INDUSTRIALIZING ACADEMIC KNOWLEDGE IN TAIWAN

The attitudes of Taiwan's universities toward transferring and commercializing academic knowledge have shifted to a more "scientific-economic" orientation since new legislation was enacted in 1999, a survey reveals.

Yuan-Chieh Chang, Ming-Huei Chen, Mingshu Hua, and Phil Y. Yang

OVERVIEW: *How to effectively utilize and leverage academic knowledge has become a concern for university leaders and faculty, firms and policymakers alike. A questionnaire survey of 122 Taiwanese universities confirms that the "cognitive-governance" orientation of universities has gradually shifted from the "scientific-government" to a more "scientific-economic" one since the Science and Technology Basic Law was enacted in 1999. For Taiwanese universities, intellectual property infrastructure build-up, patenting and licensing activities have been steadily enhanced. The survey also reveals that the transfer of knowledge from universities to industry is largely dependent on short-term, personal and contract-based mechanisms, rather than on long-term, formal organizational, and joint capability development mechanisms. These conclusions have managerial and policy implications for capitalizing academic knowledge, not only in Taiwan but in other economies as well.*

KEY CONCEPTS: *research commercialization, university patenting and licensing, academic entrepreneurship.*

Inspired by the United States' Bayh-Dole Act of 1980, Taiwan enacted the Science and Technology Basic Law (STBL) in 1999. One of the STBL's principal mandates was to clarify the ownership of intellectual property rights (IPR) that are generated from government funding research to academia. It was expected that granting IPR ownership to universities would accelerate the commercialization of new technologies and promote national/regional economic and innovative activities.

The government also enacted the *Guidelines for Ownership and Utilization of S&T Research and Development Results* in 2000. The *Guidelines* stipulate that universities need to pay only 20 percent of any licensing income to government funding agencies. Specifically, they call for distributing 40, 40 and 20 percent respectively of licensing income and royalties to implementing institutions (e.g., universities), inventors and government funding agencies.

Furthermore, the National Science Council (NSC) is the leading academic funding organization in charge of promoting industry-academia collaboration in Taiwan.

Yuan-Chieh Chang is an assistant professor at the Institute of Technology Management, National Tsing Hua University, Taiwan. He has recently been involved in a government-sponsored project to investigate the transferring and commercializing of public sector research in Asia-Pacific Economic Cooperation (APEC) economies. He obtained his Ph.D. in science and technology policy at PREST, University of Manchester, England, and M.B.A. in management of technology at the Asian Institute of Technology, Thailand. **yucchang@mx.nthu.edu.tw**

Ming-Huei Chen is an assistant professor of creativity and innovation management at Yuan-Ze University, Taiwan. Her research focuses on team creativity and entrepreneurship studies. She received her Ph.D. from Manchester Business School, England, and M.B.A. from Northern New Hampshire University, U.S.A.

Mingshu Hua is a professor and director of the Institute of International Business Studies, National Chi Nan University, Taiwan. His research interests focus on financial strategy management and international finance. He graduated from Indiana University in 1981 with a Ph.D. in economics, and was a visiting scholar at Northwestern University and the University of Illinois in 1990–1991.

Phil Y. Yang is a lecturer at the International Business Department, Chung Tai Institute of Health Sciences and Technology, and a doctoral student at the Institute of International Business Studies, National Chi Nan University, Taiwan. His research interests are technology licensing and entrepreneurial management.

In order to encourage academia to become involved in patenting activities, the NSC implemented the *Principles of Management and Promotion of Academia R&D Results* in 2002. With NT$28 million from the NSC, ten technology transfer/licensing offices were established in public research institutes by 2003 (*1*).

The *Principles* also committed to reimburse 70 percent of the patenting expenditures, including patent application and maintenance fees. This will be reduced to 50 percent in 2005.

Five Survey Conclusions

Although institutional reforms have burgeoned in many newly STBL-enacted economies (e.g., Japan, Korea and Taiwan), the systematic evaluation of the industrialization of academic knowledge has not been thoroughly investigated. This includes activities of universities in patenting, licensing and creating new firms.

Consequently, in 2003, APEC (Asia-Pacific Economic Cooperation) and the Science and Technology Policy Research Center (STPRC) of Taiwan's National Science Council funded a survey of 122 Taiwanese universities to fill the gap (*2*). The questionnaire survey investigated five dimensions of industrializing knowledge in the universities, namely: 1) build-up of an intellectual property/technology transfer infrastructure; 2) barriers to technology transfer; 3) mechanisms for university-industry partnerships; 4) patenting and licensing activities; and 5) firm incubation.

In order to assess the performance following enactment of the 1999 STBL, the survey sought information from the pre-STBL period (1997–1998) and the post-STBL period (1999–2000). Table 1 lists the survey questions. The questionnaires were addressed to the directors/managers of the central administration who were in charge of technology transfer, commercialization and business incubation. Fifty-eight universities responded (48 percent response rate). Five principal conclusions were drawn from the survey results and described below.

1. *Institutional innovation is the starting point for industrializing academic knowledge. It provides a favorable incentive system and facilitates organizational innovation across academic institutions.*

The institutional reforms provide an open environment in which universities can create new organizational forms that are good for economic creation and academic entrepreneurial activities. The establishment of an intellectual property infrastructure paves the way for increasing academic awareness of the exploitation of research results. The Intellectual Property Offices (IPOs), the Technology Transfer Offices (TTOs), incubator centers, or their equivalent have become widely established for the purpose of technology protection, transfer and commercialization.

Table 1.—Survey Questions

Subject	Question
1. Infrastructure build-up	• Has your institution established the IPO/TTO or equivalent? • When were the IPO/TTO established? • How many full-time-equivalent (FTE) employees are in the IPO/TTO?
2. Barrier to technology transfer (Likert 5-scale applied)	• Conflicting organizational objectives. • Research's attitude toward technology transfer. • Insufficient understanding of industry. • Conflicting research priority setting. • Neglect by industrial partners.
3. University-industry partnership	• The amount of contract research from industry in 1997–1998 and in 1999–2000 respectively. • The number of industrial training programs initiated. • The number of collaborative research projects formed with industry in 1997–1998 and 1999–2000 respectively. • The number of consortia formed with industry in 1997–1998 and 1999–2000 respectively. • The number of research centers jointly formed with industry in 1997–1998 and 1999–2000 respectively.
4. Patenting and licensing	• Number of patents issued in 1997–1998 and in 1999–2000 respectively. • The amount of licensing fees and royalties in 1997–1998 and 1999–2000 respectively. • Is your institution a general university/a science and technology university/a college? • Is your institution a public or a private HEI? • Did your institution have any patents granted by 1998? • Does your institution have business/medical engineering schools?
5. Firm incubation	• Has your institution established an incubation center? • When was the incubation center established? • How many full-time-equivalent (FTE) employees are in the incubation center? • The number of tenant firms and graduate firms during 1997–2001. • The number of firms started by university faculty.

The survey shows that the build-up of an intellectual property infrastructure is no longer the privilege of a few elite research universities. More than half of the responding universities and colleges have established TTOs or their equivalent, and roughly 40 percent have IPOs and/or incubator centers (Table 2). More important, these units were most often founded during the post-STBL period. Institutional innovation provides a favorable incentive system and facilitates organizational innovation across universities. Having obtained legitimacy from the STBL, universities are now able to develop their economic sensitivities.

2. *Three key actors are jointly needed for industrializing academic knowledge: university leaders as sponsors, academic entrepreneurs as champions, and university technology managers as catalysts.*

Industry–academia research collaborations have innate difficulties in transferring and commercializing academic technology/knowledge. The survey found that conflicting organizational objectives and attitudes held by academic researchers regarding technology transfer were the two major barriers to industry–academia linkages (Table 3). Consequently, understanding the background of the faculty and their institute can be helpful in easing conflicts.

Academic faculty and research institutes are evaluated technically on the basis of the number and quality of their publications, while industrial researchers are interested in generating patents and commercial products cooperatively with the university. However, university faculty fear that such cooperation can result in delays or limitations on publication. This fear constrains academic freedom to disclose research results.

University technology managers serve as catalysts and surrogates in bridging the gap between academia and industrial partners. Besides being well trained in intellectual property protection and technology transfer, technology managers with industrial experience and academic understanding are more capable of catalyzing the cooperation. Therefore, university technology managers in technology transfer offices and academic entrepreneurs jointly play a key role in harmonizing conflicting objectives between industrial partners and universities.

Moreover, university policy to encourage the establishment of venture funds and spin-offs demonstrates a commitment toward a more entrepreneurial orientation (*3*). Academic entrepreneurs need to play the role of champions who become involved from the beginning to the end of the commercialization process. Academic entrepreneurship awareness programs should be encouraged through institutional support (e.g., tenure and promotions) and incentive programs (e.g., entrepreneurial leaves-of-absence and share of royalties).

Industry, academia links remain concentrated on short-term, personal and contract-based relationships.

3. *The major links between industry and academia remain short-term, informal personal, and contract-based collaboration rather than long-term, formal organizational, and joint capability development.*

Enterprises may find themselves in a new situation when the market changes faster than they are able to adapt, or competitors bring superior products to the market. Universities can help these enterprises to enlarge their technology base and sources of innovation that support a company's present and future operations, as well as provide employees with assets that will help them adapt to future work requirements (*4*).

Education and training programs stand out as the primary mechanism of industry–academia collaboration. The basic idea is to analyze the competence development needs of the organization and transfer them into lifelong learning programs that are for the employees' advantage and that can be purchased from universities (*5*). Unlike other industry–academia collaborative mechanisms, training programs offer informal, short-term and inexpensive research linkages that are especially attractive to Taiwanese firms with limited R&D budgets.

In terms of the growth of university–industry links between 1997 and 2001 (Table 4), education and training cases and collaborative research projects grew 19.5 and 8.1 percent respectively. During the same period, industrial contract research projects and research consortia grew only 3.2 and 1.9 percent, respectively. These results suggest that the major industry–academia links remain concentrated on developing short-term, personal contact and contract-based relationships that incur the least risk and organizational commitment.

4. *University organizational characteristics affect their patenting and licensing performance.*

In contrast to the findings of Siegel et al. (*6*), the survey found that the public universities outperformed the private institutions in patent applications during the post-

Table 2.—Comparisons of IP Infrastructure Establishments

Institution type (No. of schools)	IPO or equivalent		TTO or equivalent		Incubator center	
	Number	%	Number	%	Number	%
University (26)	12	46	11	42	14	54
College (32)	9	28	21	65	11	34
Total (58)	21	36	32	55	25	43

Source: APEC-STPRC PSR Survey (correspondent year 2001)

Table 3.—Barriers to Technology Transfer

Barrier	Mean*	Rank
Conflicting organizational objectives	3.67	1
Researchers' attitude on technology transfer	3.60	2
Insufficient understanding of industrial needs	3.52	3
Conflicting research priority settings	3.22	4
Neglect from industrial partners	3.09	5

*Very important = 5; important = 4; fair = 3; less important = 2; least important = 1. Source: APEC-STPRC PSR Survey

Table 4.—University-Industry Partnerships in Taiwan (1997–2001)

Types of partnership	Average annual number (all higher-ed institutions)	Actual participating institutions (%)
Education and training program	46.36	70.7
Contract research	3.11	84.5
Collaborative research	2.86	37.9
R&D center	0.44	20.7
R&D consortia	0.10	15.5

Source: APEC-STPRC PSR Survey

Table 5.—University Patenting and Licensing Activities in 1999–2001 by Types of Higher-Educational Institution (HEI)

Type	Average number of patent applications	Average number of patents granted	Average number of patents licensed
Public HEI	5.94	2.04	0.24
Private HEI	1.86	2.19	0.28
Universities	5.32	3.84	0.43
Colleges	1.34	0.86	0.15
Experienced HEI*	12.46	8.49	1.03
Non-experienced HEI	0.34	0.31	0.05
With/Without Med. School	14.67/2.20	4.08/2.01	0.72/025
With/Without Bus. School	3.59/0.15	2.44/052	0.30/0.11

Source: APEC-STPRC PSR Survey
*Experienced HEI refer to universities that had patents and licensing in the 1997~1998 period.

*Table 6.—Incubators Affiliated with Educational Institutions (1997–2003)**

Year	Tenant firms	Graduate firms
1997	18	0
1998	113	0
1999	281	28
2000	625	79
2001	824	118
2002	866	160
2003	937	205

*Annual data are not accumulated.
Source: Small and Medium Size Administration, MOEA, Taiwan

Table 7.—Educational Institution Patenting, Licensing and Venturing in Japan, Korea and Taiwan

	Taiwan (Year 2003)	Japan (Year 2002)	Korea (Year 2001)
TTOs	16	33	Not available
No. of patent grants	303	163	186
No. licensed	59	89	44
Licensing income and royalties	US$1.98 million	US$1.39 million	US$1.03 million
Academic spin-offs	2	6	19
Total incubation centers	67	266	292
Number of incubation centers at campus	54	13	229
No. of firms in incubation centers	1,051	1,723	3,657
No. of firms graduated from incubation centers	230	1,471	1,690

Source: (*1,9,10,11*)

STBL period. However, the private universities outperformed the public ones in patents granted and in licensing. This may result from the fact that the public universities in Taiwan have more research endowments and government funds. However, the bureaucratic culture and rigid organizational structure of public institutions hinder the technology transfer from universities to industry. Moreover, the universities have steadily outperformed the colleges in patents granted and licensing (Table 5).

Furthermore, the survey indicates that the size of a university in terms of the number of faculty does not influence the performance of patenting and licensing activities. Those universities with medical schools and/or business schools are more active in patenting and licensing. Business school faculties are able to enhance a university faculty's capabilities in market sensitivity, IPR evaluation, and entrepreneurial team formation. The major share of patents and licenses is generated by life science and electrical/electronics engineering departments.

To consider the learning curve, the patenting/licensing experience among universities surveyed in the 1997–1998 period significantly outperformed that of the non-experienced institutions during the 1999–2000 period.

5. *Although the Massachusetts Institute of Technology has been the wonderland of academic spin-offs in the U.S. since the 1980s, Taiwan is inventing its own model to echo the trend of industrializing academic knowledge.*

Among U.S. universities, academic spin-offs are an important vehicle for technology transfer and economic development. One famous example is the MIT faculty and graduates who act as venture champions and run their own start-ups along Massachusetts Route 128. Roughly 20 percent of these companies have made an initial public offering (*7*). However, still in the initial stage of developing academic entrepreneurship, the Taiwanese academic-owned spin-offs are few. Rather than establishing new firms to exploit university-generated intellectual property, Taiwanese universities help industrial partners to create new ventures mainly through incubator centers on campus.

In assisting start-ups to develop the firm's technology competence, the Taiwanese incubator centers offer firms the opportunity to get involved in academic research facilities, faculty consultation, and research network build-ups. The illustrative indicators of the Taiwanese "surrogate-incubation" model found that over 43 percent of the universities have established incubator centers. There were 67 incubator centers in Taiwan in 2003, with 54 of them located at the universities. Since 1997, the number of campus tenant firms has grown more than tenfold. In 2001, there were 882 tenant firms on campus and 130 graduate firms (Table 6).

Taiwanese universities help industrial partners to create new ventures mainly through incubation centers on campus.

Lessons Learned

In the rise of a knowledge-based economy, industrializing academic knowledge to foster industrial innovation and competitiveness has become imperative. The Taiwanese institutional reforms, especially the STBL enactment and governmental guidelines as a catalyst, have encouraged the universities to transfer and commercialize knowledge on their own. Since the passage of the STBL, the intellectual property infrastructure build-up, patenting and licensing activities at Taiwanese universities have flourished. The "cognitive-governance" of academic knowledge has gradually shifted from a "scientific-government" regime to a "scientific-economic" orientation.

The institutions of higher education in other newly-STBL-enacted countries, such as Japan (*8*) and Korea, are showing a similar shift to a "scientific-economic" orientation, albeit with different exploitation trajectories. Among these countries, Taiwan is the most enthusiastic generator of university patents and licensing income (Table 7).

Despite the limited number of university patents, Japan has a higher quality of patents and technology transfer capabilities and generates more licensing income per patent. The performance of patenting and licensing activities in Korean universities falls roughly between Japan's and Taiwan's. However, Korean universities are the fastest learners in creating the MIT model of academic entrepreneurship and generating the most university-affiliated incubators and faculty spin-offs.

Most incubation centers are established at or near campuses in Taiwan and Korea. In contrast, university-affiliated incubation centers are less than 10 percent in

Japan. Most of the business incubators are owned by non-profit organizations and are being established by prefectural agencies under the support of the Regional Development Corporation. Consequently, Japan has emphasized venture incubation efficiency and had the highest firm turnover rate (85 percent) in 2002.

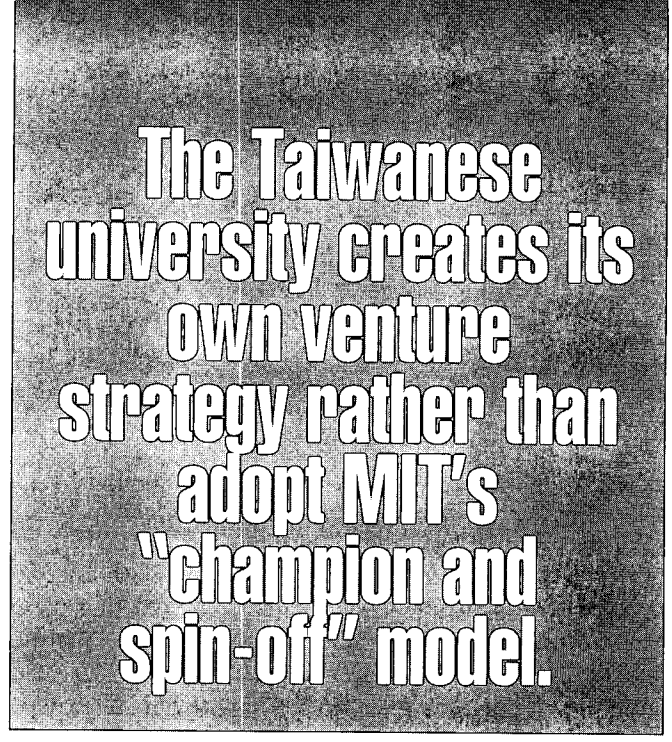
Despite the differences in how these countries exploit academic knowledge, all the figures indicate that their "scientific-economic" orientation of academic knowledge is strengthening rather than weakening (Table 7).

Among the major barriers to technology transfer and commercialization, conflicting organizational objectives and little awareness of commercial potential are the biggest. Three key roles should be in place in order to lower these barriers: 1) university leaders as sponsors, 2) academic entrepreneurs as commercialization champions, and 3) university technology managers in technology transfer offices as the catalysts.

University-industrial partnerships are still largely dependent on short-term, personal and contract-based mechanisms, rather than on long-term, formal organizational, and joint capability development mechanisms. Private universities and experienced universities consistently outperform their counterparts in terms of patenting and licensing activities.

Finally, the Taiwanese university creates its own venture strategy of the "surrogate-incubation" type rather than the MIT "champion and spin-off" model. To encourage transfer and commercialization of university knowledge, university leaders need to provide more incentives and support for academic entrepreneurs, such as seed money, entrepreneurial leaves, technology transfer support, and credit for patenting and licensing in annual personnel performance assessments. For improving the commercialization capabilities of institutions of higher education, the vulnerable entities such as public universities, colleges and non-experienced institutions are top priority.

Finally, research policies altering the existing patterns of commercializing academic knowledge toward more long-term and joint capability development of university-industry partnership and "champion and spin-off" academic entrepreneurship are welcome not only for Taiwan but for other economies as well. ◆



References

1. NSC. National Science Council Review. Republic of China, 2003.
2. Chang, Y-C., Chu, Y-Y., Hung, S-C., and Lin, B-W. Transferring and commercializing public sector research: A pre- and post-STBL comparison in Chinese Taipei. In *Science and Technology Drivers in a Knowledge-Based Economy,* Final Report to APEC-STPRC. Taiwan, 2003.
3. Di Gregorio, D. and Shane, S. Why do some universities generate more start-ups than others? *Research Policy* 32(2), 2003, pp. 209–227.
4. Woodcock, D. J. and Chen, C. Y. Taiwanese universities and educating future manufacturing managers. *Journal of Management* 19(10), 2000, pp. 853–869.
5. Clovis, J. S. Challenging industry on education. *Research · Technology Management,* Nov.–Dec., 2003, pp. 9–11.
6. Siegel, D. S., Waldman, D., and Link, A. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy* 32(1), 2003, pp. 27–48.
7. Shane, S. and Stuart, T. Organizational endowments and the performance of university start-ups. *Management Science* 48(1), 2002, pp. 154–171.
8. Fujisue, K. Promotion of academic-industry cooperation in Japan—establishing the law of promoting technology transfer from university to industry in Japan. *Technovation* 18(6/7), 1998, pp. 371–381.
9. OECD. *Turning Science into Business: Patenting and Licensing at Public Research Organisations.* Paris: OECD 2003, p. 15.
10. Harayama, Y. Industry-university linkages in Japan. *International Conference on New Trends and Challenges of Science and Technological Innovation in a Critical Era,* 2003, Taipei, R.O.C.
11. Kim, H. Promoting business and technology incubation for improved competitiveness of small and medium industries through application of modern and efficient technologies in Republic of Korea. *Proceedings of the International Workshop on Business/Technology Incubation,* 2002, Nepal.