4,846.60	656.87	13.55%
2002	7,543.60	4,800.70	626.97	13.06%
2003	8,548.80	4,796.20	677.15	14.12%
2004	9,505.20	4,707.30	654.42	13.90%
2005	10,908.40	5,085.00	661.79	13.01%

Notes:

^(a) Hong Kong Census and Statistics Department (2007) Hong Kong Monthly Digest of Statistics: Feature Article—Statistics on R&D of Hong Kong, 1998 – 2002 & 2001 – 2005.

^(b) Estimates derived from: (a) figures provided by the R&D Branch, HKUST; (b) figures provided by the Finance Office, HKUST, and; (c) figures from “Facts and Figures (1995 – 2005)” University Grants Committee, Hong Kong and Hong Kong Statistics Digest: Feature Article—Government Funding of Research and Development, Innovation and Technology Upgrading, 1995/96 – 2001/02.

In the latest Research Assessment Exercise (RAE) conducted in 2006, HKUST achieved the highest total ‘research index’ among all eight UGC-funded universities, 87.12%. This is the percentage of eligible staff who submitted research output items for assessment that were judged by the relevant RAE panels to have

generally reached or surpassed the quality standard set for the exercise. The results showed that HKUST had made remarkable improvements to achieve international excellence in research across all its disciplines.ⁱⁱⁱ

The results of the 2006 Competitive Earmarked Research Grant (CERG) validate HKUST's leading performance in the RAE. In June 2006, HKUST researchers were awarded HK\$103.4 million—21% of the total awarded to Hong Kong's tertiary institutions (for all disciplines). In this internationally peer-reviewed competition—based on the quality of proposals as perceived by international peers—HKUST achieved the highest success rate (61% of proposals were funded) for the fourteenth consecutive year and the highest funding per eligible faculty (HK\$234,000).

As further evidence of HKUST's growing importance in Hong Kong's education sector, particularly in the areas of science and technology, Table 6.5 shows that HKUST has witnessed significant growth in its research human resource commitment. In 1996, there were a mere 54 people employed by HKUST to conduct research, including faculty and support staff, but this number had quadrupled by 2005 to well over 200. While this 200+ figure accounts for a relatively low 4.6% of total research personnel in UGC-funded institutions, this percentage had nevertheless increased by some 250% over the 1996–2005 period. Furthermore, if we consider HKUST research personnel employed in selected areas of research and teaching strength (with none in medicine), we find that HKUST's research personnel comprise a respectable 7% of all research personnel in Hong Kong's UGC-funded institutions. Considering only faculty in science and engineering HKUST accounts for roughly 13% of research-related personnel among UGC-funded institutions in Hong Kong (according to 1999 figures).

[Insert Table 6.5: HKUST's Share of Research Personnel in Hong Kong, 1996–2005]

Table 6.5: HKUST's Share of Research Personnel in Hong Kong, 1996–2005*

Year	Total R&D Personnel in Hong Kong ^(a)	Research-Related Personnel in all Areas ^(b)	Research-Related Personnel in Selected Areas ^{(b)*}	HKUST All Research Personnel ^(c) ^(d)	HKUST Share of Total Research-Related Personnel in UGC Institutions	HKUST Research Personnel Share of Selected Areas	HKUST Faculty in Science and Engineering ^(e)	UST Research Personnel + Science & Engineering Faculty share of UGC Research Related Staff
1996	NA	2,886	2,172	54	1.90%	2.50%	317	12.90%
1999	10,118	3,327	2,430	150	4.50%	6.20%	276.5	12.80%
2005	22,054	4,701	3,111	217	4.60%	7.00%	NA	NA

Notes and Sources:

^(a) http://www.censtatd.gov.hk/hong_kong_statistics/statistics_by_subject/index.jsp?subjectID=7&charsetID=2&displayMode=T, Table No.132, accessed on 14 December 2007.

^(b) “Research Related Staff (Full-time Equivalent) of UGC-funded Institutions by Departmental Cost Centre Group and by Staff Grade: 2005/06 to 2006/07”, http://www.ugc.edu.hk/eng/ugc/stat/staff_full.htm, accessed on 14 December 2007. For data before 2005, email reply from UGC secretariat.

^(c) Includes all staff in Research & Development Departments and Central Research Facilities.

^(d) 2005 data from: “Departmental Staff Number (Full-time Equivalent) of UGC-funded Institutions by Source of Salary Funding, Staff Grade, Mode of Employment and Institution” http://www.ugc.edu.hk/eng/ugc/stat/staff_full.htm, accessed on 14 December 2007.

^(e) HKUST Faculty in Science and Engineering, HKUST Fact book (various issues). For 1996 and 1999, staff includes only senior staff.

* Selected areas include: Sciences; Engineering and Technology; Business and Management; Social sciences; Arts and Humanities

HKUST's research capabilities and educational standards have also begun to attract international recognition. This is reflected in the university's commendable placing in international rankings. In 2000, a mere nine years after admitting its first batch of students, HKUST was ranked seventh in *Asiaweek's* list of Asia's Best Universities (ahead of the Australian National University, the University of New South Wales, and the City University of Hong Kong), underscoring its rapid rise towards excellence. More recently, HKUST achieved a surprisingly high ranking in the 2009 *Times Higher Education Supplement's* ranking of top 200 universities in the world (Table 6.6), both overall as well as for individual faculties.

Table 6.6: Ranking of HKUST in the World University Rankings by the *Times Higher Education Supplement* 2005–2009

	2005 Ranking	2006 Ranking	2007 Ranking	2008 Ranking	2009 Ranking
Overall	43	58	53	39	35
Science	68	69	52	59	62
Technology	23	17	23	24	26
Social Sciences	58	30	63	69	82
Arts and Humanities	89	>50	n.a.	n.a.	216

Source: *The Times Higher Education Supplement* (various years).

Recent Shift towards an Entrepreneurial University Model

Most public universities developed under the British Commonwealth tradition follow the orthodox model, emphasizing teaching over research. This has for example certainly been true of HKU. CUHK can also be said to have been following this traditional model. The 1980s and 1990s saw however an increasing emphasis on research, the British Commonwealth tradition notwithstanding. This change in emphasis was best reflected at HKUST where the shift towards research catalyzed similar shifts in other UGC-funded institutions in Hong Kong. HKUST signaled this shift by creating its TTO, which it called the Technology Transfer Center, upon its inception in 1991. Contrast this action with what has

happened for example at HKU, where the TTO was set up only as recently as 1 September 2006.

The major impetus for change was due in no small measure to HKUST's founding vice-chancellor, Chia-Wei Woo, a Chinese-American from San Francisco State University (SFSU) who brought a distinctly North American ethos to HKUST in 1988. Professor Woo enjoyed the strong support of several senior executives in the then-colonial Hong Kong Government (notably executive councilor Sir Sze-Yeng Cheung). Professor Woo not only introduced several initiatives to the tertiary education sector (for example, requiring all full-time faculty—without exception—to have earned at least a doctorate degree upon assuming their duties at HKUST), but also initiated a shift toward what Etzkowitz et al. (2000) described as the 'entrepreneurial university' model.

With the core HKUST departments comfortably established Professor Woo led the creation of the Entrepreneurship Program in July 1999. This program was introduced to assist faculty, staff, and students in establishing technology startup companies. HKUST promotes such activities to benefit Hong Kong economically and socially. HKUST features other entrepreneurial initiatives as well, including an entrepreneurship seminar series, a high-technology entrepreneurship course for senior engineering students, and also a dual-degree technology and management program.

The high-technology entrepreneurship training course is a three-credit course for entrepreneurially minded engineering and business school students who are interested in starting businesses in the Greater China region. The course features lectures and seminars on high-tech entrepreneurship and practical startup exercises in a workshop environment under the guidance of departmental faculty and industry consultants. The dual-degree technology management program was first offered in 2003-04, and 30 to 40 students have enrolled in the program annually. Students who successfully complete the program receive a joint Bachelor of Engineering (BEng) and Bachelor of Business Administration (BBA) degree.

The HKUST Entrepreneurship Program incubates startup companies in the privately-funded Annex Building at HKUST. These new companies utilize serviced and furnished

space at modest cost, with access to university facilities and resources including an Advisory Committee that assists them with business development. In 2007 HKUST opened its new Enterprise Center, constructed with a donation from the Hong Kong Jockey Club, which serves as the primary interface between the HKUST academic and research communities and the business and industrial environment of Hong Kong and the region. HKUST also introduces Entrepreneurship Program companies to or matches them up with potential investors in order to sell their technologies or to secure funding.

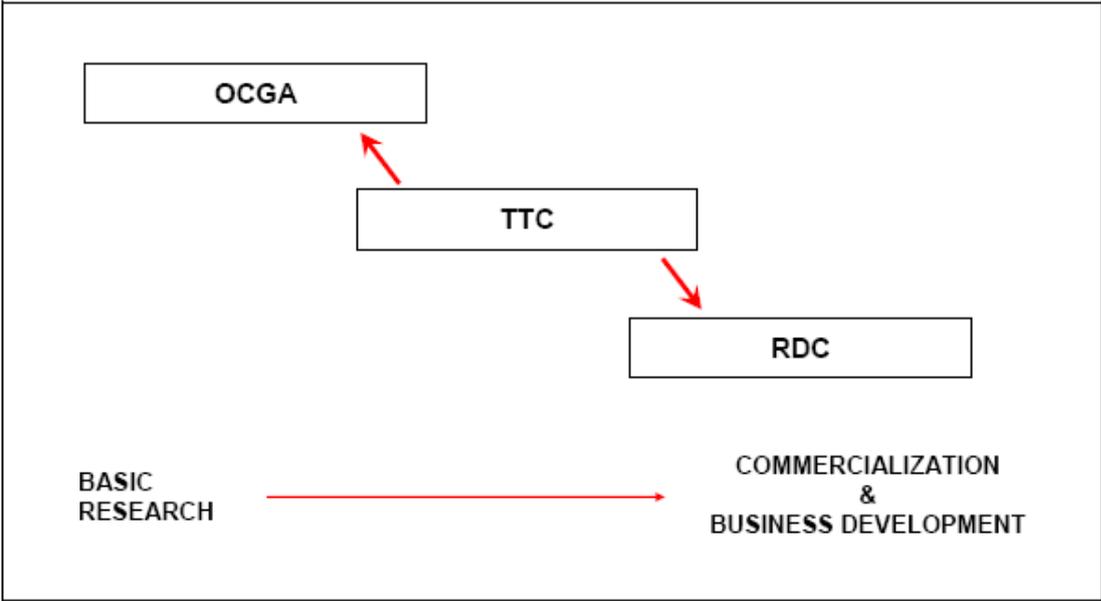
If a faculty member starts or joins a company that requires identifiable or patented intellectual property (IP), the company must obtain a license from HKUST, negotiated on a case-by-case basis, with the university paid by some combination of an up-front fee, deferred royalties or equity ownership. If on the other hand a faculty member starts or joins a company using expert knowledge, ideas, concepts, and market insight but does not require HKUST to file patent material or otherwise document any IP, the university requires no royalty payment or equity ownership. In this latter type of case HKUST assumes a base equity share of 3% in companies accepted into the Entrepreneurship Program. As such a company increases its capital share over the years, HKUST's ownership position remains at 3% until the fully paid value of its shareholding reaches HK\$300,000. The transfer of IP to the company usually increases equity. Such equity is held by HKUST's R and D Corporation Limited (RDC) on behalf of HKUST.

The Entrepreneurship Program focuses on several management issues. Most notably, companies under the auspices of the Program maintain clear separation between the HKUST's academic, educational and research environments and its own commercial and business activities. This feature is of course not unique to HKUST as eight of Hong Kong's leading universities are majority funded by the Hong Kong Government. But this separation of responsibilities means that the Entrepreneurship Program must be sensitive to issues of accountability, conflict of interest, conflict of commitment and use of public funds for private gain. Thus the Entrepreneurship Program requires unambiguous policies defining the areas that fall within the governance purview of its companies.

Since February 2000 HKUST's RDC has also managed a modest Venture Capital Fund of HK\$10 million. Startup companies may seek such funding (as equity capital) to advance their business development plans. The RDC provides seed money and seeks financial partners to co-invest in its startups. While the Entrepreneurship Program entry process gives companies the opportunity to prove their potential, an application to the Venture Capital Fund is subject to a more rigorous review process as this involves investing the assets of the RDC.

HKUST's technology transfer support structure can be summarized as per Figure 2. The Office of Contract and Grant Administration (OCGA), the TTC and the RDC work closely to facilitate research and development and to transfer the benefits to industry and society. The TTC handles 'upstream' activities, namely partnership/project development and intellectual property evaluation, whereas the RDC handles 'downstream' activities, namely negotiation, signing of contracts, billing and monitoring of R&D contracts and licensing agreements (i.e., anything of a legal nature). OCGA acts as a one-stop center for information on funding agencies and research opportunities and assists in developing proposals (for funding agencies) and preparing publications and reports (for reporting agencies).

Figure 6.3: HKUST's Technology Transfer Support Structure



Source:

<https://www.ust.hk/vpaa0/ADP/Annex%201-6%20Pdf/Annex%203.pdf>, p.40, accessed on 8 February 2008.

Notwithstanding the success of activities related to IP development and licensing, contract research, and promotion of entrepreneurship, the TTC has sought to intensify the University's efforts to develop sustainable routes for commercialization of the technology developed at HKUST. Taking a more proactive approach, the center has been developing a new framework for the adoption of technology by industry that moves beyond the simple model of creating spinoffs. This approach emphasizes the mobilization of a social network of business managers who are keen to expedite commercialization and willing to cooperate closely with the university's faculty members and post-graduate students to bring a given technology to the stage from which it can be launched on the market. The managers bring some investment to the table while the RDC provides a substantial matching investment (earning a larger equity share). These new forms of joint venture establish a much more professional environment for the commercialization of the technologies.

HKUST's experience shows that by modestly expanding the role of TTOs it is possible to proactively bridge the gap between university and industry. While HKU's and City University's TTOs concentrate on the traditional 'early-stage' role of TTOs—making academic research accessible to local industry—HKUST's Entrepreneurship Program demonstrates a viable alternative means of operation whereby university research can be made practically useful. Furthermore, HKUST's experience shows that the TTO can lead in this process by acquiring an equity stake in companies (and increasing the equity stake with the transfer of IP). The TTO's modest venture capital fund further evinces HKUST's creativity, illustrating the key finding that there is much room for expanding the roles of other Hong Kong tertiary institutions.

CHANGES IN HKUST'S PERFORMANCE AS A RESULT OF THE SHIFT TOWARD THE ENTREPRENEURIAL UNIVERSITY MODEL

Overview of Changes

The shift toward the entrepreneurial university model has only recently begun; it may be premature to assess its impact on the university's performance in terms of the broader set of objectives that the new model implies. It is also not clear what mix of performance benchmarks may be appropriate for such an assessment. Finally, any change in performance in recent years may have been due to factors other than those we have associated with this shift.

Notwithstanding these caveats, Table 6.3 provides a summary overview of the key changes that HKUST has undergone between the 2000-01 and 2006-07 academic years. In essence Table 6.3 shows only a moderate expansion of the university in terms of conventional educational and research output but a more dramatic change can be observed in entrepreneurship promotion, technology commercialization and collaborative R&D and contract research. Progress in these latter areas is further elaborated below following a brief discussion of HKUST's human resources development role.

Human Resources Development

In 2005 in Hong Kong there were 10,580 graduates from science and technology-related fields of study—representing 37% of all graduates. This figure has remained fairly steady in both absolute numbers and percentages compared with the period of 2001 (with 10,476 students representing 35% of total graduates) to 2005 (with 10,580 students, representing 37% of the total). In 2005 14% of all science and technology-related graduates in Hong Kong earned degrees from HKUST.^{iv} These graduates represent an important human resource component that contributes directly to the development of higher value-added activities.

While the figures for HKUST may seem rather low at first glance it is worth remembering that it has no medical school, unlike HKU and CUHK. The figure for science-and-technology-related graduates includes the following fields: medicine, dentistry, health sciences, biological sciences, physical sciences, mathematical sciences, computing and information technology, and engineering and technology. HKUST can claim competence in only the latter five categories. HKUST is moreover the youngest of all universities in Hong Kong and until plans for post-2010 expansion are realized its absolute contribution to the science-and-technology-related landscape is likely to remain small but vital.

While the number of graduates coming out of HKUST appears to have stabilized in the near term at around 9000, HKUST has even more importantly shifted the emphasis of its contribution to human resource development toward the training of graduate students, in line with its increasing emphasis on knowledge creation. HKUST has seen a steady annual increase in the proportion of graduate students comprising its total student population. As shown in Table 6.3 graduate student enrolment increased from 1754 (comprising 24% of the total student population) in 2000-01 to 3228 in 2006-07 (comprising 36% of the total student population).^v

Knowledge Creation and Commercialization

The output of research publications (as measured by the number of research articles) authored by HKUST faculty has grown since the mid-1990s, standing at 1556 in 2006 as compared with 879 in 1994 (see Table 6.7), with even more rapid growth in internationally refereed journal publications, as its share has risen from about one-fifth in 1994 to over four-fifths in 2006. This has no doubt resulted from HKUST's intensive efforts to develop into one of the leading universities in science, technology and business management.

Table 6.7: HKUST Research Publications 1990–2006

A Year	B Journal Publications Covered by SSCI, AHI and SCI-Extended ^(a)	C Refereed Articles ^{(b) (c)}	(B/C)
1990	9	NA	NA
1991	20	NA	NA
1992	45	NA	NA
1993	112	NA	NA
1994	186	879	21.1%
1995	386	1001	38.6%
1996	532	1285	41.4%
1997	658	1173	56.1%
1998	783	1148	68.2%
1999	864	1542	56.0%
2000	1012	1437	70.4%
2001	1046	1101	95.0%
2002	962	1429	67.3%
2003	1127	1394	80.8%
2004	1227	1613	76.1%
2005	1155	1519	76.0%
2006	1302	1556	83.7%

Notes:

- (a) ISI Thompson Web of Science
- (b) Research Grants Council (RGC) of Hong Kong, Annual Reports.
- (c) Does not include books, non-refereed journal articles, conference papers, book chapters, or reports.

Concomitant with the increase in the rate of new knowledge creation during 1994–2006, the pace of knowledge commercialization also changed just as significantly. We examine the key areas of invention disclosures, patenting, and licensing in detail below.

Invention Disclosures

The availability of data reflecting invention disclosures are patchy but they show increasing numbers. As with other universities invention disclosure documentation fluctuates because not all faculty members disclose all their inventions to their universities. The absolute number of invention disclosures is small if compared with what occurs for example at the National University of Singapore, and generally there are three reasons for the small number of disclosures: First, HKUST is small, with a mere 7000 students and approximately

400 faculty members compared with HKU's 18 000 students and roughly 1000 faculty members; second, HKUST is still a relatively young university and as Table 6.8 shows, invention disclosures are increasing annually as it acquires the necessary expertise; third, some invention disclosures result in multiple patent applications (this is truer for the more recent data—2005-2006 onwards).

Table 6.8: Number of Invention Disclosures, Patents Filed by and Granted to HKUST 1992/1993–2006/2007

Financial Year	Number of Invention Disclosures	Patent Applications	Patents Granted
1992/93	3	1	0
1993/94	9	3	0
1994/95	11	3	1
1995/96	14	5	2
1996/97	29	19	1
1997/98	20	19	3
1998/99	22	25	7
1999/00	34	38	12
2000/01	29	33	10
2001/02	17	26	8
2002/03	13	29	8
2003/04	28	37	16
2004/05	31	58	14
2005/06	48	89	22
2006/07	69	124	34
Total	377	509	138

Sources and Notes:

Information as of 31 January 2008 provided by the Technology Transfer Center, HKUST.

Fiscal year runs from 1 July to 30 June.

Patent applications include provisional applications for which formal invention disclosure forms have not been submitted yet.

Patenting

Like other NIEs such as Singapore, Hong Kong undertook innovation activities rather late as compared with advanced Organisation for Economic Cooperation and Development (OECD) countries (Hong Kong entered the domain of science and technology even later than Singapore, Korea, or Taiwan). This accounts for the relatively low number of Hong Kong-based inventions receiving patent grants. Nevertheless Hong Kong's patenting performance improved dramatically between 1970–1974 and 1995–1999. Table 6.9 shows that the average number of US patents granted to Hong Kong's inventors jumped from an average of 12 per year to an average of 114 during this period. In addition to filing US patents Hong Kong's inventors increasingly file patents in China and the European Union, leaving only a small minority to apply locally.

Table 6.9: US Patents Granted to Hong Kong's Inventors 1970–1999

Period	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999
US Patents Granted	59	75	113	177	279	570

Source:

Mahmood and Singh 2003: 1034.

HKUST has played a role in this increased patenting activity primarily as a result of its encouragement of entrepreneurial activity among its faculty members (for example through the establishment of the TTC). Since its founding in 1991 HKUST has implemented an IP policy whereby all IP created by HKUST staff are assigned to HKUST, with the TTC tasked to license the IP and distribute any return from commercialization among the inventor, his or her department and HKUST central administration. For patents commercialized with a value lower than HK\$1 000 000 the inventor receives 50% of the returns from commercialization,

the home department receives 25%, and the university the remaining 25%. For patents commercialized with a value above HK\$1 000 000, commercialization returns are distributed equally among the inventor, the department, and the university.^{vi}

The total number of HKUST patent applications has for the most part grown steadily over the 1995–2006 period, with over 124 patent applications in 2006-07 (see Table 6.8, above). The number of patents granted also registered a similar increase with a high of 19 patents granted in 2005-06.^{vii} Over three quarters of the patents granted to HKUST have been filed in the US while 10% have been filed in the People's Republic of China.

Licensing

Table 6.10 shows an increase in the intensity of technology commercialization from 2000 onwards. As of 30 June 2006 HKUST had secured 121 licensing agreements. The majority of these agreements were signed between 2003 and 2006.

Table 6.10: HKUST Licensing Agreements 1995–2006

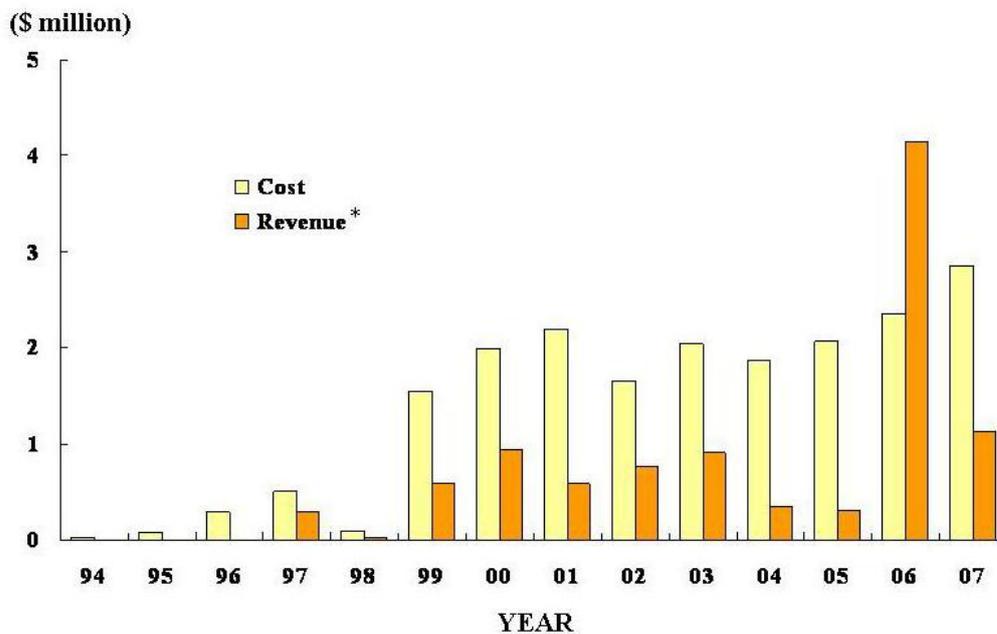
Year of License	Number of Licenses
1995	2
1996	5
1997	2
1998	5
1999	6
2000	8
2001	9
2002	9
2003	20
2004	15
2005	11
2006	29
Total	121

Source:

HKUST R and D Corporation.

In spite of this increase in technology licensing, the actual income generated from licensing remains modest. Figure 6.4 shows the expenditures/revenues from the protection and licensing of IP over the past 13 years, indicating a deficit situation for most years. The year 2006 represented a rare exception as a portfolio of 22 electronic patents was licensed for over HK\$4 million. It is not uncommon in university technology licensing to run an annual deficit. The money that universities make from technology transfer comes mostly from a small number of ‘blockbuster’ patents or growth companies. While the gestation period between licensing and royalty generation may diminish such income, interviews with the current and ex-director of HKUST’s TTC as well as representatives of the RDC suggest that encouraging technology commercialization rather than maximizing royalties is a matter of policy. Nevertheless, the potential income from anti-malarial drugs, the use of nanotechnology for wrinkle-resistant fabrics, and health foods based on cultivated cordyceps (a fungus) derived from traditional Chinese medicine is promising.

Figure 6.4: Direct Costs of IP Protection and Maintenance and Licensing/ Technology Transfer Revenues



Source:

<https://www.ust.hk/vpao/ADP/Annex%201-6%20Pdf/Annex%203.pdf>, p.42, accessed on 8 February 2008.

*HKUST’s R and D Corporation Limited has received equity in a number of companies to which technology has been transferred.

Entrepreneurial Startups and Spinoffs

Table 6.11 shows the results of HKUST's embracing of technology commercialization through spinoffs and startup formation following the establishment of the Entrepreneurship Program in July 1999. The number of startups (HKUST-based companies) incubated at HKUST has been relatively stable at an average of five or six startups in each of the four most recent years for which figures are available. There were also 14 spinoffs (companies that use HKUST technology but operate independently). The HKUST spinoff rate of around two per year is significantly lower than at such American universities as MIT, Stanford or Harvard, but the total of 61 spinoffs and startups represents a creditable return.

Table 6.11: Number of HKUST Start-ups and Spin-Offs 1999–2006

Year	Start-ups^(a)	Spin-offs
1999-2000	25	
2000-2001		
2002-2003	NA	14
2003-2004	5	
2004-2005	6	
2005-2006	5	
2006-2007	6	
Total	47	14

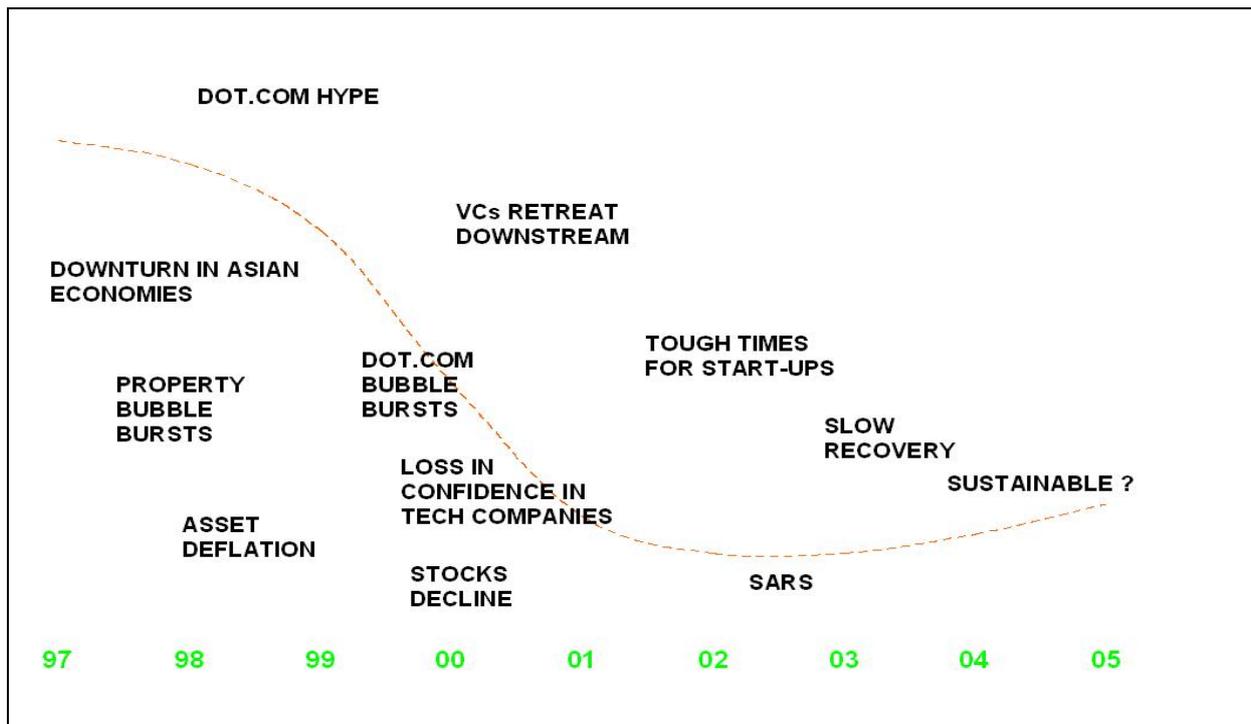
Source:

HKUST R and D Corporation.

^(a) Estimates from HKUST R and D Corporation

In spite of its successes, the HKUST Entrepreneurship Program has been a victim of poor timing, as it was established just prior to the bursting of the 'dot com' bubble in 2000. Figure 6.5 from Eastham et al. (2007) shows how the number of startups and spinoffs has fluctuated over the years in large part in response to locally felt global macroeconomic changes such as the SARS health crisis.

Figure 6.5: Pattern of Start-up Formation and Spin-offs from HKUST Entrepreneurship Program



Source:

Eastham et al., 2007.

HKUST has an opportunity nevertheless to learn from its experience with startup and spinoff companies that have not achieved commercial sustainability. Although activity in the HKUST Entrepreneurship Program has picked up in recently, it remains to learn how to sustain these companies, as HKUST must maintain operations and achieve growth beyond the inception phase.^{viii} Although a few highly successful companies such as Perception Digital Limited have moved off campus, several companies remain headquartered in the incubator facilities of the university's Enterprise Center.

Collaborative R&D and Contract Research

HKUST encourages faculty members to engage in collaborative R&D, often funded by the ITF or the newly-formed ITF R&D Centers. Since the inception of the ITF, HKUST has received 86 projects to which the ITF has contributed HK\$372 million—more than to any

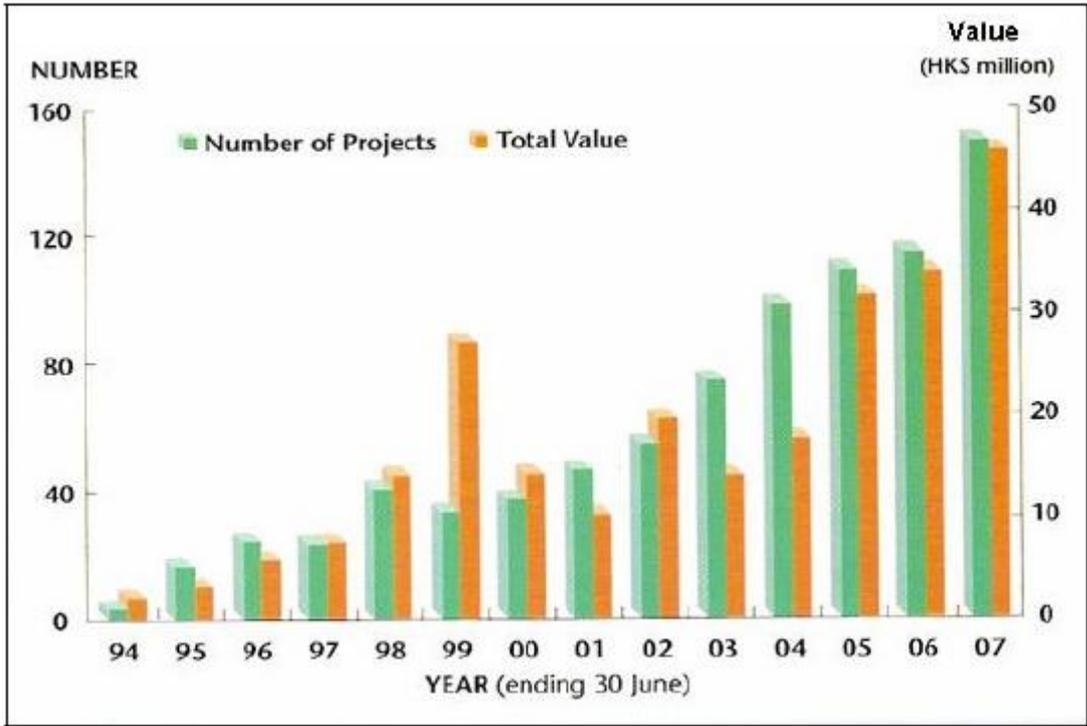
other university in Hong Kong. In addition two out of five Innovation and Technology Commission (ITC) R&D Centers are hosted or co-hosted by HKUST: the R&D Center for Nanotechnology and Advanced Materials Limited and the R&D Center for Logistics and Supply Chain Management Enabling Technologies Limited. The number of R&D contracts continues to grow, as shown in Figure 6.6, reaching 149 projects worth HK\$45.6 million in 2006-07.^{ix} Table 6/12 lists current R&D project clients.

Table 6.12: Clients of HKUST R&D Contracts as of 30 June 2008

R&D Contract Client	By Number of Projects	By Contract Amount
Hong Kong Business and Industry	50%	23%
Hong Kong Public Sector	20%	5%
Mainland Organizations	15%	10%
Overseas Companies	15%	62%

Source: Technology Transfer Center & HKUST R and D Corporation Ltd. Annual Report 2007-08.

Figure 6.6: New HKUST R&D Contracts by Year



Source:

<https://www.ust.hk/vpao/ADP/Annex%201-6%20Pdf/Annex%203.pdf>, p.43, accessed on 8 February 2008.

All HKUST R&D contracts include overhead costs, but there is flexibility in terms of the percentage of overhead applied. The norm is 30% on direct costs (excluding equipment and subcontracts), a figure that is sometimes reduced under special circumstances—if the contract is with a small or medium-sized enterprise, unusually large (multimillion HK dollars), or involves strategic partners.

In these situations HKUST seeks ownership of IP but when clients resist the university defines what HKUST-owned IP is being brought into the project. R&D contracts commonly restrict publications, requiring the submission of draft publications to clients for review, say 30 days ahead of submission, to protect confidential information.

UNIVERSITY-INDUSTRY LINKAGE CASES: PERCEPTION DIGITAL AND RAYMOND INDUSTRIAL LIMITED

In this section we illustrate the pattern of university-industry linkages and entrepreneurship at HKUST by focusing on two actual cases: Perception Digital Ltd. and Raymond Industrial Ltd.

Perception Digital: An HKUST Startup

Perception Digital Limited was established in 1999 by three faculty members from the Department of Electrical and Electronic Engineering at HKUST. The CEO, Dr. Jack Lau, has retired from his position at the university to devote all his time to managing Perception Digital. His co-founders remain faculty members but also contribute to the company as consultants. Perception Digital, with an annual turnover of around US\$75-80 million and almost 300 people employed in Hong Kong, the Chinese Mainland and the United States, provides turnkey and firmware solutions in the areas of portable MP3 players with flash or hard disk memory, portable hard disks, and various wireless audiovisual products.

The company was founded on the basis of research at the Consumer Media Laboratory of HKUST, eventually moving into the university's incubator facilities to design MP3 products to be manufactured in Guangdong province. The unpatented technologies for displays, digital signal processing and other software that were developed at HKUST provided the background for market penetration. The company's engineers have since developed other technologies and designs that are implemented in products sold under OEM agreements to major brand-name firms or sold as consumer products under its own brand. Increasingly, the firm operates as a design supply chain integrator/manager capitalizing on its core competencies including algorithms design, wireless communication, digital signal processing, power management, precise electro-mechanics design and expertise in integrating various technologies.

According to Lau (interviewed June 2008) HKUST offers fairly liberal technology transfer and entrepreneurship policies. Faculty are encouraged to involve themselves in startups and are granted leaves to pursue technology commercialization, although they must avoid heavy management responsibilities and remain on the university's teaching staff. The HKUST assumed an initial equity stake in Perception Digital but has not interfered in firm management and it helped Lau procure venture capital and business services.

Lau underscores the importance of maintaining strong linkages with HKUST, and Perception Digital remains a major employer of HKUST engineering graduates. Perception Digital's scholarships for engineering students facilitate an important channel for developing the firm's knowledge base.

Raymond Industrial: Long-term Collaboration

The collaboration between Prof I-Ming Hsing in the HKUST Department of Chemical Engineering and Raymond Industrial Limited (RIL) was initiated in 2001 as a result of a previous successful R&D project with the Chung Nam Corporation related to fuel cell technology. Professor Hsing had been introduced to Chung Nam by the HKUST TTC in 1999.

Chung Nam is the second-largest OEM watch manufacturer in Hong Kong and the project was sponsored jointly by the corporation and the ITF. The Director of the firm then introduced Professor Hsing to Raymond Wong, the Managing Director of RIL, another important OEM manufacturer from Hong Kong.

The contact with RIL resulted in a still thriving, long-term mutual commitment. RIL was also interested in developing nanotechnology applications for fuel cells in a collaborative project with ITC funding under the 90-10 rule (with HKUST keeping the intellectual property rights) at around HK\$1.3 million. Although the project did not succeed in commercializing a new fuel cell technology (and RIL is no longer involved in fuel cell development), some of the technologies developed could be used for high precision coating and machining of components for electric shaver heads (a key RIL product).

RIL has also established a joint laboratory with HKUST on its industrial estate in Nansha to assist in projects carried out at the Center for Bioengineering and Biomedical Devices located at the Nansha Campus of the HKUST Fok Ying Tung Graduate School, which is directed by Professor Hsing. At this wet laboratory local researchers conduct research in an environment that is not yet available at the Nansha campus.

When Prof. Hsing, an MIT graduate who worked with DuPont and other firms, came to Hong Kong he thought that projects funded by the RGC were not very exciting so he applied his experience and enthusiasm to his new setting. Professor Hsing believes that HKUST should emphasize its comparative advantage in advanced applied research and development over the long term rather than in solving short-term technical problems.

CONCLUSIONS

HKUST began making significant strides towards fulfilling its envisioned promise as a progressive entrepreneurial university in the late 1990s. Since finding its identity it has steadily increased its entrepreneurial profile, effecting a qualitative change in its contributions

to economic development in Hong Kong. Today we are able to observe that it is no longer content merely to provide traditional human resources and new knowledge, assuming a more visible role in knowledge commercialization through increased patenting, licensing to private industry, startup incubation and spinoffs.

The empirical evidence of HKUST's changing role supports the findings of Wong et al. (2007) that universities can more effectively contribute to economic growth by adopting the entrepreneurial university model. HKUST's embrace of this model may not fully explain its own increasing share in this entrepreneurial engagement but the programs it has employed, particularly the Entrepreneurship Program, may prove instructive to other East Asian universities.

We have been limited to some extent in this study by the relative lack of official statistics. This is however a common problem related to science and technology statistics across all sectors in Hong Kong. These developments pertaining to innovation and commercialization performance are so recent that they may not represent sustainable, long-term changes. We have yet to see substantial licensing revenue or significant commercial spinoff successes. Thus we cannot claim with utter confidence that HKUST's commitment to the entrepreneurial university model will eventually bring significant economic payoffs.

In any event we believe that a sustained focus on developing the capacity for research collaboration and personnel exchange with both new and established firms can yield significant benefits for the region and for the universities. In other words, we should not pursue technology transfer as an end in itself but rather as a means of creating or strengthening research collaboration between universities and the private sector. HKUST must nevertheless be careful not to oversell its catalytic powers in the face of heightened industry expectations. As Sharif and Baark (2008) show, the gap between universities and industry is substantial and universities must avoid widening that chasm.

To these conclusions we add several lessons, which are serving to re-orient the Entrepreneurship Program's work. First, establishing successful spinoffs and startups is difficult. Macroeconomic factors related to the Program and even to the university can

potentially affect any such program's success, as illustrated by the 'dot com' bust of 2000. Second, the road from identifying a discovery or an innovation to creating a viable commercial opportunity for that technology is long and arduous. Human capital is as vital as the technology itself to creating a successful technology-based startup. Startups need people with the relevant business knowledge, experience and acumen, without which anyone can fail even if their idea makes sense. Finally, a start-up venture must bring into the process a strongly market-oriented focus. A technologically brilliant concept will fail if there is no market for it.

In response to these lessons the Entrepreneurship Program will institute three concrete changes. First, the program is working to create a better network of early-stage investors to improve funding availability. Second, it is more actively engaging in joint ventures between its startups and well established companies. Finally, it is concentrating on identifying cutting-edge technologies with real market potential rather than enlisting existing technologies.

HKUST's transition to the entrepreneurial university model is a work in progress that represents a concerted effort to contribute more effectively to the process through which a regional economy is being transformed into a knowledge-based economic hub. The university is however setting itself up for public scrutiny of the pace and reach of its success in commercializing technologies, not least because of the considerable extent of public funding of Hong Kong's universities. HKUST faces stubborn resistance in transforming technology commercialization into a university-wide focus, and it is hard to predict success in light of heightened public expectations. Still, considering Hong Kong's slow transition into the information age, it is equally difficult to see how the transition to a knowledge-based economy can be completed without the contributions of its university system. In that respect all eyes will remain on HKUST.

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ⁱ See statistics posted on the Website of the EDB, available at <http://www.emb.gov.hk/index.aspx?langno=1&nodeid=1032> (accessed 14 June 2007).

ⁱⁱ For more detailed figures, see <http://www.ugc.edu.hk/eng/rgc/result/cerg/cerg.htm>

ⁱⁱⁱ As it did for RAE 1999, the UGC again adopted a very broad definition of research in RAE 2006 by using a definition of 'scholarship' developed and refined by the Carnegie Foundation, covering 'discovery, integration, application and teaching'. This definition was adopted to accommodate a wide spectrum of research disciplines, from sciences and technology to business to arts to education. Available at the UGC Website, <http://www.ugc.edu.hk/eng/ugc/publication/press/2007/pr02032007.htm> (accessed 28 December 2007).

^{iv} UGC (2008) Graduates of UGC-funded Programmes by Institution, Level of Study, Mode of Study and Academic Programme, 2004/05 & 2005/06. From: <http://www.ugc.edu.hk/eng/ugc/publication/report/figure2006/figures/09.pdf>, and <http://www.ugc.edu.hk/eng/ugc/publication/report/figure2006/figures/08.pdf>, accessed on 15 January 2008.

^v In line with this increase in graduate student numbers has been the increase in foreign students, from 7% in 2000-01 to 19% in 2006-07: It is not clear from the statistics, however, whether this increase in foreign students studying at HKUST can be attributed to the undergraduate level or graduate level, although anecdotal evidence suggests it is the latter.

^{vi} As regards to joint patenting with industry, almost no patents have creators from both HKUST and industry—the vast majority have inventors from HKUST alone, whereas a few have inventors from HKUST and one or more other local tertiary institution.

^{vii} Citations are not a widely used measure of patent quality. Rather, the utility of a patent is often measured in terms of whether the patent is licensed or sold.

^{viii} There are some emerging successes such as Perception Digital Limited, Googol Technology (HK) Limited, Advanced Packaging Technology Limited, Radica Systems Limited, and TIM EDPlatform Limited. All of these startups were founded by faculty members and their students as partners.

^{ix} R&D contracts are typically of the same format of R&D contracts in the US, except for some local customizations made in some cases. Overhead costs are included at 15%.