Hong Kong Innovation Project

Report No. 1

University-industry collaboration and technology transfer in Hong Kong and knowledge-based economic growth

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I. Introduction

The 21st century is the century of knowledge-based international economic competition. More than ever, the prosperity of nations depends on the ability of public and private institutions, policies, managers, and workers to mobilize and exploit knowledge-intensive capabilities and assets. Although natural resources play an important role in economic competitiveness, the ability of even resource-rich economies to raise and sustain their citizens' living standards depends on their ability to exploit the created resources of knowledge and human capital.

Governments in both the industrial and industrializing economies have sought to address the competitiveness challenge by strengthening policies and institutions that support innovation. One such institution is the research university, and governments have launched a number of policy initiatives to enhance the contribution of national university systems to industrial innovation. There are a number of reasons for the recent policy focus on research universities. Considerable evidence (Narin et al., 1997; Hicks et al., 2001) suggests that the dependence of technological innovation on advances in science has increased in recent decades, a considerable change from the "trial and error" character of innovation in the late 19th and early 20th centuries. Universities also play a unique role in conducting applied and fundamental research as well as training engineers and scientists, and their ability to expose graduates to the frontiers of scientific research provides a powerful mechanism for the transfer of knowledge and technology. Governmental laboratories rarely combine research and education to a comparable degree and therefore frequently face obstacles to the transfer and application of their research results. At least some expert groups (See OECD, 2003) also credit universities with greater flexibility and capabilities to form teams in new, multidisciplinary research fields.

Four of Hong Kong's universities (HKUST, HKU, CUHK, and the City University of Hong Kong) have consistently ranked among the better universities in Asia. The Jiao Tong University "Academic Ranking of World Universities" (http://www.awru.org; accessed 2/12/08) ranked all four universities as tied for 25th place in its 2007 "Asia/Pacific" rankings, tied with Peking University and slightly behind Tsinghua (ranked 19th). The four universities were tied in the "world rankings" of the top 500 universities at roughly 200th place, behind the Tsinghua ranking of 150th and equal to Peking University's ranking. Singapore's National University was ranked as the 10th best Asia/Pacific university in the 2007 rankings, above all of the Hong Kong universities, and was tied with numerous other universities in the global rankings at roughly 100 out of 500.

Interestingly, however, Hong Kong's universities do not appear in any of the Jiao Tong study's field-specific rankings (spanning the physical sciences, the life sciences, social sciences, clinical medicine, and engineering) in areas other than engineering and computer science, where HKUST was ranked at 37, CUHK at 77, and City UHK tied with Tsinghua at 51 out of 100 (National University of Singapore ranked 32nd in this tabulation). Hong Kong's universities have roughly maintained these positions in the Jiao Tong rankings since their inception in 2003. The Hong Kong universities thus are leading regional universities within Asia, but are in the "second tier" of global rankings. Their status as regional but not global leaders, as well as the rough parity between the leading Hong Kong universities and the leading Northern mainland universities raises some significant future challenges for Hong Kong's universities.

The 1997 analysis of Hong Kong's economic prospects by Suzanne Berger and Richard Lester, *Made by Hong Kong*, concluded from interviews and other fieldwork that a "common complaint was that the universities hold themselves aloof from the industrial sector and do not

tailor their teaching and research activities closely enough to its needs…" (Berger and Lester, 1997, p. 66). The authors noted that a number of public initiatives had been launched by the Hong Kong government since the early 1990s to expand financial support for Hong Kong university research and strengthen university linkages with regional industry, and if anything these initiatives have expanded in number and scale since that period.

The HKSAR government has increased financial support for research collaborations involving university and industrial researchers, HK universities have expanded their efforts to support technology transfer to Hong Kong industry through patenting and licensing of faculty inventions, and universities have provided support for the formation of "spinoff" firms to commercialize faculty inventions. These initiatives appear to have produced positive overall results, although realization of their full effects will take time. Nevertheless, Lester and Berger's assessment of Hong Kong's universities as "…aloof from the industrial sector…" no longer appears accurate.

Although current policy initiatives have had positive effects, a number of changes in their structure could enhance their effectiveness and impact. These policies focus on supporting applied research and faculty economic entrepreneurship. But this focus must be complemented by steps to strengthen the fundamental research capabilities of Hong Kong's universities, enabling faculty to become "research entrepreneurs," pursuing opportunities for financial support through excellence in basic research. Existing government policies also have been developed and implemented in a sequential fashion, with little or no high-level strategic vision guiding their structure, goals, and evaluation. It is important for HKSAR policymakers and industrial managers alike to develop a more realistic, shared appreciation of the nature and scope of economic benefits flowing from research universities, particularly in a small geographic and economic region such as Hong Kong. Any "university-focused" policy to support innovation

within Hong Kong should be one part of a broader strategic vision for knowledge-based growth in Hong Kong and the Pearl River Delta that includes a range of policies extending beyond the region's universities. Among other things, this broader strategy should be coordinated with the rapidly evolving innovation policies of the PRC, which involve far larger sums of money and are linked to vastly larger flows of industrial investment.

The two sections following this introduction summarize the findings of the large body of recent research on the contributions of research universities to industrial innovation and briefly discuss policy initiatives in the United States and other industrial economies that have sought to enhance these contributions. The next two sections describe and evaluate policies and performance in university-industry research collaboration and technology transfer in Hong Kong. I then summarize the discussion of the challenges facing Hong Kong and its universities, and conclude with recommendations for the HKSAR government and HK universities.

II. How does academic research influence industrial innovation?

A number of studies based on interviews and surveys of senior industrial managers in industries ranging from pharmaceuticals to electrical equipment have examined the influence of university research on industrial innovation. All of these studies (GUIRR, 1991; Mansfield, 1991; Levin et al., 1987; Cohen, Nelson, & Walsh, 2002) emphasize differences in the relationship between university and industrial innovation in various fields of research. In particular, university research advances affect industrial innovation more significantly and directly in the biomedical field than is true of other sectors. The survey of industrial R&D managers that is summarized in Cohen et al. (2002) indicates that in most industries other than pharmaceuticals, university research results play a minor role in triggering new industrial R&D projects; instead, the stimuli originate with customers or from manufacturing operations.

When asked directly about the contributions of university research to industrial innovation, R&D managers in U.S. industry typically cite the engineering or applied sciences, fields of U.S. university research with a long history of university-industry collaboration, as most important (Levin et al., 1987; Cohen et al., 2002). With the exception of chemistry, few basic sciences are deemed by industry R&D managers to be relevant to their innovative activities. Their low rankings of fields such as physics and mathematics, however, do not mean that academic research in these fields does not contribute to technical advance in industry. Instead, these survey results reflect the fact that the effects on industrial innovation of basic research findings in such areas as physics, mathematics, and the physical sciences are realized only after a considerable lag. Moreover, application of academic research results often requires that these advances be incorporated into the applied sciences, such as chemical engineering, electrical engineering and material sciences.

The survey of R&D managers by Cohen et al. (2002) also explored the importance to industrial R&D of different channels of communication linking intrafirm R&D to external performers of R&D in government or university laboratories. Although pharmaceutical executives assign greater importance to patents and license agreements involving universities and public laboratories, even respondents from this industry rated research publications and conferences as a more important source of information. For most industries, patents and licenses involving inventions from university or public laboratories were reported to be of little importance, compared with publications, conferences, informal interaction with university researchers, and consulting.

Another important feature of the relationship between academic and industrial researchers is its dynamic and interactive character. Industrial research may in fact “lead” and

influence the agenda of academic research in some fields, as was the case in the early stages of research on light-emitting diodes and semiconductors. As Lecuyer (2006) points out, Provost Frederick Terman of Stanford University encouraged William Shockley to locate his new firm near the university in 1955 to expose Stanford engineering faculty to new research in solid-state physics and electronics, and one future dean of Stanford's Engineering School served as an apprentice at Shockley Semiconductor.[1] The movement of researchers between industry and academia facilitates this interactive relationship (e.g., the move by Dr. Shuji Nakamura, a pioneering research in gallium-arsenide LEDs, from Nichia Chemicals in Japan to the University of California-Santa Barbara in 2000; see Chapter 7 in Mowery et al., 2004 for further discussion).

Although such institutions as Stanford University or MIT have been widely cited as "catalysts" in the growth of high-technology "clusters" in California's Silicon Valley or eastern Massachusetts, the role of research universities in the creation of high-technology regional agglomerations remains controversial. As Bresnahan and Gambardella (2004) point out, the creation of such clusters may rely on processes and factors that contrast with those needed to sustain such clusters. For example, the role of Stanford or U.C. Berkeley in the creation of Silicon Valley was rather modest, especially by comparison with their significant contributions to the dynamism of this regional cluster (contributions that now span electronics, computer software, and the life sciences) once it was established. Indeed, Klepper (2008) shows that most of the early entrants into the Silicon Valley semiconductor industry were spinoffs from established semiconductor firms, rather than universities. Research universities have not

[1] "[James] Gibbons [future dean of engineering at Stanford], a junior faculty in the electrical engineering department [*sic*] at Stanford, worked at Shockley Semiconductor on a part-time basis. Frederick Terman, Stanford's provost, and John Linvill, the head of the Solid-State Laboratory, had recently apprenticed Gibbons to William Shockley. They had asked Gibbons to learn the techniques required for the fabrication of silicon devices from Shockley and then transfer these techniques back to the university. This was not the first time that Terman had sought to appropriate process technologies from local firms." (Lecuyer, 2006, p. 138).

consistently been either necessary or sufficient for the development of other high-technology clusters in the global economy.[2]

III. Policy initiatives within the OECD to support university-industry collaboration

As I noted above, numerous industrial-economy governments have adopted policies to encourage higher levels of collaboration and technology transfer between academic and industrial researchers since the 1980s. Among the most influential of these initiatives is the U.S. Bayh-Dole Act of 1980, which has been cited (on the basis of modest evidence) as an important factor in the competitive revival of the U.S. economy during the 1990s.[3] Implicit in many if not all of these characterizations is the argument that university patenting and licensing were necessary to these asserted increases in the economic contributions of U.S. university research. Similar characterizations of the effects of the Bayh-Dole Act have been articulated by the

[2] Summarizing the chapters on California's Silicon Valley, Cambridge (UK), the Indian and Irish software industries, and Israel's electronics industry, in their edited volume on "high-tech clusters," Bresnahan and Gambardella conclude that "Taken as a group,…these chapters are not at all encouraging of a simple 'recipe' view of universities and higher education in starting a cluster. The 'recipe' view uses a particular local institution, in this case, a university, as a shorthand for the capabilities provided by that institution. We have shown, however, that there are different ways to achieve a supply of skilled labor and that it is the ultimate outcome (a supply of high-skilled labor), not the particular mechanism (a university), that matters." (Bresnahan and Gambardella, 2004, p. 344).

[3] In 2000, an OECD report stated that "Regulatory reform in the United States in the early 1980s, such as the Bayh-Dole Act, have [sic] significantly increased the contribution of scientific institutions to innovation. There is evidence that this is one of the factors contributing to the pick-up of US growth performance…" (OECD, A New Economy?, 2000, p. 77), and in 2002, the *Economist* magazine stated that ."Possibly the most inspired piece of legislation to be enacted in America over the past half-century was the Bayh-Dole Act of 1980. Together with amendments in 1984 and augmentation in 1986, this unlocked all the inventions and discoveries that had been made in laboratories throughout the United States with the help of taxpayers' money. More than anything, this single policy measure helped to reverse America's precipitous slide into industrial irrelevance. Before Bayh-Dole, the fruits of research supported by government agencies had gone strictly to the federal government. Nobody could exploit such research without tedious negotiations with a federal agency concerned. Worse, companies found it nigh impossible to acquire exclusive rights to a government owned patent. And without that, few firms were willing to invest millions more of their own money to turn a basic research idea into a marketable product." (*Economist*, 12/14/02). Neither assessment of the effects of Bayh-Dole included any evidence in support of these claims.

President of the Association of American Universities,[4] and the Commissioner of the U.S. Patent and Trademark Office.[5]

Although the Bayh-Dole Act encouraged the patenting and licensing of academic research advances based on publicly funded research, U.S. universities had long been active in patenting. One of the earliest U.C. Berkeley patenters was Professor Frederick Cottrell, who received a number of patents for antipollution technologies in the early 20th century, and used his licensing royalties to create and support the Research Corporation, which became an important licensing agent for many U.S. universities during the 1930 – 75 period.

University-industry collaboration in U.S. higher education was facilitated by the unusual structure of the U.S. higher education system (especially by comparison with those of other industrial economies) during the 20th century. The U.S. higher education system was significantly larger, included a heterogeneous collection of institutions (religious and secular, public and private, large and small, etc.), lacked any centralized national administrative control, and encouraged considerable interinstitutional competition for students, faculty, resources, and prestige (See Geiger, 1986, 1993; Trow, 1979, 1991, among other discussions). In addition, the reliance by many public universities on "local" (state-level) sources for political and financial support further enhanced their incentives to develop collaborative relationships with regional industrial and agricultural establishments. The structure of the U.S. higher education system thus

[4] "In 1980, the enactment of the Bayh-Dole Act (Public Law 98-620) culminated years of work to develop incentives for laboratory discoveries to make their way to the marketplace promptly, with all the attendant benefits for public welfare and economic growth that result from those innovations. Before Bayh-Dole, the federal government had accumulated 30,000 patents, of which only 5% had been licensed and even fewer had found their way into commercial products. Today under Bayh-Dole more than 200 universities are engaged in technology transfer, adding more than $21 billion each year to the economy."

[5] "In the 1970s, the government discovered the inventions that resulted from public funding were not reaching the marketplace because no one would make the additional investment to turn basic research into marketable products. That finding resulted in the Bayh-Dole Act, passed in 1980. It enabled universities, small companies, and nonprofit organizations to commercialize the results of federally funded research. The results of Bayh-Dole have been significant. Before 1981, fewer than 250 patents were issued to universities each year. A decade later universities were averaging approximately 1,000 patents a year."

strengthened incentives for faculty and academic administrators to collaborate in research and other activities with industry, and to do so through channels that included much more than patenting and licensing.

The Bayh-Dole Act did not legalize anything that was previously prohibited, since federal agencies had for at least a decade prior to the Act allowed universities to obtain title to patents on publicly funded research through "Institutional Patent Agreements." But the Act did rationalize and simplify the processes through which U.S. universities could obtain patents on publicly funded research results, and its near-unanimous passage by both houses of the U.S. Congress constituted a strong political endorsement for university patenting.

The passage of the Bayh-Dole Act was one part of a broader shift in U.S. policy toward stronger intellectual property rights.[6] Among the most important of these policy initiatives was the establishment of the Court of Appeals for the Federal Circuit (CAFC) in 1982. Established to serve as the court of final appeal for patent cases throughout the federal judiciary, the CAFC soon emerged as a strong champion of patentholder rights.[7] But even before the establishment of the CAFC, the 1980 U.S. Supreme Court decision in *Diamond v. Chakrabarty* upheld the validity of a broad patent in the new industry of biotechnology, facilitating the patenting and licensing of inventions in this sector. The effects of Bayh-Dole thus must be viewed in the context of this larger shift in U.S. policy toward intellectual property rights.

Passage of the Bayh-Dole Act also occurred during a period of significant scientific advances (largely funded by the U.S. National Institutes of Health) in molecular biology that

[6] According to Katz and Ordover (1990), at least 14 Congressional bills passed during the 1980s focused on strengthening domestic and international protection for intellectual property rights, and the Court of Appeals for the Federal Circuit created in 1982 has upheld patent rights in roughly 80% of the cases argued before it, a considerable increase from the pre-1982 rate of 30% for the Federal bench.

[7] See Hall and Ziedonis (2001) for an analysis of the effects of the CAFC and related policy shifts on patenting in the U.S. semiconductor industry.

proved to be important in the early licensing activities of U.S. universities.[8] For example, the Cohen-Boyer patent that was assigned to the University of California and Stanford University, covering an important "process technology" for the early U.S. biotechnology industry, generated more than US$250 million in licensing royalties over the life of the patent. Significantly, the application for this patent was filed before passage of the Bayh-Dole Act.

Evidence cited in Mowery et al. (2004 reveals that gross licensing revenues for Columbia University, Stanford University, and the University of California system during the period after the passage of the Bayh-Dole Act were dominated by a small number of patents. For each of these three universities, the "top 5" patents accounted for more than 65% of gross licensing revenues. These "top 5" patents were mainly biomedical inventions. Universities lacking a major biomedical research program may not produce such "home run" patents and therefore may reap lower gross revenues. The high costs of establishing and operating technology licensing offices (costs that include the legal expenses associated with patent prosecution and litigation) also depress net revenues.

Even the University of California system (which consisted of nine campuses during the period covered by these data), one of the leading U.S. university recipients of licensing revenue during the "post-Bayh-Dole" era, reaped surprisingly small net revenues from licensing activities. During fiscal 2001-2004 average annual gross licensing revenues for the UC system were roughly $75 million. The net contribution to UC operating expenses, however, a figure that subtracts the operating expenses of the technology licensing office and payments to the faculty inventor, averaged slightly more than $15 million annually. This amount represents a small fraction (less than 1%) of the annual research budget for the UC system of more than $3 billion.

[8] Indeed, their belief in the licensing potential of biotechnology research advances appears to have influenced a number of U.S. universities to lobby for the passage of the Bayh-Dole Act (See Mowery et al., 2004).

Industry funding of academic research within the UC system in fiscal 2001 (the most recent year for which comprehensive data are available) amounted to $235 million, dwarfing both the average gross and net institutional revenues associated with licensing activities.[9]

Although many of the positive evaluations of the economic effects of the Bayh-Dole Act highlight the role of small-firm startups as beneficiaries of these licensing transactions, the data compiled by the Association of University Technology Managers (AUTM, 2001, 2002) suggest that firms founded specifically to commercialize licensed university technologies account for a minority of licensees. The AUTM annual reports for 2001 and 2002 indicate that 14 – 16% of university patent licensees in these years were startup firms founded to exploit the licensed inventions. More than one-half (50 - 54%) of academic licensees during this period were small (fewer than 500 employees) firms already in existence, while roughly one-third (32 – 33%) of licensees were large firms. The emphasis in recent academic research (DiGregorio and Shane, 2003) on the role of university "spinoffs" in the licensing activities of U.S. universities thus needs to be qualified by recognition that such startups account for a much smaller share of university licensing activity than large firms.[10]

The effects of the Bayh-Dole Act on university technology licensing, to say nothing of the Act's effects on overall U.S. economic performance, thus remain controversial (See Mowery et al. 2004 for a critical assessment). Nonetheless, the Act has inspired considerable emulation by other OECD governments. Since 1990, laws or policies encouraging collaboration between

[9] http://www.ucop.edu/research/publications/pdf/resfund01.pdf, accessed February 20, 2006.

[10] Moreover, as Hughes (2008) points out, university "spinoff" firms that are licensees account for a tiny share of overall new-firm formation in the U.S. economy: "The US economy has some 560 000 firms starting up each year. That, of course, includes firms of all kinds from small restaurants to boutique high-tech businesses, not just businesses based on the exploitation of intellectual property (IP) or new products derived from advances in scientific research. In the USA as a whole, in 2004 there were 462 IP-based start-ups where the IP was from a U.S. university. That may be an impressive performance internationally, but its scale has to be borne in mind in interpreting claims of what might be gained in other economies from such spin-offs." (p. 84).

industry and university researchers and/or technology licensing by universities have been adopted in Japan,[11] Denmark,[12] Germany,[13] France,[14] Great Britain,[15] and Canada.[16] Although many of them appear to have been influenced by the Bayh-Dole Act, these "emulations" of Bayh-Dole differ from one another and from Bayh-Dole itself. The policy proposals and initiatives are based on the belief that university patenting was an essential vehicle for effective transfer of technology from universities to industry and that Bayh-Dole was essential to the growth of university-industry interaction in science-based industries in the United States during and after the 1980s. They focus narrowly on the "deliverable" outputs of university research, and ignore the effects of patenting and licensing on other channels through which universities contribute to innovation and economic growth.

After all, patenting and licensing were only one of many channels through which U.S. universities contributed to industrial innovation throughout the 20th century, and I noted earlier that surveys of industrial managers suggest that these channels are not the most important ones in most technological fields. Especially in the absence of other changes to enhance the autonomy

[11] The "Japanese Bayh-Dole Act" of 1999 shifted ownership from individual inventors to universities (http://www.nsftokyo.org/rm04-05.html).

[12] In Denmark, a 1999 law gave public research organizations, including universities, the rights to all inventions funded by the Ministry for Research and Technology. Under Denmark's previous policy (established in 1957), all such rights had reverted to employees (OECD 2003).

[13] The German Ministry for Science and Education in 2002 altered the "professor's privilege," which gave academic researchers primary responsibility for the decision to file for patent protection on inventions and granted them the rights to any resulting patents. The new policy requires that academic inventors inform their employers of potentially patentable inventions two months before papers disclosing such inventions are submitted for publication, and grants universities four months to determine whether they wish to file for patent protection (Kilger and Bartenbach, 2002).

[14] In France, a 1999 law authorized the creation of technology transfer offices at universities, and in 2001 the Ministry of Research "recommended" that universities and public research organizations establish policies to assert their rights to employee inventions (OECD 2003).

[15] Although no uniform government policy governs the treatment of university inventions in the United Kingdom, "there is now an increasing trend for Universities to claim ownership" over academic inventions (Christie et al, p. 71).

[16] The Canadian Prime Minister's "Expert Panel on the Commercialization of University Research" recommended in 1999 that universities retain ownership of inventions resulting from publicly funded research, and "be held accountable for maximizing returns to Canada," noting that "the proposed IP policy framework will inspire a transformational shift in culture within Canadian universities, as happened in the United States with the passage of the Bayh-Dole Act in 1980" (Public Investments in University Research, p. 28).

of universities and inter-institutional competition, emulation of the Bayh-Dole Act is insufficient and perhaps even unnecessary to stimulate higher levels of university-industry interaction and technology transfer. For example, recent work by Crespi et al. (2006) suggests that less than 25% of the EPO patents applied for during 1993 – 97 for which university faculty in Great Britain, Netherlands, France, Germany, Italy, and Spain are listed as inventors or co-inventors were assigned to their universities, suggesting that considerable European university faculty patenting has not been captured in existing data. If the data cited in Crespi et al. are broadly representative of the contributions of European university faculty to industrial innovation, emulation of the Bayh-Dole Act within Europe may have little effect on industrial access to and utilization of the results of academic research.

Indeed, emulation of Bayh-Dole could be counterproductive, precisely because of the importance of other channels for technology transfer and exploitation by industry. A narrow-minded focus on licensing as the primary or only channel for technology transfer could have a chilling effect on the operation of other important channels. There are potential risks to the university research enterprise that accompany increased involvement by university administrators and faculty in technology licensing and commercialization, and uncritical emulation of Bayh-Dole in a very different institutional context could intensify these risks.

IV. The local environment for university-industry collaboration: R&D investment and innovation in HK industry

Understanding current policies affecting university-industry research linkages in Hong Kong requires some discussion of the economic environment within the HKSAR that has influenced the design and effects of policies toward innovation. Interviews with HK university

faculty, administrators, and policymakers revealed considerable agreement on a specific challenge: low R&D investment by Hong Kong firms provides a weak foundation for university-industry collaboration and technology transfer. Low levels of R&D investment mean that HK firms have limited "absorptive capacity" (Cohen and Levinthal, 1990) to exploit university research advances through licensing, faculty consulting, or hiring of graduates of HK universities. HK university faculty in particular argued that the weak innovative capacities of Hong Kong industry weakened the employment prospects within manufacturing for undergraduate and graduate degreeholders in engineering and scientific fields. Indeed, several faculty interviewees noted that many technical degreeholders currently find more lucrative employment prospects in Hong Kong's financial services industries.

These perceived obstacles to the transfer of university knowledge and technology to established HK firms have led a number of HK universities to support the formation of new firms to commercialize their intellectual property. New firms may be more effective sources of "disruptive" innovation, and successful startup firms also will provide employment opportunities in technical fields for their graduates. Here too, however, local obstacles to the formation of new firms were widely cited by interviewees who argued that venture capital firms, many of which maintain offices in Hong Kong, historically have provided limited finance to new HK firms. Indeed, Hong Kong venture capitalists are more likely to finance new firms in Shanghai than in Hong Kong.

Is the gloomy assessment of innovation and R&D in Hong Kong industry borne out by data on HKSAR R&D investment trends? Investment in R&D in Hong Kong appears to have grown since the mid-1990s, in part as a result of changes in public policy but also as a result of expanded industrial investment in R&D. R&D investment grew from .43% of Hong Kong GDP

in 1998 to .8% in 2006, according to the HK Census and Statistics Bureau.[17] In spite of this growth in the share of its GDP devoted to R&D investment, Hong Kong lags well behind the PRC, as well as such neighboring economies as Taiwan or Singapore, in its R&D/GDP ratio.[18]

Although overall R&D investment in Hong Kong is comparatively low relative to the size of the region's economy, industry-funded R&D investment has grown significantly since 2002. The industry-financed share of total HKSAR R&D investment expanded from 35% in 2002 to 53% in 2006, while government-funded R&D investment declined from 63% to 43% of total R&D investment during the same period (*Statistics on Research and Development of Hong Kong, 2002 to 2006*, p. FA5). [19] As of 2006, Hong Kong's business sector performed 53% of total HKSAR R&D, an increase in its performance share from 33% in 2002, while higher education's share of overall R&D performance declined from 64% to 45%.

The Census and Statistics Bureau's 2008 summary of Hong Kong R&D investment data reports that only 6% of industry-financed R&D investment in 2006 was funded by HK manufacturing firms, a decline from 19% in 2002, while the share of industry-financed R&D investment from firms in "Wholesale, retail and import and export trades, restaurants and hotels" grew from 37% to 58% during 2002-2006. "Import and export trades" includes a number of Hong Kong-based firms that operate production facilities on the mainland,[20] meaning that some

[17] http://www.censtatd.gov.hk/hong_kong_statistics/statistics_by_subject/index.jsp?subjectID=7&charsetID=1&displayMode=T; accessed August 29, 2008.

[18] The most recent OECD data list R&D/GDP shares for the PRC, Singapore, and Taiwan in 2004 respectively as 1.23%, 2.25%, and 2.56% (*OECD Science, Technology, and Industry Outlook 2006*, p. 210).

[19] http://www.censtatd.gov.hk/freedownload.jsp?file=publication/feature_article/B70805FA2008XXXXB0100.pdf&title=Statistics+on+Research+and+Development+of+Hong+Kong%2c+2002+to+2006&issue=-&lang=1&c=1; accessed August 29, 2008.

[20] "…many establishments previously engaged in manufacturing relocated their labour-intensive manufacturing processes to the mainland of China through sub-contract processing arrangement, leaving in Hong Kong only the higher value added activities like product design and R&D." (*Statistics on Research and Development of Hong Kong, 2002 to 2006*, p. FA8).

portion of the 58% of industry-financed R&D attributed to this sector is in fact linked to mainland manufacturing industries that are managed by Hong Kong firms.

Although the share of industry-financed R&D associated with manufacturing based in Hong Kong may have declined during the past 6 years, the rising share of regional R&D financed by industry means that R&D performed in Hong Kong that is associated with financial and business services, or linked with the operation of mainland manufacturing owned by HK-based firms, almost certainly has grown. The apparent links between PRC-based production facilities and manufacturing-related R&D activities that are based in Hong Kong underscore the significance of the relationship between Hong Kong and the PRD region, the site of much of the manufacturing capacity managed by Hong Kong-based firms.

In light of the substantial role of nonmanufacturing industries such as business and financial services in Hong Kong's industry-financed R&D investment, the widely remarked tendency for science and engineering graduates to pursue careers outside of manufacturing is not surprising, and may not represent a "misallocation" of valuable human capital.[21] Moreover, the limited available indicators suggest that R&D collaboration between HK firms and universities, particularly HK universities, has increased during the past three years.

According to the 2008 edition of the *Annual Survey of Innovation Activities* compiled by the HKSAR Census and Statistics Bureau (2008, Table 2.11), almost 11% of the HK firms performing R&D in 2006 maintained some type of "cooperative arrangement" with universities, and the vast majority (85%) of these "arrangements" involved HK universities (almost 14% involved PRC universities). These reported levels of collaboration with Hong Kong universities

[21] The share of U.S. doctoral degreeholders in life sciences, chemistry, physics, mathematics, computer science and engineering employed in industry who are employed in manufacturing has dropped in all of these fields since 1973, suggesting that a tendency for technical degreeholders to seek employment outside of manufacturing is not unique to Hong Kong (Stephan, 2002, p. 54).

represent an increase from the 6% of HK establishments reporting such collaborative arrangements with universities in the 2005 survey (see Sharif and Baark, 2006).

It is difficult to evaluate such indicators of "collaboration," since we lack information on the size or content of individual "cooperative arrangements." Nevertheless, it is interesting that the reported level of 11% of R&D-performing establishments in Hong Kong that pursued some sort of "cooperative arrangement" with a local or PRC university exceeds the shares reported in the EU "Community Innovation Survey" (on which the Hong Kong survey is based) during 2002 – 2004 for such nations as Germany (8.5%), France (10.1%), or the United Kingdom (10%).[22] The extent of collaboration, based on this crude indicator, between HK industry and HK universities thus appears to be roughly comparable or above that observed in a number of very large European economies.[23] And in light of the evidence cited earlier on the substantial role played by many European university faculty in industrial patenting activity, it is at least plausible that the available data on HK universities' patenting (see below) may understate the extent of HK faculty research collaboration with industry.

In summary, R&D investment from all sources within the HKSAR remains low relative to the region's GDP, especially by comparison with R&D investment in the PRC and other regional economies. Nonetheless, HKSAR R&D investment from all sources has grown significantly during the past decade. Moreover, industry-funded R&D investment within Hong Kong has grown even more rapidly, suggesting that the "absorptive capacity" of HK firms may be improving somewhat. But growing industry-financed R&D investment within Hong Kong

[22] See Gulbrandsen and Nerdrum, 2008.
[23] The economy with the highest incidence of such "collaborative arrangements," Finland, reported that 33% of R&D-performing establishments had "collaborative arrangements" with universities (Gulbrandsen and Nerdrum, 2008).

may not close the gap between salaries for technical degreeholders in the financial services sector and compensation in manufacturing firms, even those investing heavily in R&D.

Assuming that Hong Kong's financial services industry remains strong (an assumption that may be questioned in early 2009) relative salaries in this sector are likely to outstrip those in industry for the foreseeable future, meaning that many of the graduates of HK universities in engineering and the sciences will continue to find employment in knowledge-intensive business services. Nevertheless, the overall evidence concerning industry-financed R&D investment and reported levels of industrial collaboration with HK universities suggests that the critical assessment of the innovative performance and prospects of HK industry expressed in many interviews with HK university administrators and faculty must be qualified somewhat.

V. Evolution of HKSAR policy toward university-industry collaboration

As Baark (2006) points out, until the 1990s Hong Kong's university system was small and focused primarily on education rather than research. In 1989, the British colonial governor announced plans for significant expansion in the Hong Kong university system, including the 1991 foundation of HKUST, and expansion was given additional impetus in the 2000 plan announced by Chief Executive Tung to ensure that 60% of the relevant age group of HKSAR citizens pursued post-secondary education of all types (including vocational training and nondegree studies). In 2007, the HKSAR government announced plans to shift the university curriculum to a four-year undergraduate program by 2011-2012, including an expansion in the total number of faculty in Hong Kong universities by roughly 1000. This represents a significant increase in the 2007 faculty FTE population of roughly 5400 in the eight publicly supported Hong Kong universities (HKUST, HKU, CUHK, City University of HK, HK Institute of Education, Polytechnic University of HK, HK Baptist University, and Lingnan University).

Public funding accounts for the majority of the operating expenses of these eight universities, and the combination of low taxes and high salaries means after-tax compensation for HK university faculty historically has been generous by international standards. Several interviewees, however, including former HK university faculty, noted that the structure of faculty compensation provided weak incentives for Hong Kong academics to seek external research funding or to pursue opportunities for research collaboration with industry. Hong Kong faculty are paid on a 12-month basis, rather than the 9-month salary typical of faculty at U.S. research universities, and the most important HK government research funding programs discourage use of grant funds for teaching relief by faculty outside of the humanities and social sciences. U.S. university faculty have strong incentives to seek research funding from external sources, including industry, in order to obtain additional "summer salary" funds or to release teaching time for research. The absence of comparable incentives for Hong Kong faculty in engineering, the physical sciences, and biomedical research to seek "summer salary" or "teaching relief" funding may weaken both fundamental research within HK universities and industry-university research links.

A. Public funding of HK university research

During the 1990s and early 21st century, HK universities expanded their research activities considerably. R&D performed in the university sector increased from .25% of HKSAR GDP in 1995 to .35% in 2006/7.[24] Much of this growth reflected increased public funding for university research, which was an important component of the shifts in HKSAR policy toward innovation after the 1997 Asian financial crisis and political independence.

[24] http://www.ugc.edu.hk/eng/ugc/publication/report/figure2007/15.htm; accessed August 25, 2008.

Public funding for HK university research comes from several sources. The University Grants Committee provides block grants to the eight major public HK universities to support research staff and students. There is little evidence that these grants are awarded on a competitive basis through a peer-reviewed selection process. During 2006-07, UGC block grants accounted for almost 72% of total research expenditures, more than HK$3870 million, at these eight universities. The Research Grants Council (RGC), established in 1992 within the University Grants Committee, oversees several grant programs for public funding of university research that accounted for 11% of these universities' research expenditures during 2006-07. The "General Research Fund" (GRF) program, formerly known as the "Competitive Earmarked Research Grant" (CERG) program, awards grants of up to HK$1 million on a peer-reviewed, competitive basis.[25] This source of funding accounted for slightly more than HK$612 million in 2007-08, representing 80% of RGC research funding.[26]

As Figure 1 shows, the average size of RGC grants has remained well below HK$1 million throughout the program's history, a relatively small average amount of funding for state-of-the art research in engineering or physical and biomedical sciences. Although modest in size, these grants typically are not used to support graduate students (who are supported by universities' UGC block grants), and faculty in fields other than the humanities, social sciences, and business are discouraged from using this research funding to "buy out" their teaching time.[27]

[25] The RGC website notes that the lower threshold for funding applications is HK$150,000 in Engineering, Physical Sciences, and Biologyr and Medicine, and HK$100,000 for applications in Humanities, Social Sciences, and Business Studies: "There are no upper limits, but applicants/institutions should appreciate that given the considerable competition for the limited funds available, justifications for projects costing over $1 million will need to be particularly well argued and supported." (http://www.ugc.edu.hk/eng/rgc/grf/application/cergia.htm; accessed 8/18/08).

[26] http://www.ugc.edu.hk/eng/ugc/publication/report/figure2007/15.htm; accessed August 25, 2008.

[27] "The RGC agrees in principle to provide, in cases where there is genuine need, funding for relief teachers so as to enable the PI to allocate sufficient time for research. Relief teachers engaged for this purpose are meant to relieve the PIs of their day-to-day teaching loads and administrative burden related to teaching work. Nevertheless, the RGC is of the view that it is the primary responsibility of the institutions to put their resources in areas where they

Nevertheless, as Figure 2 shows, the average size of GRF grants in fields such as the biomedical sciences (approximately US$140,000) is less than one-half of the average size of grants from the U.S. National Institutes of Health.

A second significant public research funding program that specifically targets university-industry collaboration is the University Industry Collaboration Program (UICP), established in 1999 within the Innovation and Technology Fund (ITF) that is overseen by the Innovation and Technology Commission (part of the Commerce and Economic Development Bureau, the ITC was created in 2000 as a result of the 1998 and 1999 reports of the Commission on Innovation and Technology, chaired by the late Professor Chiang Lin Tien).

The UICP provides grants for projects for which at least one-half of the total funding is provided by industry.[28] Like the GRF, however, UICP grants discourage use of funds for teaching relief,[29] and the average size of these grants, while larger than GRF grants, is modest. As of end-2008, 178 UICP projects had been funded, with an average contribution of ITF funds to each award of HK$1.1 million. Assuming that on average, the ITF contribution was matched by industry funding, the average size of UICP projects is roughly HK$2.2 million, or slightly more than US$300,000. Funding proposals to the UICP undergo separate reviews of their technical and business merits. Any intellectual property resulting from an UICP project for which industry provides 50% of total funding is assigned to the industrial participant. The UICP,

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would be best used. Hence, **such funding will be provided only exceptionally and upon detailed and sound justifications**." (emphasis in original; http://www.ugc.edu.hk/eng/doc/rgc/form/GRF2.pdf, p. 9, accessed 10/30/08)

[28] In its October 2007 "Consultation Paper," the ITF announced its intention to allow universities based outside of Hong Kong to participate in the UICP provided the company involved was based in Hong Kong (http://www.itf.gov.hk/eng/Forms/Consultation_Paper_on_UICP.pdf; accessed 8/19/08).

[29] "Unless otherwise agreed to by CIT [Innovation and Technology Commission], the ITF will not pay any emolument to (i) the existing staff of the company and (ii) staff members who are already on the payroll of a university. This principle should apply irrespective of whether the relevant service/work is carried out within or outside normal working hours of the person concerned." (http://www.itf.gov.hk/eng/Forms/itf-uicp-guide.pdf (pp. 26-27); accessed 10/30/08).

with total expenditures of roughly HK$196 million as of end-2008, accounts for a small share (5.2%) of the overall ITF program, which has spent almost HK$3.8 billion of the HK$5 billion allocated to the program in 1999. The majority of ITF spending thus far, more than HK$3 billion, has supported the "Innovation and Technology Support Programme" (ITSP), which includes the "R&D Centres" (see below for additional discussion).[30]

Nongovernmental sources of funding for HK university research account for a smaller share of overall university research. The Universities Grant Committee reported that during 2006/7, 11% of the eight major HK universities' research funding was derived from nongovernmental Hong Kong sources, much of which is likely to be industry funding.[31] But some HK universities report that industry accounts for a larger share of their research funding. Senior administrators at HKUST stated that industry funding of its research amounted to 15% of the institution's total research budget, a share that is well above those at U.C. Berkeley or Stanford, and nearly as high as the share of industry-funded research at MIT. And the CUHK website reported that more than 20% of that university's research was supported by industry during 2006/7.[32] These high reported shares of industry-supported research are surprising, given the critical portrayals in interviews of HK industry's underinvestment in R&D and weak links with university research. Some observers have suggested that these reported shares include ITF-funded research grants. As a result, some portion of this reported "industry funding" of academic research in fact comes from public sources. But even if one-half of the reported "industry funding" reflects ITF funding, the reported shares of industry-funded research at these two HK universities compare favorably with the reported industry-funded shares of research

[30] http://www.itf.gov.hk/eng/statistics/StatTable101View.asp?StatTypeId=101&StatId=516&StatCaption=Statistics+of+Approved+Projects; accessed October 27, 2008.
[31] http://www.ugc.edu.hk/eng/ugc/publication/report/figure2007/15.htm; accessed August 25, 2008.
[32] http://www.cuhk.edu.hk/iso/facts/issue/2008/research_e.htm; accessed September 29, 2008.

budgets at Stanford and UC Berkeley. A more precise reporting of data on industry funding of HK university research is needed to resolve this question. Nevertheless, these data on the shares of research at two leading HK universities that are supported by HK industry call into question some of the more critical portrayals of the commitment of HK firms to innovation and research collaboration with HK universities.

B. Nonunversity ITC programs

In the opinion of several HK university faculty and administrative interviewees, at least some of the objectives of the UICP have been undercut by the ITC's establishment of additional research initiatives that need not support research in HK universities. In response to a 2003 assessment of the UICP that concluded that only one-half of the projects funded by the program yielded results deemed useful by industrial project partners, the ITC established a set of "targeted" R&D centers with funding from the ITF that focused on the following specific areas:

Automotive parts and accessory systems

Logistics and supply chain management enabling technologies

Textiles and clothing

Nanotechnology and advanced materials

Information and communications technologies

Chinese medicine

These R&D Centers can use grants to support university research (subject to the industry matching requirement) and conduct R&D within their own research facilities.

Yet another initiative, established in 2001, is the Applied Science & Technology Research Institute, a government corporation that is independent of the ITC. ASTRI was established less to support university-industry collaboration than to support "downstream" R&D that could complement academic research on industrial technologies, facilitating the transfer and commercial application of academic research results. ASTRI, which now houses the ITC R&D center in information and communications technologies, was intended to compensate for the lack of "absorptive capacity" in many Hong Kong firms by working with Hong Kong industry on applied R&D to develop commercially applicable prototypes of technological advances for easier application by Hong Kong firms. In other words, ASTRI seeks to compensate for the widely criticized lack of in-house R&D and technological capability within Hong Kong industry. As Baark (2006) notes, the ASTRI was modeled on the Taiwanese Industrial Technology Research Institute (ITRI), which has been credited with aiding the growth of Taiwan's industrial capabilities in semiconductors, IT, and advanced materials.

C. Assessment

The establishment of the Research Grants Council in 1992 represented the first large-scale HKSAR program dedicated to awarding competitive grants for the support of university research in Hong Kong's universities. Although the recognition by the HKSAR government of the need to support faculty research as an important university mission was an important advance, the majority of the funding for university research provided by the HKSAR government is allocated on a noncompetitive, "block grant" basis by the UGC. Grants awarded by the RGC on a competitive, peer-reviewed basis account for less than 10% of total HK university research funding. Moreover, the average size of these grants is small by comparison with those awarded by industrial-economy governments, and use of these grants by engineering and science faculty

to release time from teaching is discouraged. In order to support the development of a globally competitive knowledge-based economy, more public financial support for competitively awarded, long-term research grants of greater average size is essential. Enabling faculty to use grant funds from the RGC to free up research time might enhance the incentives for faculty to seek research funding from this source and strengthen long-term research capabilities within HK universities.

None of the Hong Kong government programs providing financial support for university-industry research collaboration and innovation within HK industry is even a decade old, and more time is needed to evaluate their effects. Increased government funding for academic research linked to industry during the past 10 years has been associated with growth in industry-financed R&D investment, but it is impossible to determine whether public R&D funding has "catalyzed" higher levels of industry R&D investment. Recent growth in industry-financed R&D appears to be concentrated in industrial sectors that have received less public financial support, although the available data do not enable a more detailed and rigorous assessment.

A number of university researchers characterized the UICP grants as far too small to support ambitious research projects with potentially high long-term payoffs. In addition, the administrative and paperwork "overhead" associated with these grants, which are disbursed in 6-month installments contingent on detailed progress reports, was criticized by many researchers as a heavy burden and even a deterrent to seeking research funding from the UICP. University faculty also criticized the slow pace with which the ITC had expended its budget (nearly one-quarter of the ITF's original funding allocation remains unspent after nearly 10 years of operations), and argued that this slow disbursement of its funds reflected an excess of caution motivated by HKSAR civil servants' desire to avoid political criticism. The prohibition on using

UICP grant funds for marketing and design activities also was criticized by several recipients of funding from this source.

Researchers criticized the review process for Innovation Technology Support Programme (ITSP) funding proposals as prone to bias and conflicts of interest. In their view, the review of the economic and business aspects of ITSP funding proposals too frequently involved Hong Kong industry personnel who in some cases had private incentives to deny funding to a project that might benefit a competitor firm, and in other cases might imitate the technical development described in funding proposals. As a result, a number of faculty noted that they no longer were interested in pursuing funding from the ITSP, and many expressed interest in obtaining funding from PRC firms or even public sources, recognizing that these funds could not be disbursed through their HK universities.

With the exception of the RGC, established in 1992, the research funding initiatives undertaken by the HKSAR government since the late 1990s focus primarily on supporting industry-university collaborative research, much of which necessarily will focus on applied research. Moreover, the grants awarded by the RGC typically are small. There are few opportunities for HK university faculty to obtain large grants for long-term, fundamental research of the sort that rarely is attractive to industry sponsors. But the long-term strength of Hong Kong's universities as research institutions, as well as their attractiveness to first-rate academic researchers, depends on their capabilities in fundamental, as well as applied, research. As the research capabilities of PRC universities, particularly in southern China, improve, firms in the Pearl River region and elsewhere that seek opportunities for collaboration with university researchers in applied fields may collaborate with local mainland universities. At the same time, global firms (including some from the PRC, such as Huawei) seeking academic research

expertise in fundamental areas will look for universities in Europe and North America, unless Hong Kong universities can build their strengths in fundamental research. The current focus of the larger-scale research funding programs operated by the ITC on applied research thus must be balanced by significant support for longer-term research at the frontiers of knowledge, and such support must make greater use of competitive awards that are subject to peer review by international experts.

Both the ASTRI and "R&D Centres" programs also were criticized by university administrators and researchers, for several reasons. The most common (and unsurprising) criticism viewed these organizations as competitors for ITF funds that might otherwise support faculty research. These programs were criticized for their ineffective links with university researchers, and HKUST faculty in particular felt that collaboration with ASTRI, a necessary precondition for the research organization to fulfill its mission as a mediator between HK industry and university research, was ineffective, reflecting conflicts over intellectual property, funding, and other issues.

Finally, faculty and administrators criticized the ITF and related initiatives as fragmented and lacking support from senior HKSAR political and administrative personnel. This critical assessment, which was expressed repeatedly, stated that the HKSAR government initiatives to support innovation lacked any broad strategy and high-level political support. The lack of vision and support were linked (arguably, as both cause and effect) to the absence of any senior administrative or political leaders within the HKSAR government with training in the sciences or engineering. The lack of a high-level strategy for Hong Kong's knowledge-based growth has hampered the development of a strategic approach to managing the growth of Hong Kong's universities, as illustrated by current planning for the allocation of the large number of new

faculty positions to support the shift to a 4-year undergraduate curriculum in 2011-2012. These additional faculty positions represent an increase of nearly 20% in the overall number of current HK university faculty, and the allocation of these faculty positions among universities, research fields, and disciplines presents an opportunity to strengthen the academic research capabilities of Hong Kong's universities. Current proposals for allocating these slots, however, appear to emphasize reliance on projections of undergraduate enrollments by subject area, along with a strong preference for "fair shares" among the eight universities. Although such factors represent legitimate criteria for allocating a share of these positions, allowing them to determine the allocation of all of these positions means that a great opportunity to further enhance the research capabilities of HK universities in selected areas may be wasted. Setting aside 10 – 25% of these positions to be allocated among HK universities on a competitive basis in response to proposals from campuses (or multicampus proposals) for creating or strengthening areas of research excellence seems well worth exploring. The lack of a more strategic approach to the allocation of this large investment of public resources in Hong Kong universities underscores the broader failures of planning and vision within the agencies overseeing the universities and the HKSAR area's economic development.

VI. HK university technology transfer programs

Even before the HKSAR government initiated programs in the 1990s to support university-industry collaboration in research and technology transfer, a number of Hong Kong universities had launched programs to promote the commercial exploitation of academic research results. At least five of the eight UGC-supported HK universities (HKUST, PUHK, CUHK, HKU, and City UHK) began programs in patenting and licensing faculty inventions, along with various complementary initiatives to support faculty spinoff firms, during the 1980s and 1990s.

This section discusses the evolution of each university's programs and then examines overall trends in the quantity and quality of HK university patents during the 1986 – 2008 period. I conclude the section with an assessment of these university-based programs.

A. Evolution of HK universities' technology transfer strategies

All five of the major HK research universities active in patenting (HKUST, CUHK, HKU, City University of HK, and Polytechnic University of HK) also operate programs to support faculty entrepreneurship and research collaboration with industry. The technology transfer strategies of these five universities differ considerably, however, and have changed during the past 20 years. For example, during the 1990s Hong Kong University established an independent technology licensing firm, Versitech, to support the formation of spinoff firms to exploit HKU intellectual property. In addition, HKU established an "incubator" to house and support faculty-founded spinoff firms, although interviewees indicated that HKU now is shrinking its incubator facility. The university founded its Office of Technology Transfer in 2006 to provide support for faculty patenting and licensing, and now places greater emphasis on licensing intellectual property to established firms, including patent "aggregators," firms that seek to accumulate patent portfolios to license to other firms and/or to use as a basis for patent infringement suits. As I note below, university licensing of patents to these "aggregators" has become controversial in the United States.

By contrast, CUHK founded its Office of Technology Transfer in 1991. Although CUHK has no formal university-supported incubator facility for supporting faculty spinoff firms, various departments and research organizations (such as the Center for Innovation and Technology) provide informal support for faculty entrepreneurship. In addition, CUHK held equity positions in 18 spinoff firms as of January 2008. Other CUHK interviewees, however,

argued that the university has been reluctant to approve faculty applications for leaves of absence to work in spinoff firms, and further claimed that the university's Office of Technology Transfer now focuses its licensing efforts on established, rather than spinoff, firms.

HKUST combines a large patenting and licensing program with support for faculty entrepreneurship, including a relatively liberal leave of absence policy for faculty, a university incubator for spinoff enterprises, and in some cases, financial support for these spinoffs through the university's "Research and Development Corporation" (RDC). At the same time, however, HKUST has licensed patents to a number of established U.S. and European firms, and also licenses its intellectual property to patent aggregators. Like many U.S. universities that entered into direct management of patenting and licensing activities after 1980, HKUST's original patenting "strategy" was not selective, resulting in the issue of a number of low-quality patents to the university and high operating costs for the university's Office of Technology Transfer. The university now appears to have adopted a more selective approach to patenting that treats licensing revenues as a secondary goal relative to supporting faculty entrepreneurship and obtaining research support from industrial firms (as was noted earlier, HKUST administrators reported that industrial sources accounted for 15% of the university's research budget, more than three times the share observed at either Stanford University or U.C. Berkeley).

The City University of Hong Kong and Polytechnic University of HK (PUHK) have pursued a different mix of activities in the area of technology transfer. Both of these universities support patenting and licensing of faculty research, as well as faculty entrepreneurship. In addition, however, both universities have established programs that seek to manage faculty consulting, and share in the revenues flowing from these activities. Like the three other universities discussed above, both PUHK and City UHK have changed the mix and emphasis of

their policies during the past 15 years. City UHK established an incubator in the early 1990s that was overseen by the university's Technology Transfer Office, as part of a broad policy that relied on faculty-founded startup firms as vehicles for licensing and commercialization of university intellectual property.

City University's technology transfer operations were reorganized in 2003, shifting the incubator out of the TTO and reorienting the university's licensing policy to focus more intensively on established Hong Kong firms as licensees. Interviews suggested that this shift in emphasis was motivated by growing concern within the university administration over potential conflicts of interest and commitment associated with faculty entrepreneurial activity, as well as the limited success of the startups "spun out" from City UHK, which in turn was attributed in part to the modest management skills of faculty entrepreneurs.[33] City University also operates a "Professional Services" organization that markets and manages faculty consulting, promoting faculty expertise to industry in Hong Kong and elsewhere. The university receives 25% of gross consulting receipts as an administrative fee for providing this service.

The experience of the PUHK technology transfer programs is similar in many respects to that of City University. Like City University, PUHK manages and promotes faculty consulting activities (which have been especially significant in construction engineering and textiles production), charging a fee against gross faculty receipts. PUHK also has shifted its technology transfer strategy away from an early emphasis on faculty-founded spinoff firms, based on concerns over conflicts of interest and disappointment with the limited success of its spinoff

[33] Interestingly, the co-founder of one of City University's more successful "spinoff" firms (Tele Eye) stated that he had not used the City UHK incubator in the early years of his firm's development in order to avoid the development of an organizational culture influenced by academic, rather than industrial, norms of behavior. The co-founder stated that City UHK TTO administrators did provide useful contacts and guidance, particularly in the firm's IPO. But overall, this individual stated a preference for an incubator infrastructure in Hong Kong supported by the HKSAR government rather than by universities (Interview, Cliff Chan, 10 June 2008).

firms. The university imposes stringent reporting and financial oversight requirements on spinoff firms in which it holds equity, which (in the view of the current TTO director) have further discouraged such entrepreneurial activities, and some attention now is devoted to relaxing somewhat these requirements. The current patenting and licensing efforts of PUHK are focused on established firms, although the TTO has had limited success in attracting non-HK firms as licensees.

B. HK universities' patent activity, 1985 - 2008

Data on USPTO filings by Hong Kong universities (Figure 3)[34] indicate that university-assigned patents were almost nonexistent before the 1990s (one patent was applied for in 1986 by Hong Kong University), but applications grew rapidly during the 1990s, peaking during the 1996 – 2000 period.[35] Although overall patenting by HK universities, particularly HKUST, CUHK, and HKU, has grown during the past 15 years, the technological and economic importance of individual patents varies widely. Moreover, the experience of many U.S. universities that expanded their patenting significantly after the passage of the Bayh-Dole Act suggests that practical experience is needed in order to develop a strategic approach to patenting that produces high-quality patents. With this historical experience in mind, it is worth examining

[34] These data should be interpreted cautiously. Hong Kong universities can file for patents in the HKSAR patent office, although this is little more than a registration system, involving very limited examination of applications; for PRC patents; for European Patent Office patents; or for USPTO patents, among other alternatives. It is plausible, given relative market size and historic commercial links, that the USPTO patent trends are representative; but this is an assumption rather than a fact. It is also plausible, however, given the lower costs of filing for patents in the "home country" of a given university, that the USPTO patents issuing to both Singaporean and Hong Kong universities represent relatively high-quality patents for these non-U.S. universities.

The data on USPTO patenting by HK and Singaporean universities were collected from the USPTO website by searching the "assignee" field for university names. It is possible, therefore, that patents initially not assigned to these universities are not included in the tabulation, or that various misspellings and typographical errors in the USPTO assignee data may cause the omission of observations. The crude methods used to construct this dataset provide another set of reasons to interpret findings from this discussion with caution.

[35] Because this measure is based on the application date for issued patents, and review of patent applications can take as long as 3 – 5 years, the data are truncated, producing a decline in the number of applications for issued patents after 2002.

the "quality" of HK universities' patents, focusing on USPTO patents applied for during 1986-2006.

The usual measure of patent quality is the average number of citations to a patent made in subsequent patent applications. Citations to patents serve as a means for an applicant to differentiate their technical advance from previously patented inventions, and it therefore is necessary for applicants to base citations to prior patents on a systematic search of previous patents. Patents of greater technological and economic value tend to receive more "forward citations," on average. Figure 4 compares the average "forward citations" received by HK universities' patents with those for USPTO patents filed by U.S. and Singaporean universities (Nanyang Technical University and the National University of Singapore). Since patents that issue earlier have a greater period of time during which they can be cited than more recent patents, the citations data cover only the first five years following the date of issue of a patent. Our sample of patents therefore includes only those applied for during 1987-2003 and issued during 1988 – 2003 (citations extend through 2008). In order to control for differences among broad technology classes in the propensity to patent and to cite previous patents, we present the average citations data for five technology classes (chemicals; computers and communications technologies; drugs and medical technologies; electrical and electronics technologies; and mechanical technologies). The data include only citations to patents made by entities other than the assignees.

The data in Figure 4 indicate that HK universities' U.S. patents are cited less frequently in other issued U.S. patents than those assigned to U.S. universities in all technology classes other than "computer and communications technologies." But HK universities' patents in this technology class are cited more heavily on average than those issued to either U.S. or

Singaporean universities. Moreover, HK universities' patents in the "drugs and medical" and "mechanical" technology classes are cited more heavily on average than U.S. patents from the same time period issuing to Singaporean universities, although the numbers of patents in individual comparisons are so small that these differences are not likely to be statistically significant.

Computers and communication technologies account for almost 24% of the patents issued to HK universities included in this analysis (Figure 5), a larger share than that for the U.S. or Singaporean universities included in Figure 5 (7% and 19%, respectively). These results thus suggest that in one of the most significant technological fields in which they have been actively patenting, HK universities have focused on inventions of high economic or technological value. But in the technology field that accounts for the greatest single share of HK universities' patenting, electrical and electronics technologies (which accounts for 25% of HK universities' US patents applied for during 1987 – 2003), HK universities' U.S. patents are cited less heavily on average than those issuing during the same period to U.S. and Singaporean universities.

C. HK university links with PRC firms and R&D funding programs

Another area in which HK universities and faculty have been active during the past 15 years is the development of closer links with PRC universities, firms, students, and government R&D programs. These links have expanded considerably, although they are not captured in publicly available data. HKUST has established a research facility on the mainland, CUHK has established an industrial liaison office in the PRC, and other HK universities are active in teaching programs and other types of industry outreach in the Pearl River Delta region. Enrollment of PRC citizens in HK university graduate programs also has expanded, although

immigration restrictions have limited growth in undergraduate enrollment of PRC nationals in HK university education.

PRC government spending on R&D has grown rapidly since 2001,[36] and interviews indicated that a number of leading HK university researchers had obtained funding from PRC government R&D programs. But these funds cannot be used to defray research expenses incurred within their Hong Kong universities. HKUST administrators expressed interest in obtaining PRC government funding for their Shenzen research institute, although no grants had yet been awarded. Finally, major PRC firms, notably Huawei, have enlisted a number of HK university faculty (particularly HKUST faculty) in collaborative research projects based in the PRC. A number of interviewees, however, noted that PRC nationals employed in the engineering or R&D operations of these mainland firms often face obstacles to travelling to the HKSAR for consultations or visits to Hong Kong university research facilities.

The current scale of public R&D funding supported by the PRC government considerably outstrips the R&D spending of the HKSAR government. Moreover, both public and industry investment in R&D within the PRC is likely to grow more rapidly during the next decade than will be true within the HKSAR. Entrepreneurial faculty and university administrators will continue to seek to tap these funds, drawing on the established strengths of Hong Kong's universities in research and education. It seems inevitable that this process will link HK universities more and more closely with PRC firms and programs, regardless of the posture of HKSAR government policy. Moreover, these stronger links between HK universities and PRC

[36] The 2007 *China Science and Technology Statistics Data Book*, published by the PRC Ministry of Science and Technology, reports that central and local-government expenditures on R&D rose from slightly more than 70 billion yuan in 2001 to nearly 169 billion yuan in 2006 (http://www.most.gov.cn/eng/statistics/2007/200801/P020080109573867344872.pdf; accessed 10/23/08). These reported expenditures do not include R&D funded by state-owned enterprises.

industry, universities, and government programs will unquestionably benefit HK industry, since so much of the PRC's manufacturing activity is managed or owned by HK firms that appear to be significant sources of R&D investment within Hong Kong. But a failure to respond creatively to these growing links may limit their benefits for HK citizens and universities.

D. Assessment

The contrasting evolution of the "entrepreneurship" and technology transfer policies of these 5 leading HK universities is striking. Three of the universities (City UHK, HKU, and PUHK) have substantially reduced their institutional support for faculty entrepreneurship (including incubators), while HKUST has expanded its efforts in this area and CUHK's formal institutional support for faculty-founded spinoff firms has remained more limited. One reason for the reductions in support for faculty-founded firms is the modest success enjoyed by HK university spinoff firms, only 3 of which (EcoTek, Tele Eye, and Vertex) have been listed on the HK Growth Enterprise Market. But the recent expansion of support for faculty entrepreneurship at both HKUST and CUHK does not yet appear to have significantly expanded the number of spinoff firms from these universities that have been listed on the HK Growth Enterprise Market.

Hong Kong universities have been active in patenting for less than two decades, but the university administrators overseeing these activities have adopted a realistic view of the likely payoffs from university patenting and licensing. In contrast to what one heard in many U.S. universities after more than a decade of expanded patenting in the aftermath of the Bayh-Dole Act of 1980, Hong Kong university officials did not portray patenting and licensing as potential sources of large revenue streams for universities from royalty and licensing income. Instead, patenting and licensing were viewed as one instrument among many to enhance links with industry and expanding the contributions of university research to regional economic

development.[37] As such, it is unreasonable to focus on the number of patents, the number of licenses, and/or the inflow of licensing royalties as indicators of the "success" or "failure" of this aspect of Hong Kong universities' efforts to transfer technologies to industrial practice.[38] At the same time, interviewees argued that few established Hong Kong firms had sufficient internal expertise to understand the potential payoff to licensing of university technologies, and/or lacked the expertise to manage inward licensing effectively. [39]

Overall, HK universities' patenting performance has been fairly effective, keeping in mind that they have pursued significant levels of patenting for no more than 10-15 years. The fact that patents in the technology category accounting for second largest share of HK universities' patenting are more heavily cited on average than those assigned to U.S. universities during this period is also noteworthy.

As I noted earlier, both CUHK and HKUST have negotiated licensing agreements with so-called patent "aggregators," enterprises that seek to construct portfolios of patents to license as packages to other firms. Such licensing agreements may generate significant licensing fees, but do not always result in the successful application of the technologies under license. In the United States, a number of patent aggregators have behaved as "patent trolls," seeking to develop a position that blocks other firms from pursuing innovations in a given field and litigating

[37] Nevertheless, Sharif and Baark (2006) cite an interview with the CEO of an HK microdisplay firm who criticized the HKUST Technology Transfer Center (TTC) for focusing too narrowly on building its patent portfolio and providing minimal assistance to his firm: "Having drawn on the TTC's services in the past, the microdisplay manufacturer now prefers to go it alone, engaging with the TTC at only a superficial level to gain access to HKUST resources such as laboratories and equipment, and for proper documentation of practices and procedures." (p. 19). It is unclear whether the experience of this one firm is representative of HK firms' dealings with HKUST more generally.

[38] I did not attempt to obtain licensing data from the universities that we visited, since these data generally are sensitive and available only under nondisclosure agreements, if then. Licensing data (identifying the licensee and the extent of any royalty income) would allow an evaluation of the statements from most interviewees that Hong Kong universities had negotiated relatively few licenses with non-Hong Kong enterprises, such as multinationals (HKU mentioned licensing biomedical technologies to some multinational firms).

[39] Analysis of licensing data, including the identity of licensees, would enable this characterization to be assessed.

aggressively. The "Nine Principles to Consider in Licensing University Technology" statement issued by 12 leading U.S. research universities expressed some ambivalence over licensing agreements with patent aggregators, noting that "universities would better serve the public interest by ensuring appropriate use of their technology by requiring their licensees to operate under a business model that encourages commercialization and does not rely primarily on threats of infringement litigation to generate revenue."[40] Licensing to aggregators has the potential to produce near-term income from licensing fees, but could reduce the possibilities for using patent licenses as an instrument to obtain research funding from industry, especially if potential research sponsors view aggregators holding licenses from these universities as a threat to their business operations.

Another issue that merits consideration in any discussion of HK universities' patent licensing activities is the value of interinstitutional collaboration in managing patenting and licensing activities. The annual flow of faculty inventions, patent applications, and licenses at each of the leading five HK universities is small, and the costs of staffing and managing technology transfer offices are high. Moreover, a large share of these operating costs (e.g., patent prosecution costs, or the expenses of the necessary minimum staff of licensing professionals) are fixed, and do not vary with the volume of disclosures, patent applications, or licenses. The cost structure of technology licensing operations, along with the limited supply of expertise and the strong evidence that considerable "learning by doing" can improve the efficiency and effectiveness of these offices, all represent strong arguments for greater collaboration among HK universities their technology licensing activities. Some of the activities

[40] "In the Public Interest: Nine Principles to Consider in Licensing University Technology," March 6, 2007. Signatory universities and organizations were Caltech, Cornell, Harvard, MIT, Stanford, the University of California, the Wisconsin Alumni Research Foundation, the University of Illinois-Chicago, the University of Illinois-Urbana Champaign, Yale University, the University of Washington, and the Association of American Medical Colleges.

of these licensing offices, such as working with faculty in the development of patenting and licensing strategies for a given invention, almost certainly must remain decentralized at the individual university level. But other activities, such as applying for patents or defending these patents, might well be shared among HK universities.

Although these arguments apply equally to the modest technology licensing programs of many U.S. universities, there are few if any examples of such interinstitutional collaboration among U.S. universities in technology licensing. Indeed, at least some organizations founded to provide "technology broker" services to multiple U.S. universities, such as the Research Corporation, have been marginalized by the increased number of U.S. universities that mange their own patent portfolios. The obstacles to such collaboration should not be minimized, but the ability of such collaboration to support more efficient and cost-effective technology transfer activities means that the idea deserves serious consideration, particularly within HK universities that generate relatively small numbers of patents and licenses.

There also may be greater scope for informal informational exchange among administrators at these universities who are seeking to expand university-industry collaboration. Moreover, the declining institutional support for entrepreneurial activities at three of these five universities could provide an opportunity for expanded initiatives spearheaded by the HK government, by a cooperative effort managed by HKU, PUHK, and City University, or by these three universities and the HK "Cyberport" (which currently operates an incubator and provides other services for startup firms), supporting a regional incubator facility that might better address the continuing interest of faculty and industry in entrepreneurial activities.

There is little evidence of strategic thinking or policy within the HKSAR government on the management and encouragement of links between PRC programs, firms, or universities and

HK universities and faculty. The modest R&D initiatives sponsored by the HKSAR government do not appear to be coordinated with the priorities and goals of the far larger PRC R&D investment programs.[41] Moreover, opportunities for expanding enrollment of PRC nationals within professional-degree and undergraduate programs within the HKSAR could be exploited more extensively. Graduate students, postdoctoral research fellows, and even master's degree students are often important channels for the development of research linkages between industrial and academic researchers, and obstacles to PRC nationals pursuing these opportunities within HK universities reduce the prospects for collaborative research links with mainland firms. Restrictions on travel by PRC R&D professionals to HK universities for collaborative research also increase the incentives for HK university faculty and administrators to shift their R&D to the mainland.

VII. Conclusions

Hong Kong's public universities have been the focus of a series of policy initiatives during the past decade that have sought to enhance university-industry collaboration and technology transfer. In addition, the HKSAR's public universities have undertaken a number of initiatives to expand their patenting, technology licensing, and "faculty entrepreneurship" activities during this period. These initiatives are fairly recent and the institutional transformations that they entail require considerable time to work through. Accordingly, it is

[41] One exception to this general characterization is the "Technology Cooperation Funding Scheme" (TCFS), which is part of the ITF's "Innovation and Technology Support Program." The TCFS supports collaborative R&D projects involving HK universities or firms and firms Guangdong province, and requires that firms provide a portion of the funding for projects. Although the R&D Centers within Hong Kong are eligible recipients of funding through this program, there is little other evidence suggesting that the TCFS's R&D grants are focused on specific areas of R&D and/or that they are coordinated with funding programs overseen by the Guangdong provincial or the PRC central governments (see http://www.itf.gov.hk/eng/TCFS.asp for additional details)

important that policymakers and other interested parties exercise patience in their efforts to evaluate and (as appropriate) modify these initiatives and policies.

Since the late 1990s, the transformation in public research funding programs and in public expectations concerning the role of universities in education, research, and economic development in Hong Kong may well have exceeded anything seen in the United States during the same period. More time is needed to assess the effects of these shifts in policy and expectations on the role of Hong Kong's universities in knowledge-based growth within the region. But the broader environment within which Hong Kong's universities operate also is changing rapidly as a result of the development of the PRC economy and expansion in PRC government programs to strengthen knowledge-intensive growth on the mainland. Greater effort should be devoted to coordination of the HKSAR and PRC (as well as regional government) strategies for economic development and knowledge-based growth in Pearl River Delta region. In addition, the efforts of HKSAR policy to encourage faculty entrepreneurship in starting new firms and commercializing their discoveries should be complemented by expanded efforts to develop "research entrepreneurship" within HK universities, by increasing these grants' size, flexibility, and financial benefits for faculty.

Indeed, the pace of the transformation of the PRC economy and innovation system mean that the focus of HK government policy on supporting university-industry collaboration in applied research needs to be reexamined and greater balance brought into policies for supporting university research. Although funding for applied research is important, the fundamental research capabilities of Hong Kong's universities also require support. HK universities currently are ranked as roughly equal to the best PRC universities (Peking University and Tshinghua University), and the quality of these mainland institutions is likely to improve significantly as a

result of increased PRC government spending on research and education. Moreover, the universities in the Pearl River Delta, which lag behind HK universities in research capabilities, may well narrow this gap in the future. Merely maintaining the relative position of Hong Kong's universities relative to the best PRC universities thus will require considerable funding to strengthen their fundamental research capabilities. And support for this type of longer-term research necessarily will have to come largely from public sources, it is less likely to attract industry collaborators, and it will require programs capable of awarding grants of larger scale and longer duration.

At present, HKSAR research support for universities relies too heavily on noncompetitive block grants, while the competitive, peer-reviewed grants that are supported by the RGC are too small on average to strengthen the fundamental research capabilities of HK university faculty. Moreover, the rigid policies governing RGC grants limit their attractiveness for faculty, and may weaken the attractiveness o HK university positions for world-class researchers.

The efforts of Hong Kong's universities to expand their efforts in technology transfer and support for faculty entrepreneurship have enjoyed mixed success. Nonetheless, after less than 20 years' experience in patenting and technology licensing, university administrators at all 5 of the HK universities active in these areas have developed a fairly sophisticated understanding of the potential and limitations of such policies. Rather than seeking to manage these programs as large revenue sources, licensing managers at virtually all of these HK universities emphasized the use of patents and technology licensing to achieve a broader set of goals. Indeed, the development of these more nuanced management strategies has occurred much more rapidly at these HK universities than at many U.S. universities.

At the same time, the emphasis in many HK universities on faculty-founded startup firms as a solution to the perceived weaknesses of HK industry as a collaborator or licensee for university-developed technologies may be unrealistic. Although a small number of anecdotes of success receive enormous international attention, U.S. universities have had mixed results with spinoff-centered technology transfer strategies (as I pointed out earlier, spinoff firms account for a relatively small share of overall U.S. university technology licensees), reflecting the high mortality of new firms generally, as well as the limited managerial talents of faculty entrepreneurs. The modest supply of venture capital for new enterprises in Hong Kong means that the possibilities for transformation of the Hong Kong and regional economies through university-spawned startup firms may in fact be ever more limited than is true of the United States.[42] Although the efforts of HK universities to support faculty entrepreneurship should be maintained, expectations concerning the long-term transformative effects of these strategies on the regional Hong Kong economy must be tempered, and the emphasis on "economic entrepreneurship" among HK university faculty must be balanced by policies that create great incentives and opportunities for faculty "research entrepreneurship."

Indeed, a central assumption of the "spinoff-focused" technology transfer, the belief that HK industry lacks the necessary "absorptive capacity" to collaborate with HK university researchers and/or hire technical degreeholders, is open to question. Data covering the past decade indicate considerable growth in industry-funded R&D investment within Hong Kong, and the HK Innovation Survey suggests that firms' self-reported levels of collaboration with local

[42] Moreover, new, knowledge-intensive firms may spin off from numerous sources other than universities, as Klepper (2008) has pointed out. In particular, established firms in high-technology industries are an important source of new firms. Policy-related obstacles to the formation of such spinoffs include "noncompete" agreements and other limitations on employee mobility. HKSAR policymakers wishing to encourage entrepreneurship should consider a review of these policy-related obstacles to the "spawning" of new firms by established firms with a view to removing them where possible. A fuller discussion of the importance of this phenomenon and the extent of these obstacles to new-firm formation in Hong Kong unfortunately is beyond the scope of this paper.

universities also have grown. Nor is the tendency for technical graduates of HK universities to seek employment in nonmanufacturing industries unique to Hong Kong. Either the data fail to measure the characteristics of HK firms that discourage their reliance on an innovation-oriented competitive strategy, in which case better data are needed, or the data are accurate and the repeated criticisms of HK industry's failings reflect other impediments to more effective university-industry interaction. In either case, a more detailed survey of incentives and impediments to research collaboration and technology transfer would be invaluable in developing a clearer analysis of university-industry collaboration within Hong Kong and the PRD.

Finally, any policy recommendations to improve the contributions of HK universities to knowledge-based growth within Hong Kong should be part of a broader, more coherent HKSAR strategy to support innovation that spans a broader array of instruments and institutions that universities and industrial firms alone. At present, such a strategy that has been endorsed by the highest levels of HKSAR political leadership is lacking. The absence of such a strategic vision means that any recommendations on specific steps to enhance the contributions of HK universities to technology-based growth are likely to be ignored entirely or implemented on a piecemeal basis, and/or poorly integrated with other policies. Indeed, this characterization is appropriate in describing the current array of HK government policies for support of university-industry collaboration and technology transfer. Even more important, however, the absence of any clear strategy for the HKSAR impedes coordination with the rapidly evolving (and generously funded) portfolio of central- and regional-government policies on the mainland.

VIII. Recommendations

A. HKSAR programs supporting university-industry collaboration

The current ITF programs to support university-industry collaboration, primarily the UICP and the ASTRI R&D Centres, were the subject of widespread criticism in interviews with HK university faculty and industry managers. The slow pace with which the UICP funds have been disbursed also was criticized. The ASTRI R&D Centres were criticized by university administrators and faculty for competing with universities for research funding, for their poor links with university research, and for their diversion of funding to administrative and facility expenses. The R&D Centres program is relatively new, and has already been the subject of criticism and turnover among its senior management. The ITSP grants were also criticized for their rigid administrative policies and review procedures that often gave rise to conflicts of interest among industry reviewers of proposals. It seems likely that some steps may be taken to address some of the flaws in this program identified by university personnel.

Current schemes for HKSAR government support for fundamental research in the region's universities also have flaws. The UGC research grant program relies too heavily on a block grant system that may not always reward research excellence. The RGC competitive grant program, the GRF, accounts for too small a share of overall HKSAR funding for university research, and its average grant award is quite small. Steps should be taken to shift a greater share of the HKSAR government's financial support for university research toward competitive, peer-reviewed allocation processes. Serious consideration also should be given to allowing university faculty to use research grants from HKSAR and other sources to support their salaries and reduce their teaching loads, enabling a more intensive focus on research activities. These comments lead to the following recommendations:

1. **Recommendation**: The ITF UICP program should be overhauled, to enhance its flexibility, reduce its rigid administrative and audit requirements for researchers, and reform its processes for proposal review in ways that eliminate potential conflicts of interest among reviewers.

2. **Recommendation**: The ASTRI R&D Centre program should be given an opportunity to develop, but should be reviewed within the next 5 years. In the interim, steps should be taken to reduce obstacles to cooperation between ASTRI and HK university researchers.

3. **Recommendation**: The RGC's competitive research grant programs should be expanded to account for a greater share of overall HKSAR public funding for university research, perhaps as much as 25%. The administration of these grant programs should ensure that proposals are subject to peer review by internationally recognized, scholars not employed by HK universities.

4. **Recommendation**: Serious consideration should be given to enabling HK university faculty to charge a portion of their salaries to competitively awarded research grants from the RGC, the UICP, or other sources.

B. University technology transfer programs

Each of the five leading HK universities engaged in technology transfer through patenting, licensing, and support for spinoff firms has adopted a somewhat different approach. Overall, however, HK universities' management of their patenting and licensing activities appears to be reasonably effective, based as it is on a realistic appreciation of the financial and other benefits for universities from these activities. Moreover, many of these university technology transfer programs have undergone considerable change since their inception in the

1980s and 1990s. Such diversity is by no means a negative development, and reflects differences among these universities in their areas of greatest research strength, the nature of their links with local and foreign firms, and the varied results of their technology transfer programs. Nonetheless, these contrasting experiences may themselves provide opportunities for greater cross-institutional information exchange and learning. In addition, it may be useful to explore opportunities for cross-institutional collaboration in management of their technology transfer activities.

The current emphasis in the technology transfer programs within many of these 5 HK universities on support for spinoff firms has had limited success thus far, and similarly to the experience of many U.S. universities, the long-term potential economic benefits from such efforts may be modest. Inasmuch as university spinoffs in the United States, which has a strong VC industry, have enjoyed mixed results, it may be unrealistic to rely heavily on new firms as vehicles for commercialization of university technology in Hong Kong, where venture capital for local startups appears to be scarce. Nevertheless, since each university's programs have adapted over time to deal with their varied success, this area does not seem to be one in which broad recommendations for changes in HKSAR government policies are appropriate.

It is also important to note that the limited data on university patenting reported by HK universities may not reveal an accurate picture of the extent of HK faculty collaboration with industry in R&D and innovation. As I noted earlier, data on faculty patenting within Western Europe suggest that the majority of faculty patenting has not operated through the universities employing these faculty. It is possible that currently available data on HK university patenting, which also do not include faculty patents not assigned to their universities, may omit a substantial share of the patenting of HK university faculty.

Finally, the occasional suggestions that internal reviews of HK faculty performance should include recognition of their entrepreneurial activities should be resisted. The primary contributions of HK universities to the long-term development of the region's knowledge-based growth will flow from their teaching and research activities. Moreover, improvement in the quality of research in particular is more likely than changes in internal performance criteria to attract greater industrial interest from local and foreign firms in research collaboration with HK university faculty. If anything, HK universities should take steps to enhance the rewards for faculty research excellence as a means of strengthening the region's universities and potentially, enhancing their contributions to knowledge-based growth.

5. Recommendation: The UGC or the ITC should consider sponsoring a cross-university forum for regular exchanges of information among HK universities concerning their technology transfer programs' structure and strategies.

6. Recommendation: Opportunities for cross-institutional collaboration and cost-sharing in such administrative activities as legal advice in patent prosecution and defense, as well as in the funding and operation of incubator facilities or the provision of classes and workshops for would-be faculty entrepreneurs, should be explored, perhaps with the sponsorship of the UGC and/or in collaboration with Cyberport staff engaged in similar activities.

7. Recommendation: Consistent with the "Nine Principles to Consider in Licensing University Technology," HK universities should review and as appropriate reconsider the desirability of licensing their patents to patent "aggregators."

8. Recommendation: Recognizing that the primary channels through which HK universities contribute to economic growth and public welfare is the teaching and research

activities of their faculty, these activities should remain the central focus of internal evaluations of faculty performance.

9. Recommendation: More complete data on patent filings by HK university faculty should be collected, to provide better indicators on the extent of HK faculty collaboration with local and foreign industrial firms in research leading to patents.

C. Management of HK university resources and faculty incentives

Several interviewees noted that the structure of HK university faculty salaries limits faculty incentives to pursue opportunities for research collaboration with industry. Shifting the university faculty salary structure on an optional, experimental basis to a structure that more closely resembles those of U.S. research universities could create greater incentives for faculty to seek research grants and to seek opportunities for collaboration with HK and foreign industrial firms. Faculty could be provided an opportunity to accept a reduced salary "guarantee" (e.g., 10 months rather than 12), on the understanding that they could obtain additional salary funding through research grants (e.g., 3 months' "summer salary," which in this example would leave a successful grant applicant with an additional month of salary). Such a shift in the structure of HK faculty salaries could enhance incentives for both "research entrepreneurship" and "economic entrepreneurship."

A second area in which HKSAR policy merits revision by way of providing stronger support for the development of HK universities' research capabilities concerns the allocation of the 1000 additional faculty positions that are to be added as part of the shift in the undergraduate curriculum to a 4-year program of study. A portion (e.g., 15 – 25%) of these faculty positions should be awarded on a competitive basis to the universities able to develop proposals for the creation of research centers of excellence. In some cases, such centers might involve the

collaboration of two or more universities. Regardless of the specifics, the opportunity provided by this large expansion in faculty resources for strategic "repositioning" of HK universities in selected research areas should not be ignored.

10. Recommendation: The UGC and relevant HKSAR agencies should implement on an experimental basis a program enabling interested faculty to shift from a 12-month salary to a 10-month salary, with the option of "topping up" their salaries with up to 3 additional months of research funding.

11. Recommendation: The UGC should develop a competitive, peer-reviewed process for allocating a portion (15 – 25%) of the 1000 new faculty slots to be added to HK universities by 2011-2012 to universities or collaborations among universities proposing new research initiatives or research initiatives building on current strengths.

D. Improving coordination with PRC university research policies and initiatives

At present, the entrepreneurial efforts of administrators and faculty in HK universities are creating a web of links with PRC firms, universities, and research funding sources, responding to the rapid growth of regional and central-government research funding on the mainland, as well as the emergence of PRC firms with considerable interest in collaboration with university researchers. These efforts and the resulting links with PRC institutions and firms ultimately could benefit Hong Kong universities, HKSAR citizens, and the firms and citizens of the Pearl River Delta region.

12. Recommendation: Obstacles to cross-border enrollment of PRC nationals as undergraduates in HK universities should be critically evaluated and where feasible, reduced or removed. Remaining obstacles to cross-border enrollment of PRC nationals in HK universities'

postgraduate professional and advanced degree programs should be removed. Finally, opportunities for cross-border movement of PRC nationals to postdoctoral research appointments in HK universities should be removed. Any similar obstacles to cross-border enrollment by HKSAR citizens in PRC university programs also should be evaluated critically and where feasible, removed.

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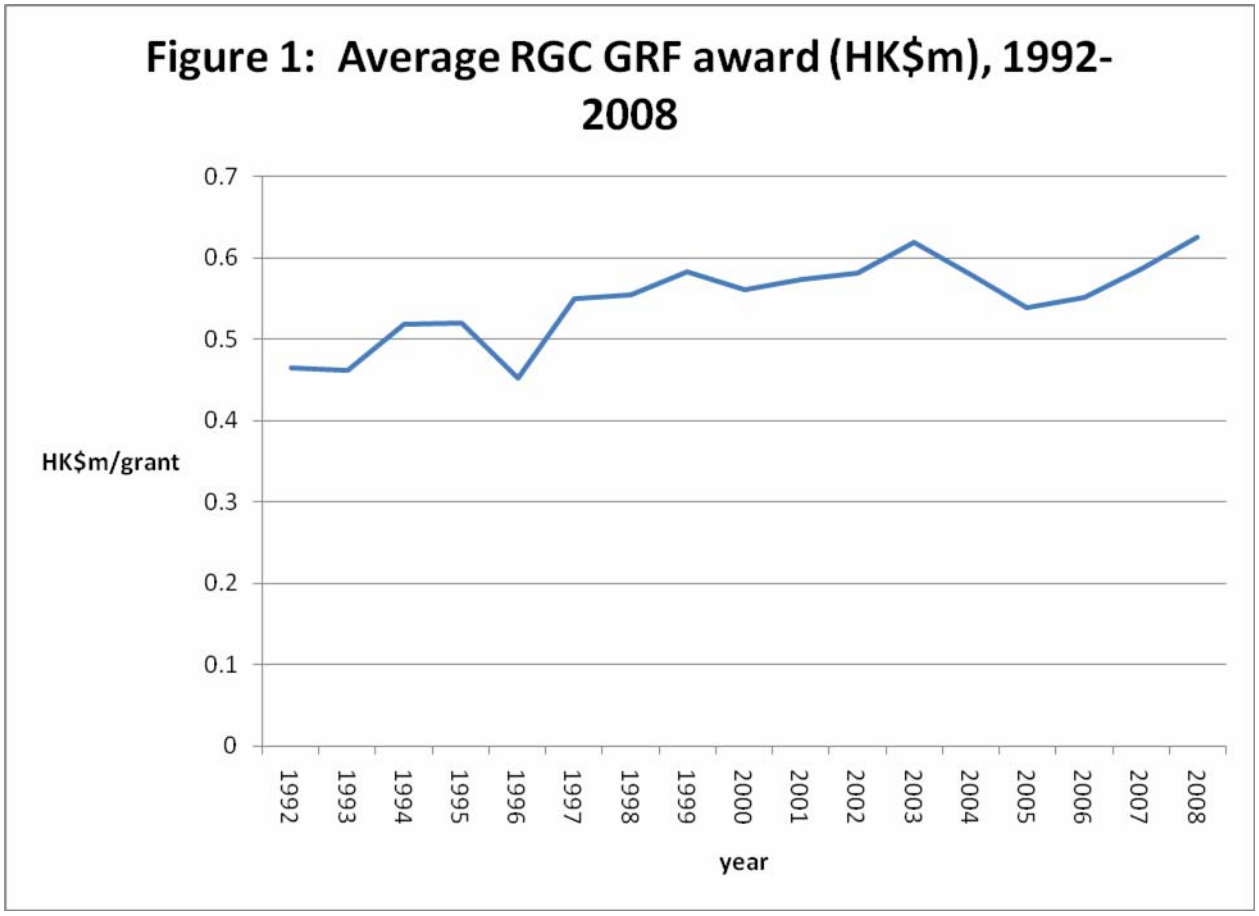
Figure 1: Average RGC GRF award (HK$m), 1992-2008
HK$m/grant
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2005
2006
2007
2008
year

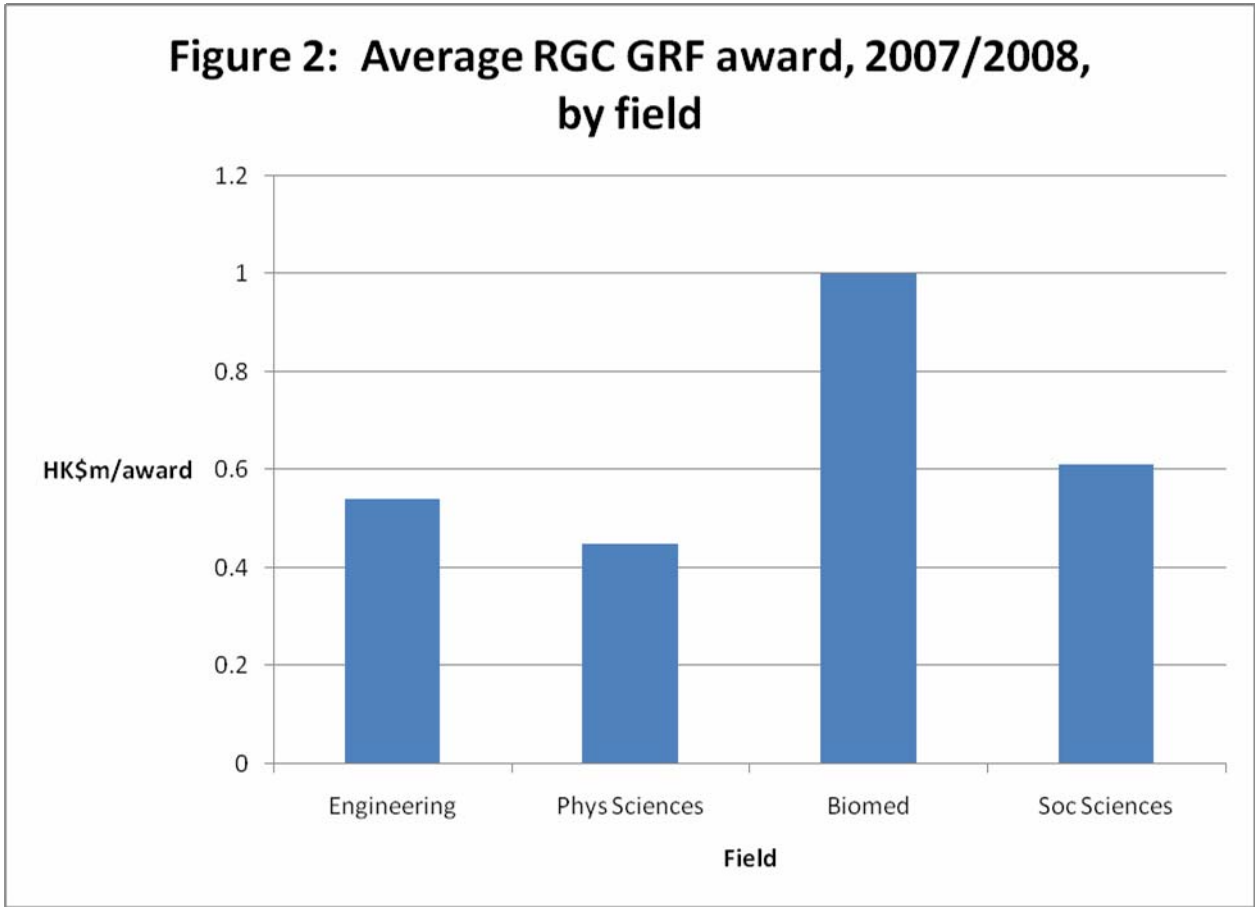
Figure 2: Average RGC GRF award, 2007/2008, by field
1.2
1
0.8
0.6
0.4
0.2
0
HK$m/award
Engineering
Phys Sciences
Biomed
Soc Sciences
Field

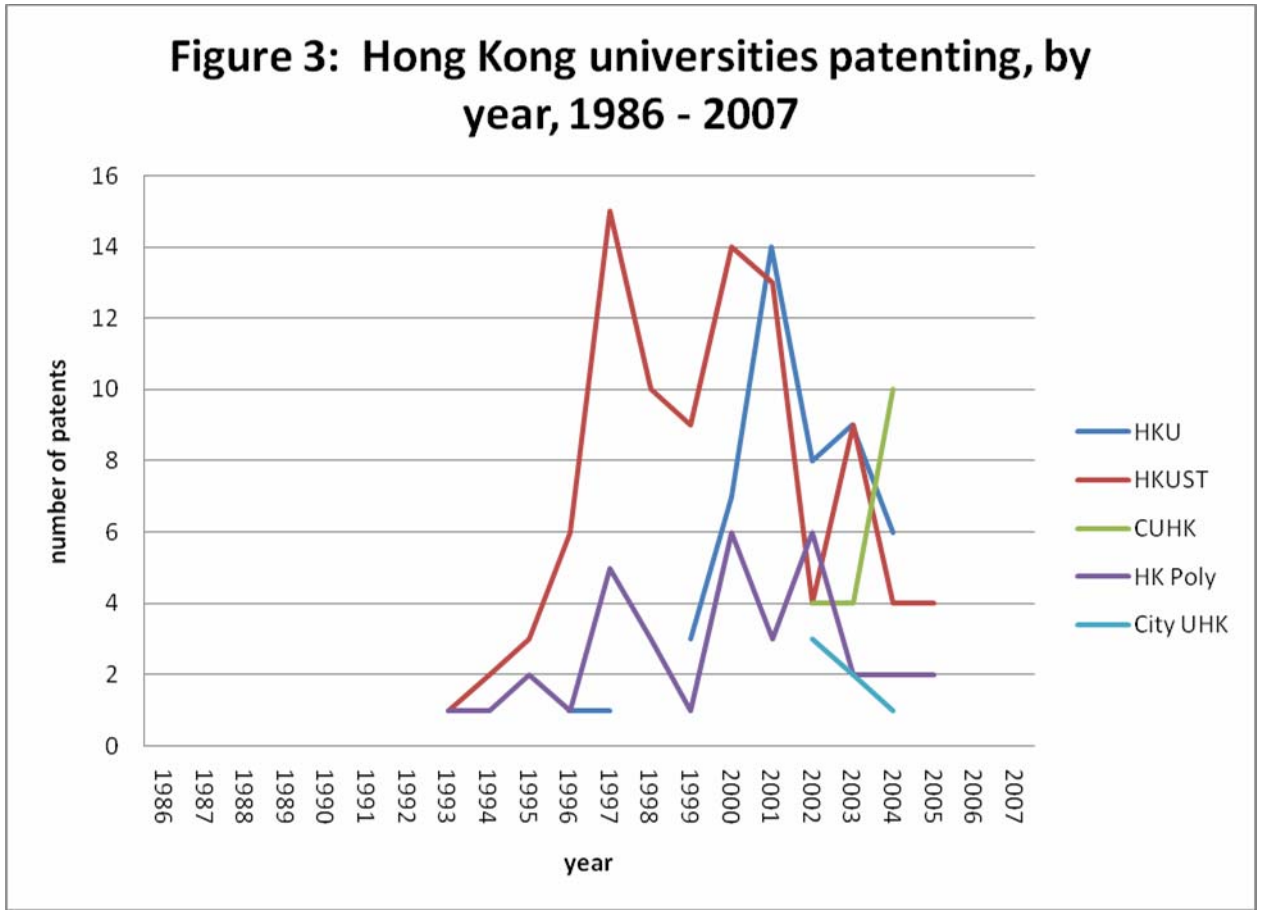
Figure 3: Hong Kong universities patenting, by year, 1986 - 2007
number of patents
16
14
12
10
8
6
4
2
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
year
HKU
HKUST
CUHK
HK Poly
City UHK

Figure 4: Mean forward citations/patent, 1986 - 2003 patents assigned to U.S., Singaporean, HK universities (exc. self-citations)

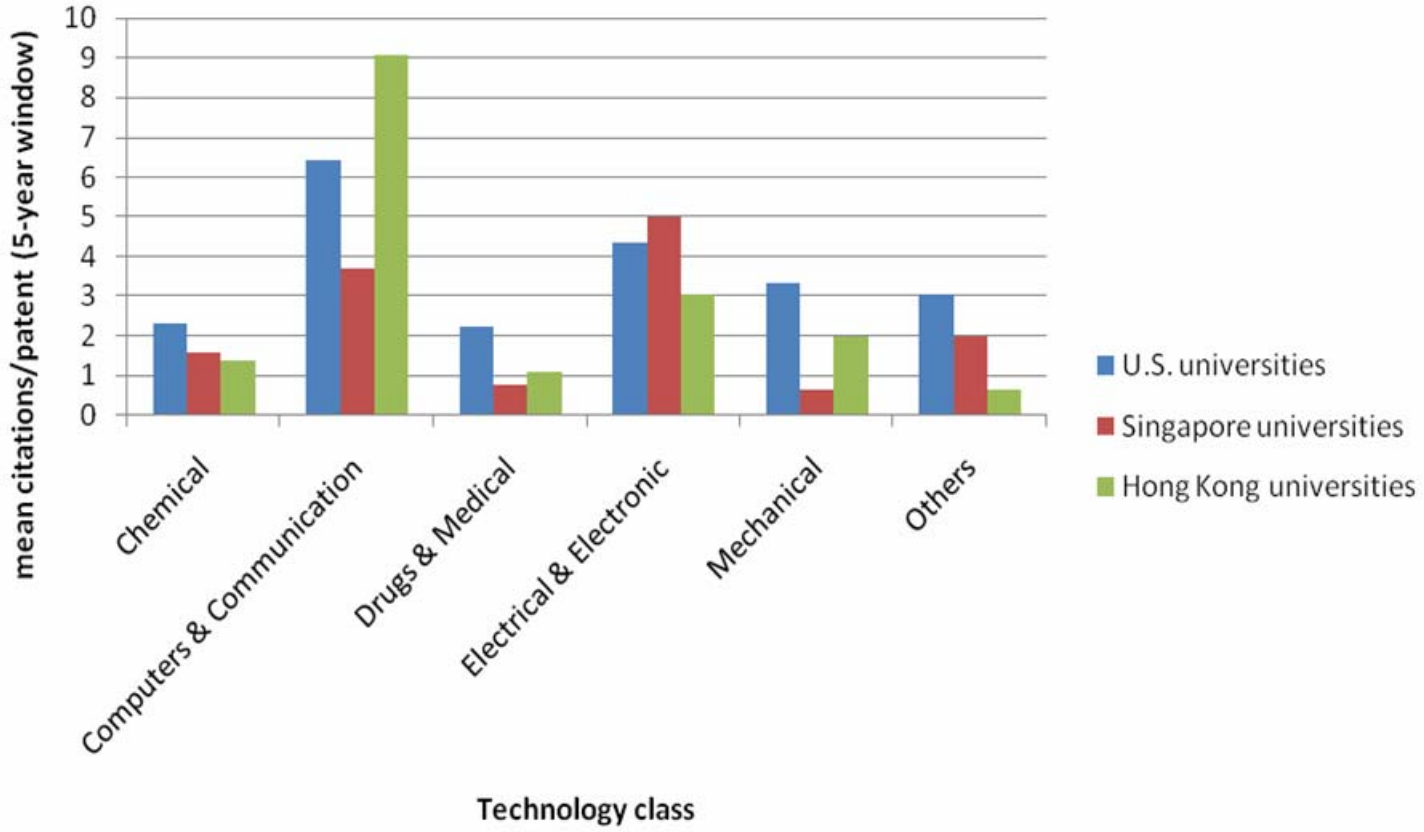

Figure 5: Technology class shares, 1986 - 2003 patents assigned to U.S., Singaporean, HK universities