The Strategic implications of Triple Helix model for Knowledge-based Innovation in China

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ABSTRACT

The strategic value of Triple Helix relations of university-government-industry (TH) in creating new knowledge infrastructure and developing the knowledge economy has been widely discussed within the existing innovation and knowledge economy literature. However current research and empirical evidence has been primarily focused on developed countries such as US, Japan and European countries. There has been little research undertaken on the implications of TH innovation model in developing countries, such as China, which has created economic legacy of maintaining 9% economic growth in the last three decades. The purpose of this paper is to evaluate the strategic implications of Triple Helix (TH) innovation model based on university-government-industry relations for developing knowledge-based innovation in China. Based on the critical literature review, document analysis and interviews with academics and professional personnel involved in the TH development in China, the paper evaluates and explains the evolution of the Science & Technology innovation policy in China with particular attention paid on the nature and roles of each institutional actor in building up the knowledge economy. In so doing, a theoretical framework of the knowledge production system in China is established to provide a strategic guidance on the current development of knowledge-based innovation in China as well as identify the key factors that have an effect on the inter-institutional relations and evolutions of different knowledge functions within the Triple Helix innovation networks. We argue that both the formation and operation of knowledge production system in China on the one hand reflects the three dimensions within TH model: normative control (government), wealth generation (industry) and Novelty production (university and public research institutions), on the other hand highlights dynamic institutional interactions and transformational processes in creating the knowledge economy. Further investigations through empirical case studies are needed in order to develop a deep understanding on how specific social, economic and political factors shape the transformational changes within and between university, government and industry in China.

Keywords: knowledge-based innovation, Triple Helix, university-government-industry interactions, Science & Technology policy in China
1. INTRODUCTION

This is a conceptual paper that investigates the strategic implications of Triple Helix model of knowledge-based innovation in China, which is now one of the fast growing economies in the world and aiming to become ‘an innovative oriented country’ by 2020. Drawing on the theory of Triple Helix model of knowledge-based innovation, which has been argued as one of the important models that depicts the key features of new knowledge production in creating wealth and growth, this paper provides an overview on the development of Science, Technology and Innovation policy in China and its strategic impact on the implementations of knowledge-based innovation in China. In so doing, particular attention is paid on the structures and characters of the Chinese innovation system and the knowledge functions operating within innovation networks. The Triple Helix innovation model is adopted in this paper as an analytical framework to capture the inter-relationships between different knowledge functions and the process of building up knowledge infrastructure in China.

As the world economy is increasingly driven by knowledge creation and diffusion, the capacity of applying as well as acquiring and disseminating knowledge becomes crucial for creating robust and a successful economy. The pressing challenges of knowledge-based economy call for on-going research into the new forms of innovation that enables the effective production and commercialization of new knowledge. Scholars from various disciplines reported different perspectives on the notion of knowledge-based innovation. These include the examinations on the meanings of knowledge economy (Thompson, 2004), transitions from Mode 1 to Mode 2 of new knowledge production (Gibbons M et al., 1994), the interactive nature of innovation in the knowledge economy (Cooke P & Morgan K, 1998; Cooke P., 2002), the transforming of institutions in regional and national innovation systems (Cooke, 2004), innovation based on various learning processes (Lundvall, 1992) across organizational boundaries, networks and clusters (Maillat, Crevoislier, & Lecoq, 1994; Malecki E.J., 2000; Maskell, 2001).

As innovation moves beyond a single organization and often across different organizational and institutional boundaries, the transforming process and relationships within and between institutions become more important. One way of investigating the process of knowledge-based innovation is based on the Triple Helix model of university-government-industry relations, which takes account of border crossing and the co-evolution between technological and institutional transformation.

The Triple Helix framework has been argued as a heuristic model that on one hand, enriches the analysis of different dimensions within the knowledge-based production system, on the other hand, produces specified meanings in different context depending on the roles of innovation actors (Etzkowitz, 2002; Etzkowitz H. and Leydesdorff L., 1997, 2001; Inzelt, 2004; Leydesdorff, 2000; Leydesdorff & Etzkowitz, 1998; Leydesdorff & Meyer, 2006). The promotion on new institutional configuration and overlapping system with each taking the role of the other is underpinned by various policy initiatives and government funded innovation projects which require collaborations between university, government and industry.

China, as one of the world largest developing countries, has become the major player in the global economy with its annual GDP growth on average of more than 8% since 1978. The China economy has expanded by 10.7% in 2006, marking the fastest growth economy in the world. China has been argued as a leading nation in science and R&D (Zhou & Leydesdorff, 2006). Moving towards a knowledge-based economy through the development of science and technology innovation has been regarded as the key strategic agenda for Chinese government. Despite various science and innovation policies initiated by the Chinese government to forge R&D collaborations between universities (public research institutions) and industries for technology transfer and commercialization, how institutional relationships are formed and developed to generate new knowledge has yet been fully understood properly. According to the Triple Helix model, the university-industry-government relations are emerging from different institutional starting points in various parts of the world, and perform different knowledge functions. However, to what extent the Triple Helix model, which was originally developed from the western countries based on the observations and data collected from a few successful knowledge regions in USA, Italy and Germany etc., can be adopted or adapted to the Chinese economic context calls for further critical investigation and evaluation.

The remaining of the paper is organized as follows: Section 2 examines the narratives and assumptions that underpin the Triple Helix innovation model. Section 3 discusses the current knowledge-based innovation system in China with particular focus on the different nature and roles of knowledge functions operating within the innovation networks. Finally the strategic challenges and policy implications of Triple Helix model for developing knowledge-based innovation in China and other developing countries are discussed and recommendations for further empirical research are suggested.

2. THE TRIPLE HELIX AS AN ANALYTICAL FRAMEWORK OF KNOWLEDGE-BASED INNOVATION
Knowledge-based innovation has been studied from different perspectives with various theoretical underpinnings. For instance, National Innovation System emphasis on the interactions and flows of knowledge and information among enterprises and technology institutions (Lundvall, 1988; Nelson, 2000) and considers firms as the key player of R&D and innovation. The emergence of localization and geographical concentration of R&D leads to the investigations on the role of region in shaping knowledge-based innovation (Asheim & Gertler, 2005; Cooke, 2000; Cooke P., 1998; Todtling & Sedlacek, 1997). In order to provide support for firms’ R&D and commercialization, the role of university in the knowledge-based economy has also been paid increase attention by scholars (Lazzeroni & Piccaluga, 2003; Vogel & Kaghan, 2001; Webster & Etzkowitz, 2000).

The Triple Helix (TH) model is created with an attempt to capture and explain the dynamics of innovation processes and complex networks across institutions for knowledge exploration and exploitation. The basic idea within the TH model lies in the recognition on the shift of innovation policy from the traditional liner approach towards a dynamic and network model which involves different innovation actors. According to the founder of the TH Model, a triple helix of overlapping spheres of university-industry-government is increasingly the core, rather than the periphery, of national, regional, and multinational innovation systems (Etzkowitz, 2003).

The emerge of Triple Helix model to the great extent challenges the traditional ways of approaching innovation which has been criticized as a linear process from scientific invention to technology application and production with less attention paid on the changing needs of market. It is argued that the new knowledge production system takes into considerations of the complex markets and emphasizes on research across disciplinary boundaries and incorporates various interests into the process of knowledge production. Knowledge that is generated through the new forms of innovation not only involves research institutions such as universities, but also industries and government agencies to form the new production of knowledge (Gibbons et al., 1994). The key features addressed within the TH model of innovation are described as below:

- Building effective collaborations between researchers, firms and government agency is seen as essential for the success of knowledge-based innovation
- Academia, firms and government share information and knowledge across institutional spheres to generate new innovation opportunities
- Institutional boundaries become blurred and innovation actors gradually take each other’s role during the process of interaction
New policies and innovation agendas emerge as a result of close interaction and knowledge sharing between academia, firms and government.

The significance of TH model lies in a number of prescriptive implications. First of all, the TH model emphasizes the importance of science-based business in creating knowledge economy, particularly in the regional settings. This does not only recognize of the economic value of existing science, but also encourage the development of applied science research for economic development. Secondly, the TH model incorporates the transformational changes of universities from historically teaching and research institutions towards knowledge infrastructure as the seed of social and economic wealth through the development of human capital and intellectual property. It is pointed out that channelling knowledge flows into new sources of technological innovation has become an academic task, changing the structure and function of the university (Etzkowitz and Leydesdorff, 2001). Thirdly, the TH model provides a practical framework for improving the understanding of the development of science-based innovation and technological change and anticipating the effect of such changes in bringing about new knowledge-based innovation policies. Finally, the research undertaken under the TH banner helps to identify the best practices of generating new knowledge and the causes and conditions for the success of knowledge-based innovation.

Without undermining the strategic value of TH model in providing an analytical framework for the study of knowledge infrastructure (Leydesdorff and Etzkowitz, 1997, 1998), the claims made by TH theorists are challenged by a number of theoretical and methodological issues. For instance, O’Malley (2002) et.al critically evaluates the TH model and the research undertaken under the TH banner. It is pointed out that most TH researchers use the TH as a descriptive term to cover any interactions between university, government and industry with the focus particularly on university-industry interactions and government playing a background role. Despite some in-depth analysis on the behavioural and organizational changes within the TH model, such as the observations on academic entrepreneurial culture and the professors of practice (Etzkowitz H. and Webster A., 2000; Meyer, 2003). It is argued that there is limited study on TH as an introductory background and then independently develop their own models and methods of analysis (Frenken, 2000; O'Malley, McOuat, & Doolittle, 2002).

In addition to the concerns on the limited critical approach to TH model, the general comments made by TH theories in new knowledge creation are also questioned. Eun et.al (2006) point out that the core idea of the Triple Helix group is that the “nature of knowledge” in newly emerging industries (typically in biotechnology) is different from that in traditional industries, and this difference makes it necessary to form a new institutional setup, i.e. the TH
model comprised of university, industry, and government. It is argued that the TH model emphasis the importance to the newly emerging industries and it has minimum relevance for the situation in most of the developing countries that tend to inherit mature industries from the advanced countries to produce standardized products (Eun et.al 2006). What’s more, questions are also raised in relation to the context in which the model is applied and the role it can play in developing the regional knowledge economy. In particular economics geographers argue that the conditions for creating TH based knowledge infrastructure may vary (Benneworth, 2003; Brown & Duguid, 2002; Jensen & Tragrdh, 2004). Whilst successful regions such as Silicon Valley has its unique culture of socialization and knowledge sharing between business communities and research institutions, less-developed regions might not have the favourable conditions that help to cultivate interactions between academics, industries and government agencies, particularly issues such as organizational structure within TH networks and the coordination mechanisms for supporting effective university-industry interactions have been paid less attention by TH researchers (Kleyn, Kitney, & Atun, 2007; Lu, 2006). To what extent the TH model can be applied in different geographical and economic context remains to be further investigated.

What has been reflected from the aforesaid literature is essentially the paradox between ‘integration’ of resources for innovation in order to create critical mass and ‘differentiation’ of different institutional agendas between Normative Control (government), Wealth Generation (Industry) and Novelty Production (University) (Ledesdorff and Meyers, 2006). Therefore the TH model should be treated as a heuristic model which denotes a process of evolution as well as the configuration of new institutional arrangement. It is argued that the TH model can be used as an analytic framework that combines knowledge production functions with local institutions into the knowledge infrastructure, which is essentially a Triple Helix network of university-government-industry relations (Leydesdorff, 2006). The TH model in this paper is hence not treated as a normative model that can be generalized in a different context. Rather it is adopted as an analytical framework which would help to inform the analysis of institutional relations and changes for creating knowledge-based innovation in China.

3. THE KNOWLEDGE-BASED INNOVATION SYSTEMS IN CHINA

The traditional Science & Technology Innovation policy has been geared towards the manufacture of capital equipment through the creation of self-reliance plants in regions. As a result, a solid foundation of engineering experiences and a wide range of technical capabilities have been established. Developing science and technology and building up national knowledge innovation system for economic development was emphasized during the
National Technology and Innovation Conference in 1999. The Chinese government has committed itself to strengthen the nation through science, technology, and education and the more recent notion of empowering the nation through talent. In January 2006, China unveiled what it called its 15-year ‘Medium-to-Long-Term Plan for the Development of Science and Technology.’ The plan calls on China to become an ‘innovation-oriented society’ by the year 2020, and a global leader in science and technology by mid-century. The plan calls for steep increases in research and development (R&D) expenditures over the next 15 years, from 1.23% of gross domestic product in 2004 to 2.5% of a significantly larger GDP by 2020. The plan also calls for China to become one of the top five countries in the world in the number of invention patents owned to Chinese citizens, and for Chinese-authored scientific papers to become among the world's most cited (Cao, Suttermier, & Simon, 2006).

The innovation policy in China has been shifted from the ‘technological self-reliance’ towards ‘indigenous innovation’ (zizhu chuangxin) where the targeting the national strategic needs and world frontiers of science and striving to accomplish world-class science and technological innovation have become the core of the national innovation strategy and creating knowledge economy. It is also recognized that implementing new Science & Technology innovation strategy requires close interactions between various research institutions, universities, enterprises and government agencies. The unique Chinese social, economic and political systems lead to the specific characters and operational mechanisms of knowledge-based innovation system in China. Figure 1 presents the organizational structure of TH in China and the key factors that shape the implementation of TH innovation networks. The key features of TH innovation system in China can be summarized in fourfold.

Figure 1: the TH model in China
First of all, unlike the original TH model where university is regarded as the key source of knowledge, this function is split into two elements in the China: universities and state research institutions. Though both institutions have the responsibilities of undertaking research, the universities in China have been traditionally regarded as ‘teaching and graduate training institution’ rather than an economic player. The role of higher education (universities) was only recognized and emphasized in the 1990s along with the rise of knowledge economy and promotions of TH theories in creating high-tech industrialization in developed countries such as US, Japan and Western Europe.

Secondly, the state research institutions not only play an important role in conducting national research project in key technology areas through the National Key Laboratories and providing policy guidance to the national and regional government, but also initiating and implementing new knowledge-based innovation programmes in various corporate R&D centres and High-and New Tech Developmental zones for technology communalization. One of the typical examples of the State Research Institution is the China Academy of Sciences (CAS), founded in 1949, is the nation’s highest academic institution in natural sciences and high technology. The CAS has 115 direct controlled institutes, 10 universities and support organizations and 12 management organizations which are distributed across China.

In addition, whilst the TH model emphasizes interactions between university-government-industry, the academic research within TH innovation model in the China context has been dominated by the interactions between industry (Chan), university (Xue) and research institutions (Yan), which is under the policy umbrella of government. The role of government in promoting knowledge-based innovation has been rarely mentioned and analyzed in existing literature although Li et.al (2006) point out that the government should promote, coordinate, monitor and evaluate the collaborations between university and industry. Despite of prevalent research and government policy on university-industry collaboration, there has been lack of critical evaluation on the process and outcome of university-industry collaborations in China (Li & Tan, 2006).

It should also be pointed out that there are two types of the innovation emerging from the strategic collaborations between government, university, research institutions and industry. One is knowledge innovation which is focused on the science-based innovation and technology transfer from university/research institutions to industry. The other type of innovation is technological innovation which is focused on the development of innovation capacities of enterprises through collaborations between university, industry and research institutions.
Finally, the dynamic regional economic characters and complexities of horizontal and vertical organizational structures within higher education and research institutions in China create unique challenges in understanding the forms of collaborations within TH networks and the development of knowledge-based innovation at both regional and national dimensions.

Whilst the achievement through successful university / research institution-industry interactions is significant in terms of technology transfer and commercialization, the challenge and issues surrounding the transformational changes and innovation process within and between university, research institutions, industry and government have become the central topic for TH researchers.

5. THE ORGANIZING FORMS OF TH IN CHINA AND THE PRESSING CHALLENGES

The TH knowledge-based innovation model in the China context can be seen as a configuration of ‘three-source, four-system’ innovation networks. The three sources include innovation sources (including information, science & technology research, human capital, funding, market research, management expertise etc.) from university, research institutions and industry. Four systems refer to different organizational structure, operation and mechanisms of coordination within government, state research institution, university and industry systems.

The organizing forms within TH innovation networks are identified as below:

(1) Technology transfer and commercialization through university-run enterprises. (e.g. Tsinghua Ziguang http://www.thunis.com/, Tinghua Tongfang http://www.thtf.com.cn/, Beida Fangzheng http://www.founder.com/ etc.). Although the university enterprises actually dates back to the late 1950s when the university enterprises served as sites for student experiential learning and generators of employment as well as supplemental funding for universities (Ma, 2004).

(2) Establishing university science park as a platform for academic-enterprise collaboration (e.g. Tsinghua Science Park http://www.thsp.com.cn/ etc. The university science park also provides facilities for incubators and helps graduates set up enterprises.

(3) Project-based Collaboration between university / research institutions and industry. One of the examples of such forms of collaboration is called ‘replanting sapling with original soil’, which means that university professors may bring this research project to firms and work with industrial R&D professionals on technology commercialization. By replanting sapling with the original oil, the knowledge generators can interact closely with engineers and business
managers on new product development. In some cases where the university professors are more interested in pursuing academic research than commercialization, they may support their PhD students participating in the commercial aspect of research and product development without leaving the academic position within the university.

(4) Development of University spin-off firms, which encourage individual researchers and professors establish their own high-tech firms with the funding support from the university and industries.

(5) Establishing ‘knowledge bridge’ through founding TH innovation Journals and website for university and enterprises sharing knowledge and information in high technology and new development of research. (e.g. http://www.iura.gov.cn/ in Shanxi Province, http://cxy.gdstc.gov.cn/ in Guangdong Province etc.). Firms can also publishing specific R&D problems on website and invite academic researchers for collaboration.

The organizing form of TH innovation in China is illustrated in Figure 2. It should be noted that the organization of TH innovation networks is embedded within both national and regional innovation networks. The main Science & Technology innovation policy is made by the central government in which the Ministry of Education and China Academy of Sciences play an important role in policy making process. The reform of China Higher Education including the creation of 211 universities and 985 universities within regions and the distributions of CAS and other National research labs within regions have also blurred boundaries of implementing TH innovation through university-government-industry. This means that the interactions between university, research institutions, government and industry are not necessarily from the same region. For instance, firms in one region may collaborate with the key research universities located in another region for R&D and technology commercialization because of lacking research expertise from local universities. The collaboration between central and local government is also an important form of supporting the development of TH innovation. For instance, the cooperation agreement between the Ministry of Education and Guangdong Province in promoting TH knowledge-based innovation has been signed in early 2007 and special fund has also been allocated to facilitate university-industry R&D collaboration.
Figure 2: The Organizing Form of TH in China

Although the importance of TH relations in creating knowledge economy has been addressed by the Chinese government, the implementation process is facing pressing challenges due to the complexity and dynamics of different social, organizational and managerial systems within the TH networks.

The Role of Government and the Strategic Purpose of TH in China

Whilst the strategic purpose of TH model in western countries is pretty clear, that is to generate new knowledge through the effective collaborations and interactions between university, government and industry. In this respect, government is seen as the ‘strategic partner’ within the collaborative innovation networks. The strategic purpose for developing various forms of TH innovation has not been clarified and sufficiently investigated. In fact, the implementation of Science & Technology innovation in China is almost decided by the government, which act as a leader over other partners rather than a ‘collaborative partner’ within the TH innovation networks. Consequently, the Chinese version of TH has been converted from ‘university-government-industry’ into ‘industry-university-research institution’ under the leadership of government at the top. Although the government has been trying to establish partnership relations with industry, e.g the MOST (Ministry of Science & Technology) attempted to form partnership with enterprises. The collaboration hasn’t been seen successful due to different systems and cultures between government and industry.
Despite the Chinese government calls on creating knowledge-based innovation system, evidence shows that exiting Science & Technology innovation policies have been geared towards reform in higher education and the university and state research institution as the ‘subject’ of knowledge economy have been overemphasized. Hence TH as a strategic tool for generating knowledge-based innovation through effective collaborations between university-government-industry has been overshadowed.

The Impact of Changing Government Funding on Universities

The changing government funding structure creates further challenges for both key research universities and regional universities in developing research excellence as well as undertaking higher education teaching tasks. The percentage of government fund within the overall budget for national research universities has decreased from 84.80% in 1994 to 57.65% in 2001, and from 79.08% to 52.95 for regional universities (Liu & Hu, 2005). The different imperatives associated with alternative forms of funding are serving to disorganize traditional research structures within many Chinese universities (Turpin & Garrett-Janes, 1997). The differentiation between national key universities (such as 211 and 985 projects) and normal regional universities also has certain impact on the allocation of government funding and the innovation capacity building of universities. As regional universities are disadvantaged in terms of receiving government fund for research, firms are reluctant to collaborate with the regional universities which have less research outcome to offer comparing with 211 universities.

The Innovation Capacities of China Firms

The operation of TH innovation not only depends on the innovation capacities of universities but also relies on the absorptive capabilities of firms and the structures of intermediate organizations, such as university-run enterprises (Eun, Lee, & Wu, 2006). According to the survey conducted by the SCIENCE & TECHNOLOGY department within Ministry of Education, the demand for R&D collaboration with universities and research institutions has not yet been paid enough attention by Chinese firms, particularly within large state-own firms (Yang, 1995). Building up innovation capacities has been seen as the core strategy of creating competitive advantages for Chinese firms (Li-Hua, 2007). The 2003 research on the impact of TH innovation on firm competitiveness in Zhejiang Province shows that the interactions between university-industry has significant impact on quality and the market acceptance of firms’ products (Zhou & LU, 2005). However the complex process of engaging with university and the difficulties of managing risks involved in R&D collaborations with academics have resulted in low trust relations between university and industry and the failure of innovation collaboration. Xu (2001) points out that the credibility of collaboration partners,
the success of technical design, the effective management and the reward system are essential for the success of firms seeking TH mode of innovation. In addition, access to funding has also been raised as a critical issue facing university-run enterprises (Segal, 2003).

**The Coordination Mechanism within TH**

Another key issue facing TH innovation actors is the lack of appropriate operational, coordination and evaluation and reward mechanisms developed within the TH innovation process that allows effective information and knowledge sharing between academics and industry and provide incentives for academics and professionals developing successful projects. According to Professor Etzkowitz, the founder of TH model, the advantages of TH model is the complementary and reconfiguration of internal resources within the sphere of each institutions through dynamic interactions so that innovative ideas and initiatives can be created in the process of interactions. In this respect, the role of government is regarded as a facilitator rather than a controller in shaping the knowledge-based innovation agenda. Zhou (2007) reviewed the history of science and technology innovation and industrial development in the North East of China and indicates the TH innovation in China is a government-pulled innovation system in which government has the overall control in initiating and implementing science and technology innovation programmes through the administrative structure of the government organization, university and research institutions (Zhou, 2007). This has to some extent constrained the innovation capacities of research institutions in terms of separating the market demand for applied research and the scientific strengthen of research institutions. As a result, the advantages of science cannot be fully exploited and explored for productivity and economic growth.

**The impact of TH on regional knowledge economy**

The development of TH innovation in China has to the great extent been shaped by both national and regional policy and innovation environment. In particular, the critical policies determining the national R&D framework, investment priorities for institutions of higher education, and allowance for rewarding commercialization are largely decided by the central government (WU, 2007). The TH innovation system is the process of reconfiguration existing resources between three different systems. i.e. education system, research system and industry system (Xu, 2001). Therefore the analysis of TH innovation model cannot be merely regarded as an issue for economic development, rather analysis need to be focused on how the resources from different systems complement to each other. However the challenge facing regional government is how to take the advantages of TH innovation and promote university-industry collaboration within the region under the situation where the Science & Technology
innovation policy and funding structure has been emphasized on selected research universities across the country. The main challenges identified in developing TH innovation in China highlight the dynamic and complex innovation systems in China during the transition from planned economy to the market economy and moving towards one of the top innovative nations. The unique social, economic, and political environment in China means that the issues rising from the operations of TH in China cannot be simply understood and analyzed within a single research domain and theoretical framework. Current research on TH development in China has either focused on the reform in higher education system, or the government policies in establishing science parks or special economic zones as well as the innovation capacities of Chinese firms. There is little in-depth and integrated approach of evaluating and analyzing the impact of TH innovation model on the overall innovation capacity building of the knowledge infrastructures in China. This not only calls for the scientific evaluation and quantitative measurement on the economic output of university-government-industry interactions, but also points to the need of initiating and implementing comprehensive case studies on the process of managing TH networks in different regions that are shaped by different local conditions.

7. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we have reviewed and analyzed the Triple Helix university-government-industry relations as the strategic tool for creating knowledge-based innovation in China. The economic transition within China and the entry to the WTO has created pressing challenges for China to become the world top innovative nation. The adoption and promotion of knowledge-based innovation surrounding the effective interactions between TH university-government-industry is clearly a strategic choice for the Chinese government to reinforce the development of technology transfer and commercialization within university and research institutions as well as strengthen the higher education reform under the changing government funding structure. However, the key questions raised is whether the TH model which was emerged from the US and widely diffused and researched in Europe with different political and social values embedded in the regional and national innovation systems, is appropriate and effective in the Chinese context, if so, in what way the TH can be adapted.

In addition, we also argue that the forms of collaborations and appropriate coordination mechanisms within TH model needs to be carefully designed and implemented, particularly in less developed regions where there is lack of conditions and economic environment for developing the TH innovation model which aims for developing high-tech knowledge-based innovations. In addition, the appropriate support for developing innovation capacities and entrepreneurial cultures within the non-211 universities also needs to be considered by policy-
makers as part of the regional economic strategy. The TH as a heuristic model for knowledge-based innovation, it has certainly provided us with strategic value in terms of identifying the transformational changes within and between the institutional spheres of university, government and industry. The ever lasting debates on the effectiveness of TH model within the academic world have created a useful platform on which further investigations in the wider international experiences may be conducted and explored. Only when the appropriate premises and conditions underpinning the university-government-industry relations are identified, the TH model in creating the knowledge-based innovation can become more effective.

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