APRU
Association of Pacific Rim Universities

Technology Spin-offs from Pacific Rim Universities

Entrepreneurial Context and Economic Impact

A study based on the
"Technology Transfer and Wealth Creation" research project
of the Association of the Pacific Rim Universities

APRU Special Papers

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APRU is a consortium of leading research universities in the Pacific Rim. Formed in 1997, it aims to foster cooperation in education, research and enterprise thereby contributing to economic, scientific and cultural advancement in the Pacific Rim.

The views expressed in the Special Papers are strictly those of the author(s) alone and do not necessarily reflect the views of APRU.

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Entrepreneurial Context and Economic Impact

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This paper is based on the Technology Transfer and Wealth Creation (T2WC) research project conducted by APRU which looked at how universities transfer and apply new knowledge and technologies generated by research. It involves a multi-university study on the scope, pattern, trends and impact of technology transfer activities by universities along the Pacific Rim.

The study was conducted in 2002 with a research workshop held at University of Southern California in May that year.

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Abstract

University research has played an important role in the founding of new ventures, creating economic activity in the form of start-up ventures and new jobs. An increasing number of research universities are establishing technology business incubators, parks, and venture capital funds to support start-up companies. The trend is known as “academic capitalism” and is seen by many as the new engine for economic growth. But the contribution of university research to start-ups and subsequent economic activity is not solely a U.S. phenomenon. Our research attempts to study this phenomenon across the member universities of the Association of Pacific Rim Universities (APRU). More specifically, we are trying to answer the following questions:

- How does the U.S. phenomenon of university spin-off ventures compare with technology commercialization from universities in the other Pacific Rim countries?
- What is the effect of university policy as an environmental context on the start-up of entrepreneurial ventures from university research?
- How does economic impact from university spin-offs differ across the Pacific Rim countries?

Introduction

University research has played an important role in the founding of new ventures, creating more than $29 billion in economic activity and more than 280,000 jobs in the U.S. in fiscal year 1998 alone. More than 1,900 companies have been founded as spin-offs of U.S. universities since the inception of the Bayh-Dole Act in 1980. The trend is known as “academic capitalism” and is seen by many as the new engine for economic growth. But the contribution of university research to start-ups and subsequent economic activity is not solely a U.S. phenomenon. We are beginning to see more and more start-ups coming out of non-North American universities in the Pacific Rim.

Our research attempted to study this phenomenon of academic capitalism across the member universities of the Association of Pacific Rim Universities (APRU), which is a consortium of 36 leading universities from 16 economies in the Pacific Rim. Formed in 1997, it aims to foster cooperation in teaching and research, thereby contributing to the economic, scientific and cultural advancement of Pacific Rim economies. In the current study, we addressed the following questions:

- How does the U.S. phenomenon of university spin-off ventures compare with technology commercialization from universities in the other Pacific Rim countries?
- What is the effect of university policy as an environmental context on the start-up of entrepreneurial ventures from university research?
- How does economic impact from university spin-offs differ across the Pacific Rim countries?

Literature Review

In the past decade, a number of diverse factors converged to propel the issue of technology commercialization and the role of innovation in stimulating economic growth to the forefront of attention in both industry and academe. Some researchers propose that the “triple helix” of academia-industry-government relations may be the principal component of a national or multinational innovation strategy (Etzkowitz & Leydesdorff, 1997). For industry, companies seeking to commercialize the technologies they develop now face a dynamic set of challenges, attitudes, and values. The marketplace demands better, faster and cheaper technology products, a product development nightmare for companies trying to survive while staying ahead of their competitors. Shorter product life cycles and rapid technological change have spurred a need for technology transfer across organizational and national boundaries to gain competencies not resident in the firm. In this sense, firms now act as boundary spanners in the transfer of technology (Lynskey, 1999). However, the transfer of technology and know-how is not always clear-cut. The resource-based literature speaks of the inherent stickiness of the factors of production as well as the time and cost required to accumulate and absorb them (von Hippel, 1994). So, if the technology/know-how that is transferred does not in the end enhance capabilities in the firm, its value is diminished. Given the idiosyncratic nature of the firm in the resource-based view, the unique assets and tacit knowledge acquired over time make the technology transfer path rockier and the chance for a mismatch higher. Furthermore, as firms continue to reduce the scale and scope of their internal laboratories and seek external partners, we are seeing more of a systems view of innovation, a network of agents within a particular technological discipline.

Universities are playing an increasingly important role in the innovation and commercialization process. They have become direct producers of goods and services for end-users (Sutz, 1997). Industry rules now apply in an academic setting and this has produced discord among those who would keep the university in its ivory tower. Universities rely heavily on research grants to support their R&D function, but, more and more, government and foundation funders are stipulating that the results of research must have a commercial application, that is, return something of value to society. They are, in fact, demanding that universities and research institutes align themselves with industry to make their work sustainable and to begin charging for new knowledge, something that runs counter to the open source view of the university. As a result, universities are faced with the dilemma of how to stay true to their primary mission—to educate, conduct independent research, and provide service to their communities—while simultaneously responding to these demands to commercialize their research findings. The issue of whether university research contributes solely to industrial research activities domestically or internationally as well is of interest. With the university playing an increasing role in national and regional innovation systems, it inserts itself between faculty and researchers and their industry funders. Applied research is now gaining strength where previously only basic research was deemed sufficiently pure to satisfy the ethos of academic legitimacy. Today, an academic researcher who can finance his or her research through contacts with government and industry is not only socially useful but academically legitimate. In general, however, many believe that erasing the epistemological boundaries between academia and industry will threaten the long-term accumulation of knowledge in favor of short-term gains (Sutz, 1997).

Despite more effective tools and knowledge about commercialization, new technology adoption is still a very slow and incremental process with only a mere fraction of all new technologies ever achieving mass adoption. Those technologies that do achieve mass adoption do so only after significant delays (Farzin, Huisman, and Kort, 1997). For example, the Technology Marketing Group (TMG) of Acton Massachusetts worked with a new firm in the chemical industry to develop a technology for use in pharmaceutical research, development, and production (Hruby & Lutz, 2002). The firm assumed that since it was a pharmaceutical company, its initial customers would definitely fall into the early adopter category. After much research, TMG discovered that the lag time for adoption of the company's new technology was five years; however, since innovators in the industry had not yet adopted the technology, TMG estimated that it would be 10 years before the new firm could sell sufficient volumes of the product. Calculating the return on investment over that length of time resulted in a decision not to pursue the technology. The slow pace of technology adoption is due in large part to the uncertainties inherent in the commercialization process. The more rapidly an invention gets to market, the more likely it is that it meets market needs defined during the development process. Yet, there are no guarantees, and perhaps one of the major uncertainties of the process is that so much of the process is out of the control of the entrepreneur or firm.

U.S. versus Pacific Rim University Venture Activity

The Global Entrepreneurship Monitor (GEM) project looks at entrepreneurial activity in the U.S. and 28 countries around the globe including Singapore, Japan, Australia, New Zealand, and Mexico, which qualify as Pacific Rim countries for purposes of the current research (GEM, 2001). From this report, we can see that Australia, New Zealand, and Mexico are relatively more entrepreneurially active than the U.S., which, at any given time, has 11.7 percent of the adult working population (18-64) involved in the start-up process or is the owner of a business less than 42 months old. Japan and Singapore rank Nos. 2 and 3 at the bottom of the list. In terms of opportunity-based versus necessity-based entrepreneurship, the U.S. is highly opportunity-based with more than 80 percent of new businesses being opportunistic. By contrast, the Asian and Latin-American countries in the Pacific Rim countries generally start ventures that are necessity-based.

The GEM study also looked at entrepreneurial framework conditions that affect the start-up of new ventures: government policy, education and training, culture and social norms, and financial support. It appears that non-U.S. countries had lower opinions of government support for entrepreneurship than did the U.S. The U.S. is the benchmark in the world for entrepreneurial culture and education and training. Financial support, including access to debt and equity markets, is perceptually very high relative to other countries in the GEM study.

There has also been a rapid rise in entrepreneurship in transition economies like China despite the lack of protection for private property. It appears that wherever the government has few restrictions, pockets of entrepreneurship develop. The promise of capitalism and the failure of state-owned enterprises have worked to remove restrictions on private firms and encourage entrepreneurship. Since the mid 1990's, about 70 percent of total industrial output in China has come from the nonstate or private sector (Mugler, 2000).

In the U.S., innovation has been touted as the key to societal and organizational success (Donlon & Pellet, 1998) and as a principal component of entrepreneurship (Berger, 1991). By contrast, East Asian countries do not attribute equivalent importance to innovation; rather, they tend to focus on harmony (Redding & Ng, 1982). In East Asian countries the possibility to gain face through a higher social status from entrepreneurship is a primary incentive to start a new venture. At the same time, the possibility of losing face through business failure is also very relevant and a deterrent to entrepreneurial endeavors, whereas this is not so in the U.S. (Earley, 1997). Therefore, Asians entrepreneurs tend to spend more time doing due diligence to judge the feasibility of a venture before undertaking it than do their U.S. counterparts.

East Asian cultures are inclined to support community norms and operate in groups, so more often they reward conformity over individualism, which may discourage entrepreneurship as it is known in the West (Hofstede, 1980). By contrast, the U.S. prizes individuality and encourages independence, so the culture is highly supportive of entrepreneurial endeavors. In Latin America, support for social policies that correct economic and social backwardness are prevalent. Therefore, more funding tends to go to pre-university educational levels and not to entrepreneurial endeavors.

The contribution of university research to industrial R&D and to technology transfer and commercialization varies from country to country. For example, U.S. and Japanese universities differ widely in how they allocate research funding (Yamamoto, 1997), in their incentives for faculty research (Hicks, 1993), and how ownership of resulting intellectual property is held (Fujisue, 1998). Generally, in laissez-faire countries such as the U.S., the government plays a larger role in stimulating innovation and we are seeing the governments of former socialist societies releasing their control of technology and moving toward a more laissez-faire stance.

The influence of a technological community or national innovation system has an impact on the technological activities of research organizations (Lundvall, 1992: Nelson, 1993). These communities vary from country to country, but, in general, technological knowledge derived from them tends to generate useful outcomes in the local economy for local rivals, more than for foreign competitors (Almeida,

1996; Jaffe, et. al, 1993). Research has learned that firms that operate in the global industry environment from the beginning will tend to be higher performers; therefore, more firms than universities will be likely to disseminate knowledge and technology in the global rather than national community (Spencer, 1996). Furthermore, since universities are often focused on developing resources for their region or local community, they will more likely target research efforts to domestic needs and start local ventures (Cutler, 1989; Mowery & Rosenberg, 1993).

U.S. universities typically offer incentives to scientists to focus on commercially relevant research by providing government funding to solve real issues. In fact, much research is sponsored at the state level, which is generally not true in other countries. Moreover, U.S. antitrust policies and decentralized industry structures also serve to encourage new high-technology ventures, particularly by academic researchers.

By contrast, Japan is representative of many Pacific Rim countries in terms of structures and incentives that inhibit commercialization. Studies have found that the low quality of research, the inability of faculty to move between schools, bureaucratic rules regarding research funds, and little financial support all work together to make Japanese university-based research unattractive to industry (Hicks, 1993). Other research noted that Japanese researchers have less exposure to the marketplace because far fewer of them are involved in joint projects with firms than are U.S. university scientists (Cutler, 1989). Institutional rigidity and sociocultural aspects have combined to oppose any linkage of research to private profit.

Policy as an Environmental Context for University Spin-offs

The market system does not permit the natural diffusion of technologies to the marketplace. One of the primary reasons for this is that the investment community does not invest sufficiently in basic research largely because there are no reliable methods for accurately assessing risk at such an early stage (Cohen & Noll, 1991, 18). A further problem is that of appropriability, which is the gap between private and social rates of return on R&D; that is, it is unlikely that the rates of return to the investor will match or even come near to matching the returns to society

(Jamison & Jansen, 2000). Because most of the benefit of technological advances is passed on to consumers and is not part of profitability calculations, the profit to the inventing company is generally too small to justify a private investment (Mansfield, 1980 & Scherer, 1982). It has been estimated that the private rate of return on investment in R&D is about 25 percent and the social rate of return on R&D is 56 percent (Mansfield, 1986). The appropriability problem often extends to applied research as well where the application does not have a specific value to a particular company.

The "technological gap theory" applies in the U.S. where defined mechanisms for supporting applied research don't exist; consequently, a gap exists between scientific advances arising from academic research and technologies commercialized in the market (National Academy of Sciences, 1992). The Bayh-Dole Act of 1980 (P.L. 96-517, later amended by PL. 98-620) has gone a long way toward narrowing this gap by making it easier for industry to participate in the development of federally funded basic research. The Bayh-Dole Act, the popular name for the Patent and Trademark Act Amendments of 1980, radically changed the incentive structure for non-government organizations performing federally funded research. Prior to the act, the federal government retained title to patents generated from its grants. Since it then gave non-exclusive licenses to develop technologies, there was no incentive by companies to do the development because their competitors could also obtain a license on the same technology. With the increase in global competition, however, the government became concerned that most of the technologies developed under its grants were not being commercialized. So Congress pushed through the Bayh-Dole Act, which provides for ownership by universities and others of patentable inventions resulting from federally-funded research. In addition, a series of federal judicial decisions that followed the passage of the act significantly broadened the definition of patentable inventions and strengthened the legal protections of holders of intellectual property rights (Newberg and Dunn, 2002).

Securing intellectual property protection is a critical element of the commercialization process where licensing and outside funding are being considered. Since the Bayh-Dole Act, the number of invention disclosures and patents filed at universities

has been increasing, which has stimulated interest from the investment community (Santoro & Betts, 2002). In fiscal year 2000, 13,032 invention disclosures at universities were reported, up 6 percent from 1999. In the same year, 6,375 new U.S. patent applications were filed, up 15 percent from fiscal year 1999. In fiscal year 2000, 4,362 new licenses and options were executed, up 11 percent from fiscal year 1999. Ninety percent of these licenses and options to start-ups were exclusive (Pressman, 2002), which is surprising because universities tend to be reluctant to grant exclusive licenses to industry partners. The opportunity cost of revenue streams from other segments of that company's industry or other industries is lost with an exclusive license. Moreover, exclusivity can impede the university's ability to disseminate knowledge — it's primary mission.

The climate for university-industry collaboration is far more encouraging than in the past. For industry, global competition has forced businesses to turn to universities to find ways to make their organizational processes more effective (Abrahamson, 1996, Micklethwait & Wooldridge, 1996, Pfeffer & Sutton, 2000). Moreover, many companies, in an effort to reduce overhead, have decreased the size of their R&D staffs and are using universities to fulfill that function (Cohen, Florida, Randazzese, & Walsh, 1998). An additional benefit is that public policy provides tax breaks for corporate funding of university research and requires university/industry partnerships as a condition of funding.

In the past, collaborations were essentially sponsorships by industry of university research to solve industry-specific problems. Today industry views the university as a source of complementary expertise, knowledge, and resources that are frequently not easily available in the industry environment (Starbuck, 2001). Moreover, university partnerships usually don't carry with them the conflicts of interest so prevalent in industry partnerships. At the same time, industry-university collaborations have also sparked serious criticism that they compromise and weaken the academic mission (Cohen et.al, 1998). One of the main dilemmas is the conflict between the open inquiry principle at universities and industry's desire to restrict the diffusion of information to maintain a competitive advantage. Despite some of the negatives, industry's and the university's share of R&D is increasing while government's share is decreasing (National Science Foundation, 1996).

Economic Impact of University Spin-offs

Although arriving late to the game of technology commercialization, university licensing and spin-off activity has had a significant impact on the economy. For example, in 1999, commercialized academic research in the U.S. produced more than $40 billion in economic activity including over $5 billion in federal, state, and local tax revenues, more than 340 new companies started, and more than 270,000 jobs (AUTM, 1999). In fiscal year 2000, 464 start-up companies were formed based on licensing technology from 121 institutions. Of these, 80 percent started in their home state (AUTM, 2000).

One of the surrogates for economic impact of university spin-offs is the amount of venture capital invested as a percent of GDP. In the U.S. venture capital investment represents 1.02 percent of the GDP, while in Korea, it is .38 percent, and Japan is at .036 percent. (GEM Study, 2002). In other words, the U.S. invested 28 times the rate in Japan. Even with the current decline in venture capital investing, these numbers are significant when it is noted that the bulk of venture capital goes for adding employees or purchasing goods and services, all of which have a positive effect on the economy.

Academic research is also a valuable resource for government policy-makers as they look for ways to be more competitive in a global market and in this sense offers a less direct form of economic impact (Spencer, 2001).

Methods

The survey was conducted jointly by the University of Southern California and the National University of Singapore between January 28 and April 26, 2002 under the auspices of the Association of Pacific Rim Universities (APRU), an association of leading universities in East Asia, Australia and Pacific America. A structured questionnaire survey form was sent to the directors of Technology Licensing Offices or their equivalent organizations in each of the 29 member universities of APRU that had agreed to participate in the study.

The survey covered questions on the universities' activities and policies regarding invention disclosures, technology licensing, technology transfer, start-up companies, incubation, and other technology commercialization support services, as well as basic information about the structure and organization of their technology licensing offices. Standard definitions of variables as used in the annual survey of the Association of University Technology Managers (AUTM) survey (covering North American Universities) were adopted wherever possible to facilitate benchmarking. The initial draft of the survey instrument was circulated to all the respondents to incorporate their comments and feedback before finalizing the questionnaire.

At the close of the survey, 22 out of the 29 universities that were sent questionnaires provided valid responses. Almost half of these (ten) were from North America. Another nine were from Asia, and one each from Australia, New Zealand, and South America. A listing of the participant universities is found in Figure 1. With one exception, the remaining universities that did not provide complete responses indicated that they either had not established a proper technology licensing office yet, or their offices were too new to have collected the kind of data requested in the survey instrument. The response rate was 76 percent (91 percent for North American universities and 67 percent for other universities). The majority of the universities (86 percent) were public universities. There were only three private universities: two from the US, and one from Japan. Some APRU member universities from outside North America were not able to participate in this survey because they have not yet set up a Technology Transfer Organization (TTO), or they have not developed capacity to collect such data yet. Some of the participating universities indicated that this is the first time they have compiled such data.

Data collected were analyzed using descriptive statistics, analysis of variance, and regression analysis.

FIGURE 1: DISTRIBUTION OF RESPONSES FOR APRU STUDY

	Frequency	Percentage
North America	**10**	**45.5**
Stanford University		
University of British Columbia		
University of California, Berkeley		
University of California, Irvine		
University of California, Los Angeles		
University of California, San Diego		
University of California, Santa Barbara		
University of Oregon		
University of Southern California		
University of Washington		
Japan	**4**	**18.2**
Kyoto University		
Osaka University		
University of Tokyo		
Waseda University		
Asia (excluding Japan)	**5**	**22.7**
Hong Kong University of Science and Technology		
National Taiwan University		
National University of Singapore		
Seoul National University		
University of Science and Technology of China		
Australia/New Zealand	**2**	**9.1**
University of Auckland		
University of Sydney		
South America	**1**	**4.5**
University of Chile		
TOTAL	**22**	**100**

Results

We look at the results of the APRU survey in terms of the three research questions we were attempting to address.

U.S. versus Pacific Rim University Spin-offs

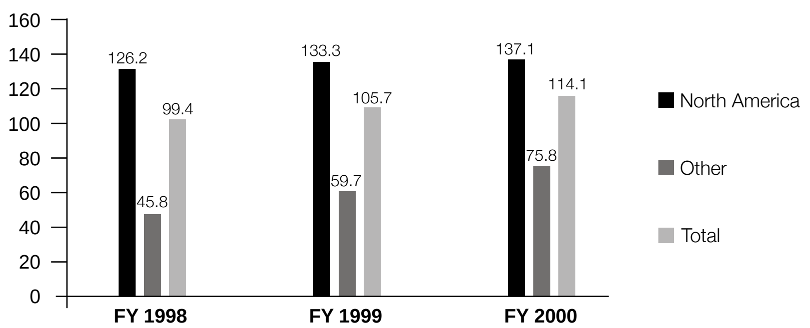
The first question we attempted to address was how does the U.S. phenomenon of university spin-off ventures compare with technology commercialization from universities in the other Pacific Rim (PR) countries?

The current study found a notable difference between North American universities and those in other countries in the area of research expenditures. As a proportion of the operating budget, research expenditures remained constant at 22 percent in North American universities over fiscal years 1998-2000, while it increased in the other Pacific Rim universities in the study, from 16 percent in fiscal year 1998 to 20 percent in fiscal year 2000.

The government remains the primary source of research funding for universities in all countries. Industrial sources of research funding remained at about 13 percent in North American universities for fiscal years 1998-2000, but increased in other countries, from 13 percent in fiscal year 1998 to 16 percent in fiscal year 2000. Engineering and medical schools accounted for the largest share of research expenditures (between 20 to 30 percent of research expenditures in all years surveyed). Research expenditures in life sciences and pharmacy remained roughly constant at 22 percent in the North American universities (from 7 to 8 percent of FY1998 to FY2000), at the same time they rose in universities in other PR countries (from 6 to 10 percent over the same time period).

Indirect costs were significantly higher in North American universities than in other PR universities (41 percent and 13 percent of total sponsored research expenditures respectively). North American universities had a much higher number of invention disclosures than other universities as depicted in Figure 2. However, other PR universities had a higher growth rate in invention disclosures over the three years used in the study (compound average annual growth rate of 29 percent, versus 4 percent for North American universities). North American universities had a higher number of patent applications and patents issued in all categories (home country, the US, and other countries), for all years. However, it should be noted that since patents issued in the U.S. are domestic patents for US universities and foreign patents for universities in other countries, and given a tendency toward patenting in the country in which the university is located, the figures for patenting in the US are not comparable between North American and the other regional universities. The volume of patents filed on research conducted in separate schools/departments reflects the level of research expenditure in the schools/departments. That is, in North American universities, research expenditures are highest in medical schools, which also have the highest percentage of patents (mean = 39 percent); while in other PR universities, research expenditures were highest in engineering, and the engineering schools had the highest percentage of patents (mean = 51 percent).

FIGURE 2: MEAN NUMBER OF INVENTION DISCLOSURES - NORTH AMERICA VERSUS OTHER PACIFIC RIM COUNTRIES

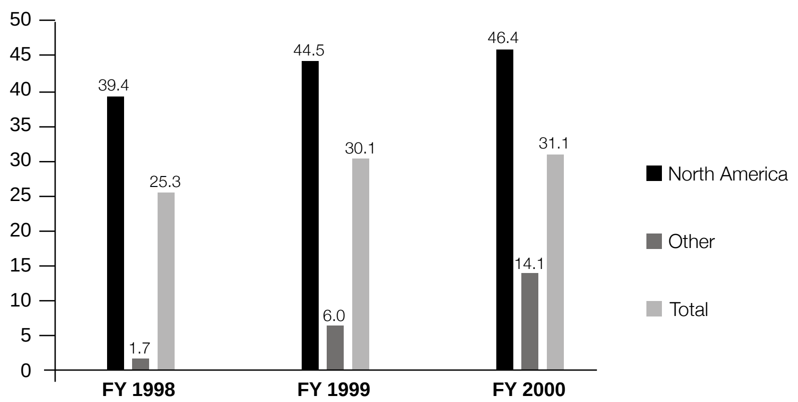


** Mann-Whitney U is significant at 0.01 level * Mann-Whitney U is significant at 0.05 level

As with invention disclosures and patents, North American universities had a higher number of license/options executed (mean cumulative number = 353 as of end fiscal year 2000, compared to 33 for other universities) as depicted in Figure 3. The difference is less stark for licenses/options executed with equity. In that case, the mean cumulative number of licenses/options as of fiscal year 2000 for universities in North America was 21, compared to seven for other universities. As with

invention disclosures, the growth rate of licenses/options executed every year was higher for universities outside North America (191 percent versus 9 percent for North American universities), which can partially be explained by the fact that the non-North American universities were starting from a smaller base causing the percentage increase to appear to be higher. Licenses to existing companies were more common than those to start-ups. The mean cumulative number of licenses by universities to existing companies was 191 as of the end of fiscal year 2000, while the mean number of licenses to start-ups was 24. North American universities had a higher mean cumulative number of licenses to both start-ups and existing companies as of end fiscal year 2000. However, the trend for both regions was for the number of licenses to increase on an annual basis over fiscal years 1998-2000.

FIGURE 3: MEAN NUMBER OF LICENSES/OPTIONS EXECUTED - NORTH AMERICAN UNIVERSITIES V. OTHER PACIFIC RIM UNIVERSITIES



** Mann-Whitney U is significant at 0.01 level * Mann-Whitney U is significant at 0.05 level

Note: One outlier from “Other” has been excluded. Including this exceptional case increases the average for “Other” to 23.3, 31.1 and 34.2 for FY1998, FY1999, FY2000. This in turn increases the mean for “All countries” to 32.8, 39.0 and 40.3 for each of the three years

University Policy as an Environmental Context

The second question addressed in this study was what is the effect of university policy as an environmental context on the start-up of entrepreneurial ventures from university research? University policy appears to have a significant impact on new ventures spinning out of universities. In general, transfer of technologies for the public good and providing service to researchers were more highly rated objectives for North American universities than for other PR universities, although the difference was only significant at the 10 percent level. Conversely, contributions to the prestige of the university (difference significant at 1 percent level), and the amount of sponsored research grants generated from technology transfer (difference significant at 10 percent level) were significantly more important for universities outside North America. On average, almost one-quarter of research funds were centrally allocated in the university, with the average being higher for North American universities (28 percent of research funds) than for other PR universities (20 percent).

About 80 percent of North-American universities held patent rights to technology developed by faculty and students. Only about 40 percent of non-North American universities had this policy. About 40 percent of non-North American universities shared ownership of intellectual property with the inventor. No North American university reported having this policy.

On average for all countries, 37 percent of royalties went to the inventor, while one-third went to the university. Another 17 percent went to the inventor's department/school, and 10 percent to the TTO. For the universities in our sample, the largest share of equity went to the university (41 percent on average), while almost one-third was given to the inventor. The inventor's dept/school and the TTO received 14 percent and 9 percent respectively.

All but one of the universities allowed its tenure-track faculty members to serve on the board of directors of an existing company. However, 55 percent of the universities required approval to be granted first. A similar situation existed regarding tenure-track faculty members serving on the board of directors of a start-up company to commercialize their inventions. One university prohibited it completely.

The rest allowed it, but 60 percent required the faculty member to seek approval first. Again, only one university did not allow its faculty members to take no-pay leave for involvement in a start-up company to commercialize an invention, but 70 percent required them to seek approval. All universities allowed their faculty members to consult for industry, 55 percent requiring approval to be granted first.

The universities in our sample provided a wide range of services to assist start-up companies. Among the most common were helping start-ups to gain access to funding, for example, by providing advice on government commercialization grants (provided by 90 percent of universities); by facilitating access to venture capital (85%); or by taking equity in start-up companies (85%). In addition, 80 percent of universities also ran an entrepreneurship center, which provided entrepreneurship-related education and outreach events. The least common forms of assistance were establishing a university-affiliated research/science park (30%) and directly investing in start-ups from a university endowment fund (15%).

In terms of policy, North American universities appear to be more prepared for interaction with industry and technology licensing. Almost all North-American universities (90%) had a written policy on conflict of interest for faculty members' involvement with business/industry, and an equity management policy pertaining to start-up companies receiving technology licensing. By contrast, just over half of the universities in other PR countries had a written conflict of interest policy, and only about 20 percent had an equity management policy.

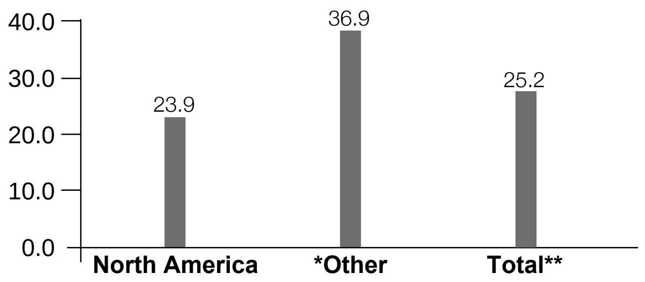
The university treasury most commonly managed the equity received from licensing university technology to start-up companies (true of 31 percent of universities with an equity management policy). Having a university-controlled holding company to manage equity was more common in universities outside North America. About 50 percent of those with equity management policies had this arrangement. The corresponding figure for North American universities was only 13 percent.

Economic Impact from University Spin-offs

The third question addressed by the study was how does economic impact from university spin-offs differ across the Pacific Rim countries? Most universities (half in North America and two-thirds in other countries) tracked the number of companies started by faculty members, but only two tracked those started by alumni. The cumulative number of companies started by PR faculty members as of end FY 2000 averaged to 34 (for those with technology licensing from the university) and four (for those without technology licensing).

North American universities had a much higher number of companies started by faculty members as compared to universities in other countries (mean cumulative number = 64 and 9 respectively as of end fiscal year 2000) as depicted in Figure 4.

FIGURE 4: START-UPS WITH TECHNOLOGY LICENSING FROM UNIVERSITY PER 100 US PATENTS*



* Start-ups by faculty members only. Cumulative numbers as of end FY 2000 used for both start-ups and patents.

Note: Since patents registed in the US are domestic patents for US universities and foreign patents for other PR countries, figures for patenting in the US for N.American universities will be biased upwards

The economic impact/wealth creation indicator most commonly tracked by universities was the number of jobs created by start-ups (tracked by 37 percent of universities in the case of companies with technology licensing, and by 25 percent of universities for companies without technology licensing). Sales revenue generated and external investment were both tracked by 26 percent of universities in the case of companies with technology licensing, and by almost 20 percent of universities for companies without technology licensing.

Aside from these indicators, other indicators tracked by universities included:

Ph.D.s' roles in industrial biotech companies
Location of company
Stock prices
Government grants
Space requirements

Conclusion and Implications

Based on the findings of this study, North American Universities in APRU experienced a significantly higher level of technology transfer activity than other PR universities, which may be explained in part by the longer history of involvement in such activities. In the U.S., technology transfer and commercialization were propelled forward by the passage of the Bayh-Dole Act and the subsequent pressure by government funding agencies to commercialization technology funded by their agencies. In short, North American universities are encouraged, supported, and incentivized to transfer and commercialize the results of research in a way not yet seen in the other PR countries. Nevertheless, technology transfer intensities are growing at a faster rate among universities outside of North America where the percent of the operating budget devoted to technology transfer activities is growing rapidly. Industry support of university research is also growing more rapidly in non-North-American countries than in the U.S.. Furthermore, non-North American universities reported being far more interested in tracking start-up ventures than North American universities, which were more interested in licensing.

At the fuzzy front end of the innovation process, however, U.S. universities produce far more invention disclosures and patent applications than their PR counterparts. And, they have started many more new ventures from university technologies than the other PR universities in APRU. Nevertheless, the area of tracking and understanding technology transfer as a wealth creation mechanism is in the earliest stages. Most universities do not do an effective job of tracking the results of their commercialization efforts over time, particularly in the area of spin-off ventures. Further research will focus on these spin-off ventures and their contributions in terms of new jobs created, sales revenues, and gifts back to the university.

Although technology transfer activities have been closely monitored in the U.S. through AUTM, this study represents the first time that comparable data have been collected on Pacific Rim universities and their spin-off ventures. The diversity of APRU members makes the organization an ideal forum for promoting comparative research on best TT practices under different environmental contexts and for facilitating information exchange and knowledge sharing. In that regard, the APRU study has created a new awareness among the member universities of technology transfer practices and efforts in the Pacific Rim. Moreover, it contributes to our understanding of the context in which a technology opportunity is identified and the ability of the entrepreneur to exploit that opportunity.

The new role of the university in stimulating the economy through innovation and partnerships with industry requires that it develop policies and an environmental context that will support and encourage entrepreneurial ventures that will effectively take the results of research to the market for the benefit of society.

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