Patterns in research university technology transfer

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Abstract: This paper focuses on the developing mechanisms of patterns in research university technology transfer. Based on the different transfer directions, five patterns were identified and analyzed by comparing their advantages, disadvantages and applications. With comparisons of patterns, we find: 1) from pattern I to V, they are becoming increasingly close to the market and industry with decreased technology transfer span; 2) as a whole compared with the first three traditional patterns with little attention to further development of technology, pattern IV and V are more accepted and adopted by the university in recent years; 3) The prior pattern is always the precursor of the next one which can cover the certain shortage of the prior one.

Keywords: research university; technology transfer; pattern

1. INTRODUCTION

"*Technology transfer*" is a kind of "information" (such as technology innovation) application (Everett et al., 2001; Ensign et al., 2014) through some effective patterns, which can only succeed when the transferor and the transferee decide what to be transferred and how to transfer to achieve their objectives (N. Somsuk, 2010). In Research university technology transfer (RUTT) , the transferor refers to a research university and researchers in this university, then the transferee can be private sectors, enterprises, individuals, universities and so on (Kalar B., 2015).

A research university plays an important role in the "shift" from cross-national technology transfer to domestic technology transfer. However, in this process, there are many unsolved problems such as, how a research university opens its door to the public, how technologies can be a source of financial gain to university and what kind of policy suggestions can be made for generating economic growth of countries.

Previous studies focused only one or two patterns and mainly described the contribution of patenting and licensing, spin-offs, take equity or incubators (Mowery et al., 2001; Feldman et al., 2002; Bray et al., 200), or summarized all patterns in the context of a college or a region (Hong and Yun, 2001). We here attempt to take a comprehensive perspective to broaden the analysis of patterns in RUTT. Five patterns of technology flows are identified and their characteristics and relationships of each other are given next. With the results of the five patterns analysis, there are several obvious benefits for the researchers and the practitioners. Firstly it could provide concentrate TT information and guides when single or multiple patterns needed be chosen; secondly, technical level is identified as a common factor influencing the choice of all patterns.

2. PATTERNS' DEFINITION AND CLASSIFICATION

Five patterns founded on the directions of technology

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flow during RUTT are identified: the radiation spread of knowledge, technology network spreading by people links, one-way flow from the university to the society, technology interaction between the university and the industry and autogenic transformation for technology.

2.1 Technology-knowledge radiation spread

Technology-knowledge radiation spread is a spontaneous diffusion movement without any stable directions. In the modern civilization, the radiation can be reflected by two familiar channels: *paper publication* and *patent*.

- *Paper publication* reflects the innovative capacity of knowledge, which will improve scientific and technological level. Paper publication is not always an effective means of technology transfer, although it is the most frequently used technology transfer activity by university-based research centers.
- *Patent* represents technology innovative capacity. As an important part of intellectual property, it becomes an effective way to protect innovation and inventions. According to the World Intellectual Property Organization(WIPO), 90％～95％ of innovation and creation can be cited in the literatures of patenting, and 70％ of those haven't been published in other literatures.

As mentioned above, both *paper publication* and *patent* are important and continue to broadcast the novel technology despite the fact that papers publication is not an effective mechanism to transfer technology as described by Everett et al.(2001).

2.2 Technology network spreading through people links

Robert (1989) showed that "people intensive" was the most efficient mechanism to transfer technology, rather than "paper intensive". *People links* in a university include conversations with peers, collaborations with leading colleagues, and academic communication activities. *People links* are the best way to impart some tacit knowledge that cannot be spread and understood only through papers or patents. In modern industry, Conferences remain to be a common source for companies to learn about public research.

Academic communication brings great benefits for all participants: For the university, it can contribute to academic exchanges with institutions of higher education and cooperation with enterprises. Those exchanges can provide a chance for the university to learn more advanced or cutting-edge scientific & technological knowledge, which could further improve the knowledge structure of the faculty. Those cooperation can make the university much closer to the market and complete the direct transformation from the technology into the benefits.

In spite of less spectrum and scope of technology diffusion, the pattern Ⅱ, compared with the pattern I, has specific directions and targets for requirements and can simplify the process of technical control.

2.3 One-way technology flow from university to society

One-way flow represents a linear movement from the university to the outer where technology is transferred from owners who won't participate in its further development to demanders who are eager for advanced technology. As depicted in figure 1, taking three letters A, B, C to represent technology providers, technology accepters and intermediary respectively, where A and B are indispensable elements in the technology transfer and C serves as a technology agent.

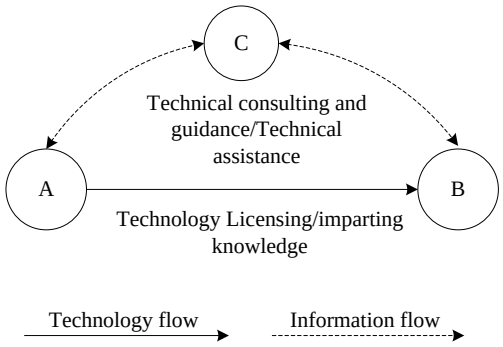

Figure1. One-way technology flow from university to the outer

Four representative kinds of transferring activities are involved in the process from A to B, which are *technical consulting and guidance*, *technical assistance*, *technology licensing* and *imparting knowledge*.

- *Technical consulting and guidance* has become a means for researchers in universities to obtain benefits, which further enhances financial ties between academic researchers and private industries.
- *Technical assistance* contains two types: *paid assistance* and *aid gratis*. *Paid assistance* represents that a university transfers knowledge and/or practice skills to client groups. *Aid gratis* generally refers to cross-national technology transfer of a research university.
- *Technology licensing agreements* typically involve company's being entitled to use a university's inventions, which are contingent upon the commercial success of the technology in a downstream market (Feldman, 2002).

- *Imparting knowledge* always occurs in the classroom or labs of a university where the professors share their knowledge with students. It is a very useful way to broadcast technology knowledge, and also a general mechanism to foster talents.

In fact, there are no clear boundaries among these pathways all of which belong to the pattern of one-way technology flow, with the same function in facilitating research results open to the public and serving the society as well as receiving revenues from the process. Sometimes they are intersected together.

2.4 Technology interaction between the university and the industry

Figure 2 described the technology interaction among university, industry, government as well as intermediary, E, U, I, G, F, M represent "Enterprise", "University", "Industry" "Government", "Funds of risk" and "intermediary" respectively. Cooperation on a core technology development among university and industry and institute is the core of this pattern.

In recent decade, universities, enterprises, government and intermediaries are combined in mainly three different manners or mechanisms for RUTT which are *the university-industry collaborations or alliances, the university-industry-government-institute relationship*, and *taking equity*.

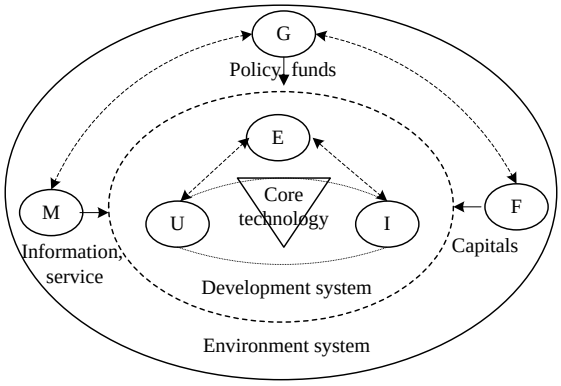

Figure 2. Interaction among universities, industries, government and intermediary

The university-industry collaborations or alliances are a win-win relationship. This partnership provides a chance for the university to meet the requirements that the society really needs and obtain a significant funding resource. Companies, in return, can get a high reputation by encouraging the advanced technology from the university. The government who serves as an assistant supports and supervises the cooperation of university-industry alliance.

The Government-Industry-University-Institute relationship has been widely studied especially in China because the government owns the power to control technology, economy and culture (Henry and Loet, 2000). "Industry Research Institute of Tsinghua University in Beijing" acted as a "bridge" to connect the university with rational development successfully incubated 17 projects into the phrase of industrialization.

Taking equity is an efficient mechanism for promoting the commercialization of academic research and increasing revenues for university intellectual property. Equity can be regarded as an agreement in which a university has an equity in a company meanwhile allows the company to use university intellectual property (Feldman, 2002).

After analyzing the functions, characteristics and objectives of these patterns, we find that during three sub-patterns the university and the enterprise are leading actors compared with the assistant actors as the government and the intermediary. Even though there are different forms of combination, they have the same forms of cooperation and development such as constructing research base, cooperation labs and so on.

2.5 Autogenic transformation for technology in a research university

Autogenic transformation for technology implies that a research university tries to explore its technology market by organizing funds, equipment, factories and staffs by itself. Several hot key words, such as *spin-offs*, *university science parks*, and *incubators* (Carayannis, et al, 1998; Mian 1997; McAdam et al., 2008; Rhonda, 2002), can be found in the booming literatures about this pattern.

A *spin-off* is an independent organization formed when group of employees around a core technology leave their parent entity (Carayannis et al., 1998). The prior employer could be a firm, a university or other organization. The spin-off represents one potential mechanism for technology transfer from research universities, as they will make increasing contributions to their region's economic growth (Mian, 1997).

University science parks provide a number of shared resources for new technology-based firms, university spin-offs and corporate spin-offs. Science parks, which are well-organized, planed and managed, aim to create a unique environment to provide the launch pad concerning technical infrastructure, logistic and administrative matters that startup company need where government, academia, and business can carry out high technology business through small firms (McAdam, 2008).

University incubators provide technology business incubators for universities, which have three characteristics: preferred focus on technology-based business, easy access to

technically advanced laboratories, equipment and resources and major objective for technology transfer or commercialization (Rhonda 2002).

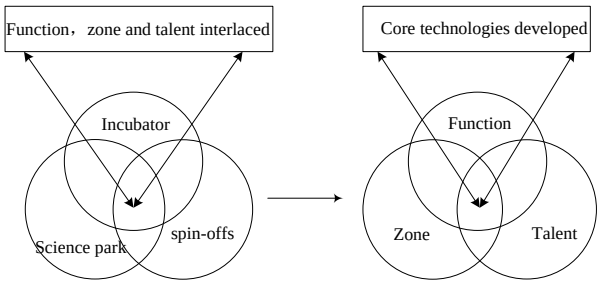

Figure 3. Function, zone and talent interlaced in the pattern of autogenic transformation

Figure 3 shows incubators, science parks and spin-offs overlap with each other while zone and talent interlaced at the interfaces. But core technology is the nature of the interlacing of function, zone and talent.

3. COMPRASIONS AMONG PATTERNS

In this part we evaluate the characteristics and identify the application of all patterns to show a comprehensive perspective in RUTT and then provide a wider view and deeper understanding on each pattern (see table 1).

Table1. Advantages, disadvantages and application of each pattern

Patterns	Advantages	Disadvantages	Applications
Pattern Ⅰ	Large scope and span; great radiation spectrum	General-purpose and untargeted	New technology knowledge found and diffused
Pattern Ⅱ	Remarkable depth for people communication and technology diffusion; easily be controlled	Narrow span; little revenues for a university; only staying in a state of information with no father technology development	Controlling tacit knowledge; cultivating professional talents; creating people network relationship; an efficient mechanism fostering talents
Pattern Ⅲ	Traditional with many mature policy; efficient ; rapid revenues for licensing; Complete law mechanism	Little scale; Lacking long and deep collaboration between universities and industries	spreading process of general technology; rapid revenue requirements of universities;
Pattern IV	university and industry work together with the same economic interest; pooling risk; enough supports from governments	With the requirement of a full-fledged legal system guaranteeing the cooperation	When a technology reaches the degree of pilots; the shortage of funds in the university
Pattern V	Synergetic effect; geographical proximity; high reward for a university	High capital operation risk;	Mainly Concentrated in some domain like biotechnology, medical and computer

Based on the characteristics of all patterns, the comparison and relationship among them are described in Fig 4.: 1)from pattern I to V, they are becoming increasingly close to the market and industry with decreased technology transfer span; 2) as a whole compared with the first three traditional patterns with little attention to further development of technology, pattern IV and V are more accepted and adopted by the university in recent years because they have higher funds and continue to strive to walk in the forefront of new technology.

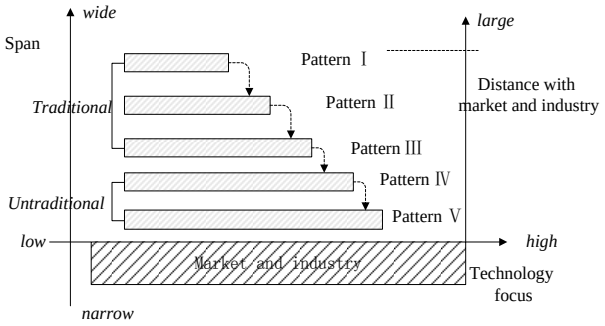

Fig.4 span and focus of five patterns and relationship between them

The five patterns have some internal connections in spite of different characteristics on the transfer scope, distance to the market and the industry and high-technology contents. The prior pattern is always the precursor of the next one which can cover the certain shortage of the prior one, and the rest can be done in the same manner. For example, paper publications of pattern I often bring further exchanges between scientists in universities and engineers in industry of pattern II; academic communications (pattern II) may promote the exchange of technical advice and technology licensing(pattern III); university professors who provide technical advice and consultant for enterprises(pattern III), could lead to a network with business, which creates on chance for technology interaction between the university and the industry(pattern IV). As the cooperation with the industry (pattern IV), the university will gradually possess the capacity to transform the technology into the economic benefits by itself (pattern V).

4. CONCLUSIONS

Through a comprehensive analysis of each pattern and comparisons among each pattern, this paper find that the first three patterns have some common characteristics like little technology development, an "indifferent" relationship and limited interaction between the transferor and the transferee; while the last two patterns have reflected close relationship and amicable links with the market.

ACKNOWLEDGMENT

This research was supported by National Natural Science Foundation of China (Nos: 71601066; 71501055), and the Humanities and Social Science Foundation of Ministry of Education in China (Nos. 16YJC630093).

REFERENCES

Bray, M. J., Lee, J. N. (2000) University revenues from technology transfer: Licensing fees vs. equity positions. *Journal of Business Venturing*, 15(5) :385-392.

Boyd, E.A., Bero, L.A. (2000) Assessing faculty financial relationships with industry. *JAMA: the journal of the American Medical Association*, 284(17) :2209-2214.

Carayannis, E. G., Rogers, E. M., Kurihara, K., Allbritton, M.M. (1998) High-technology spin-offs from government R&D laboratories and research universities. *Technovation*, 18(1) : 1-11.

Dr. M. Polanyi. (1958) Personal Knowledge: Towards a Post —CriticalPhilosophy [M] . *The University of Chicago Press*.

Ensign, P. C., Lin, C. D., Chreim, S., & Persaud, A. (2014) Proximity, knowledge transfer, and innovation in technology-based mergers and acquisitions. *International Journal of Technology Management*, 66(1), 1-31.

Everett M. R., Shiro T., Jing Y. (2001) Lessons learned about technology transfer. *Technovation*, 21:253-261.

Feldman, M., Feller, I., Bercovitz, J., Burton, R. (2002) Equity and the technology transfer strategies of American research university. *Management Science*, 48(1) :105-121.

Henry E., Loet L. (2000) The dynamics of innovation: from National Systems and "Mode2'' to a Triple Helix of university–industry–government relations. *Research policy*, 29:109-123.

Hong L., Yun Z.J. (2001) Technology transfer from higher education institutions to industry in China: nature and implications. *Technovation*, 21:175–188.

Kalar, B., & Antoncic, B. (2015) The entrepreneurial university, academic activities and technology and knowledge transfer in four European countries. *Technovation*, 36, 1-11.

Mowery, D. C., Nelson, R. R., Sampat, B. N., Ziedonis, A. A. (2001) The growth of patenting and licensing by US universities: an assessment of the effects of the Bayh–Dole act of 1980. *Research policy*, 30(1) :99-119.

Mian,S.A.,1997. Assessing and managing the university technology business incubation: An integrative framework. *Journal of Business Venturing*, 12:251–285.

McAdam, M., McAdam, R. (2008) High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation*, 28(5) :277-290.

Somsuk N. (2010) University-Industry Technology Transfer Programme's Success Analysis: Using the Analytic Hierarchy Process-Based Mode. *Proceedings of the 2010 IEEE IEEM*, 901-905.

Robert S. C. (1989) A comparison of Japanese and US high-technology transfer. *IEEE transactions on engineering management*, 36:17-24.

Rhonda G. P. (2002) Technology business incubators: how effective as technology transfer mechanisms? *Technology in Society*, 24:299-316.