Comparing approaches to systems of innovation: Confronting to the Chinese telecommunication sector

Shu Gao, Harro van Lente

Innovation Study Group, IMW department, University Utrecht, The Netherlands

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Abstract

This paper identifies and compares three approaches to study systems of innovation, namely, the national innovation system (NIS), the regional innovation system (RIS), and the sectoal innovation system/technological innovation system (TIS). Based on the descriptions of the common elements, namely actors, interactions and institutions, the differences and features of approaches are summarized. Furthermore, this paper also discusses the strengths of the three approaches while confronting them to the Chinese telecommunication sector. These three approaches map systems of innovation differently, provide a complimentary view, rather than substitutive ones, for constructing a complete configuration of an innovation system. Therefore, the choice of a methodology to analyze of the innovation systems mainly depends on the research purposes and research scopes.

Keywords: approaches of innovation systems, NIS, RIS, SIS, Chinese telecommunication

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1 Introduction

National economic growth is becoming even more dependent on knowledge creation, use of knowledge and knowledge transfer. Thus, 21st centry can be considered as a knowledge-based economy era. It has been estimated that the major OECD countries are knowledge-based economy countries (Maskell, Eskelinen et al. 1996). In contrast economy growth in most developing countries mainly depends on the manufacturing and the exports of textiles. For instance, as a developing country with fastest GDP growth, most Chinese enterprises have invested in importing technology more than developing their own R&D capabilities. In 2005, as a percentage of GDP, China's R&D expenditure was just 1.3%[1], which is far less than the developed countries'. A national innovation capacity significantly influences the national economic growth and development in the long-term. Since the term of innovation system emerged, it has seen a growing research interest for understanding the factors that determine the economic development and technology changes. Therefore, the study of innovation system at a national level is widely adopted by policy markers, because it is a conceptual tool to analyze the current economy situation and predict future economic growth.

In recent years, the various approaches to systems of innovation have been proposed to map and explain interactions between firms, education organizations, and governments that influence the innovations. However, there is little research about the comparison of these approaches as a central theme. The aim of this paper is to compare and confront approaches, and provide a better understanding for the policy maker as using them.

Three approaches applied to study systems of innovation are identified and compared, namely the national innovation system (NIS), regional innovation system (RIS) and sectoral innovation system (SIS) / technological innovation system (TIS). Section 2 examines these three approaches proposed by leading researchers. Our research offers definitions followed by a discussion of common elements in the innovation system, namely actors, interactions and institutions. In section 3, we describe briefly the current situation of the Chinese telecommunication sector. And then the applications of each approach individually to reveal their strengths of analysis are discussed in section 4. Finally, we conclude that it is difficult to identify the ideal or optimal approach to innovation system due to their different analysis focuses and research scopes. They provide a complimentary view, rather than substitutive ones, for constructing a complete configuration of an innovation system. Therefore, the selection of research methodology might mainly depend on the research scopes and purposes.

2 Conceptual review of approaches to systems of innovation

2.1 Introduction

Innovation systems have been defined at different levels for different purposes of analysis. The core focuses of innovation system research are the differences in national or sectoral institutional set-up matter and learning process (Edquist and Hommen 1999). Institutional development and learning process can not be understood outside specific historical and

[1] From http://www.bbcer.com/special/001001/6440/ 10-04-2008

country or sector context, thus it normally studied from historical and evolutionary perspectives. Over the last decades, combing the institutional theory with evolutionary theory, it leads to different approaches of innovation system.

We have identified three approaches of innovation systems. They are

1. the national approach, as suggested by Freeman, Lundvall, and Nelson
2. the regional approaches, as used by Cooke et al. and Doloreux;
3. the sector approach/technological approaches proposed by Carlsson and Stankiewicz and Breschi and Malerba;

The delineations about these three approaches to systems of innovation are different from different perspectives. Therefore, there is no right or wrong way to draw system boundaries (Markard and Truffer 2008),and defined them in the social and economic context. Most delineations about the national and regional innovation system largely determine by organizations and institutions inherently characterized by a certain territorial sphere of influence and interactions. In contrast, sectoral innovation system may be determined in terms of technology flow in the industries' structure that usually cross geographic boundaries. However, according to Carlsson and Stankiewicz (1991), actors, interactions and institutions are three basic elements in all the innovation systems. As a result, in this paper, we use these three basic elements to delineate the approaches to systems of innovation.

2.2 National innovation system

The concept of National innovation system (NIS) has been gained much attention as a core conceptual framework for analyzing technological change at national level, since Freeman, Lundvall and Nelson proposed in 90s. The definitions of NIS can be classified into broad and narrow definitions. The broad definition encompasses all interrelated institutional actors that create, diffuse, and exploit innovations, for instance, Lundvall defines NIS as 'a system of innovation ……constituted by elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge' (Lundvall 1992)(P.13). The narrow definition can be quoted from Nelson and Roenberg, which is 'a set of institutions whose interactions determine the innovation performance' (Nelson and Rosenberg 1993), such as R&D department, technological institutions, and universities. Moreover, Freeman also gives a definition from a narrow sense, which regards it as a 'network of institutions in the public and private sectors whose activities and interactions imitate, import, modify and diffuse new technologies' (Freeman 1987) (P.1). In short, national innovation system approach involves socio-institutional adaption, supplier-customer interactive learning, and firm competence and routines (MH.McKelvery 1991), all of which influence the diffusion of the innovation in the national domain.

As stated, the core focus of innovation system study are institutional set-up and learning process, which are characterized by cultural, social and linguistic features in a national domain. Freeman (1995), in his review study on the national innovation system, suggests that major differences exist among the developed countries during 1970s and 1980s. These differences are mainly in how NIS is organized and sustained the development,

introduction, improvement and diffusion of technological innovation within the national economies. In other words, nations differ not only in how many percentage of R&D takes in GDP but also in the methods by which the innovations are adopted and diffused in the market. For instance, in 1970s, USSR got 1.5% higher R&D expenditure ratio than Japan; however, Japan had a strong user-producer and subcontractor network linkage, comparing with USSR's weak or non-existent linkages between marketing, production and procurement (Freeman 1995).

2.2.1 Main actor

Basing on the definitions from the broad and narrow sense, the actors of the NIS could be from both private and public sectors. Their behaviors and interplays, to some extend, influence the innovation process and economy growth at the national level. However, due to the plenty amount of individual actors involves, different researchers have identified difference groups of actors according to their roles in the NIS. For instance, Capron et al.(2000) addresses that four groups of actors, that are, the administrative organizations, the private research sector, the high education institutions, and the bridging institutions that act as intermediaries among the other actors. Nelson states that R&D system, government and universities are main actors in the national innovation system. He stresses that government as a guiding institution and universities as the purveyors of basic scientific knowledge exist in the innovation system. In this paper, we identify three groups of actors, which are industry, education and research organizations and central government.

2.2.2 Institutions

Institutions in innovation system are defined as a set of "common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups" (Edquist and B.Johnson. 1997) (P42). They consist of both formal rules and informal exchanges (Edquist 1997). Edquist summarizes three basic functions of institutions, which are: reduce uncertainty by providing information, manage conflicts and cooperation, and provide incentives. OECD (1999) suggests that an NIS requires institutions with six different functions: technology and innovation policy formulation, performing R&D, financing R&D, promotion of human resource development, technology diffusion, and promotion of technological entrepreneurship.

As a policy maker, central government plays an important role in establishing, maintaining and adjusting institutions in the NIS. Two main roles can be addressed here in brief, on one hand, in order to protect the development of domestic industries and improve the competitive advantages at the global level, central government can take advantage of policies as the strategies to prevent the foreign enterprises from entering the home market. On the other hand, government could encourage the enterprises to increase their own innovation capacities by finance investments, which also can enhance the national innovation capacity as a whole in the international competitive environment.

Since China's reform and opening up to outside world, China's economy has been moving from planed economy to market economy. However, the speed of its institutions renews slowly and lags behind the economy growth. Currently, the government in China

only centrally develops a series of S&T plans, and then uses these plans as a basis to allocate resources and assign R&D work to relevant institutions. These plans are proposed by State Science and Technology Commission, State planning Commission, and State Economic and Trade Commission (Chang and Shih 2004), which are the main organizations to make technology policies and develop R&D activities in China. Actually, this situation gives the government most power to decide the development direction within a particular period for a whole country. On the other hand, these relevant research institutes are financed by government, thus they do not suffer the full losses resulting from failure in innovation activities by nor do they benefit fully from success. These R&D works are like tasks for the research institutes rather than an ambition for the enterprises in the competitive environment. Therefore, it is hard to stimulate all the passion of institutes in improving the innovation capacity.

2.2.3 Interactions

As one of main elements in innovation systems, interaction among the actors can be considered as a bridge of integration for a whole system. OECD(1997) states that four main interactions within NISs, namely joint industry activities, public/private interactions, technology diffusion, and personnel mobility. Chang and Shih (2004) also defined four interactions, which are R&D collaboration, informal interactions, technology diffusion and personal mobility in a nation domain.

Chinese reforms drastically changed the nature of linkage activities in China's innovation systems, affecting the distribution of technology and R&D activities (Liu and White 2001). The government's central position in Chinese innovation system has changed, in contrast, the enterprises are investing more funding to improve their innovation capacities. This situation changes the interactions among the main actors as well. According to the main actors defined in this paper, the interactions among the government, industry and education and research organizations are classified into R&D collaboration, joint industry activities, technology diffusion and personal mobility, these four interactions.

2.3 Regional innovation system

Regional innovation system emerged at the beginning of the 1990s, focusing on analyzing regional economic and economic geography. It has already gained much attention from policy makers and researchers. Ohmae (1990)states that region-state has become a focal point of economic activities replacing the nation-state in the globalize economy. He believes that regions are more dynamic and reflexive than states in R&D and economic activities. Breschi and Malerba (1997) argue that the regional innovation activities can stimulate industrial cluster for the whole state, and it can improve the balance of state economic development. Therefore, studying at regional level is growing in importance as a mode for innovation system research.

2.3.1 Main actor

The definitions of regional innovation system reduce the scope of innovation study into a region or local area within a nation. Thus, a RIS can be defined as 'a complex of innovation actors and institutions in a region that are directly related with the generation, diffusion, and appropriation of technological innovation and an interrelationship between

these innovation actors' (S.Chung 2002)(P487). In other words, its research focuses on revealing the skills on the local supply in management and technology aspect, the ability of accumulating tacit knowledge, and the capacity of 'knowledge spillover' in a limited geographical area (Chang and Chen 2004). By studying RIS, the nations can prevent the problem of unfair geographical concentration of technological and economic capabilities, and develop the national economy as a whole(S.Chung 2002).

Like a NIS, a RIS is composed of three main innovation actor groups: universities, industrial enterprises, and public research organization. In addition, regional government replaces the central government to effectively direct and coordinate innovation activities in each region. But the actually actors of innovation activities are universities, private enterprises, and public research organizations. These actors make a significant contribution to enhance regional and national technological competitiveness.

2.3.2 Institutions

Within a region, a set of networks among the firms, universities and public organization can be formed, and the formulation of these networks depends on trust and the common interests. A set of institutions both public and private, producing pervasive and systemic effects encourage firms to adopt common norms, expectations, values, attitudes and practices(Doloreux 2004) .Thus, institutionalized learning characterized by embeddedness emerges within a specific region. Cooke et al.(1997) stress this institutional learning is one of three key institutional forms. He also states that in regional innovation system financial capacity and productive culture need to be taken into account. Considering on the characteristics of these three institutional forms, it suggests that no hard institutions, such as laws and policies published by the central government, force the enterprises to develop the innovations and technology changes. On the contrary, the cooperation emerging in the firms cluster and organizations cluster is voluntary in the social and economic context. Therefore, the institutions of RIS are characterized by micro-constitutional regulation conditioned by trust, reliability, exchange and cooperative interaction (Cooke et al. 1997). In summary, regional institutions stimulate technical innovation limited in a specific region, and provide the normative structure in a competitive environment to integrate the local firms' innovation behaviors and enhance the governance of the communications between firms and other organizations.

2.3.3 Interactions

It is evidenced that RIS involves the interaction and functional relationships among firms, universities and public research organizations. Since innovation is a social process, the result of interaction is considered between economic actors and social actors. There are internal and external interactions for firms within a regional innovation system. Internal interactions focus on tacit knowledge exchanges and technology cooperation between the firms, basing on frequent, close and face-to-face learning that shares a common regional culture. The external interactions for the firms mean the cooperation existing between the firms and the research organizations. The social nature of learning process implies that these interactions no mater inter-firms or external firms work best, when the actors involved are close enough to one another to allow for frequent knowledge exchange(Asheim 2002). Actually, knowledge management department are set up in big

international companies recently. And the cooperation between the firms and the universities or the other research organizations is increasing.

However, a region's boundary is a controversial issue. Until now, there is no clear definition of regional demarcation in the regional innovation system. For instance, Cooke et al. (1997) propose 'productive culture' as a descriptive standard of regional demarcation. Consequently, the size and boundaries of RIS research are vague.

2.4 Sectoral innovation system/Technological innovation system

As stated by Chung (2002), a RIS is a good tool to formulate sectoal innovation system. The question is what sectoral innovation system is and what the differences between NIS or RIS and SIS/TIS are. Unlike NSI, in sectoral innovation system (SIS) analysis, it stresses the dynamic of technology development and the technology flows between firms and institutions place amongst them in a specific sector (Chang and Cheng, 2004). In other words, the SIS/TIS approach provides an analytical framework to identify the performance of technology change on the level of the industrial sector.

2.4.1 Main actor

Most definitions of SIS / TIS are in terms of technology flows and technology change. Breschi and Malerba (1997) define sectoral innovation system as 'the specific clusters of the firms, technologies, and industries involved in the generation and diffusion of new technologies and in the knowledge flows that take place amongst them'(P131). And other definitions involve the term of knowledge base and interactive learning process. For instance, Carlsson and Stankiewicz (1991) define SIS as networks of agents interacting in a specific technology area for purpose of technology flows, which are supported by institutional infrastructure creating the knowledge and information. These agents within SIS/TIS include both individuals and organizations. The individuals indicate consumers, entrepreneurs and scientists, while the organizations may be enterprises and non-firm organizations, such as universities, government, technical associations. In theoretical, SIS/TIS involves a large number of actors, and it can be classified into three groups, which are firms, non-firm organizations and individuals. Actors are characterized by a specific learning process, competence, belief, organizational structure and behavior (Breschi and Malerba, 1997).

2.4.2 Institution

Institutional infrastructure is one of the main elements of SIS/TIS, which directly or indirectly support, stimulate, and regulate the innovation process and technology diffusion (Chang and Chen, 2004). In SIS, government, as a non-firm organization, may influence a specific technology flow from creation to diffusion through the formulation of technical standards. The technical standards can remove the barriers of interactions among the actors and enhance learning capacities and the technological negotiability.

2.4.3 Interaction

A successful innovation system requires the interaction among the actors with different competences. Moreover, the nature of innovation and technology change contain scores of uncertainties and complexities, networks formed by the actors provide other

alternatives for firms and other research organizations in governing innovations (Carlsson and Stankiewicz 1991). Thus, the interactions emerged among the industries are important element in SIS analysis. To some extent, innovation in one industry can provide inputs into production processes in other industries in a sectoral innovation system. And the actors interact through the processes of communication, exchange, co-operation, competition and command, and these interactions are shaped by institutions (Malerba 2002).

SIS studies involve several industries located in small area where they cooperate during the innovation process, but compete with other at global level. Therefore, the SIS approach shows that different industry may have different competitive, interactive, and organizational boundaries extending beyond national borders (Chang and Chen 2004). In short, SIS/TIS approach reveals the technology flows in an industry cross the nations.

2.5 Comparison of three approaches

Summarizing these three approaches to the systems of innovation introduced above, table 1 demonstrates and reveals the differences and features of these approaches basing on three basic elements.

	NIS	**RIS**	**SIS**
Main actors	ı Industry ı government ı Education and Research organizations	ı Universities ı Industrial enterprises ı public research organization	ı Firms ı Non-firm organizations ı individuals
Institution	ı National policies ı Laws ı National finance supports	ı Informal Institutions depending of trust and reliability among the actors	ı Standards ı regulations
Main Interaction	ı joint industry activities ı R&D collaboration ı technology diffusion ı personnel mobility	ı Inter-firms interactions ı External interactions for firms with research organizations ı R&D collaboration	ı Inter-industry Interactions ı Interactions among firms and non-firm organizations

Table 1: three approaches' summary

To illustrate the research relationships among three approaches, figure 1 gives the clear research boundaries, basing on the relationship of SIS, TSIS and NIS proposed by Hekkert et al (2007).

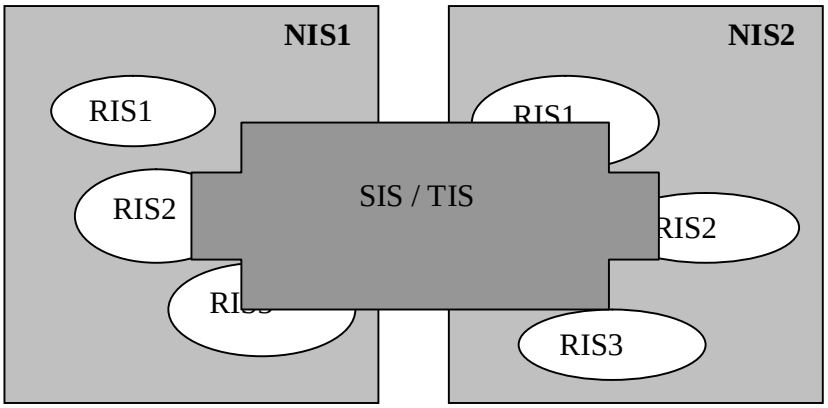

Figure1: boundary relationship between national, regional and sectoral innovation system / technological innovation system

3 Description of the Current Chinese Telecom Situation

Rapid technological development, innovation and technology diffusion have turned telecommunications into a major economic growth generator globally(Lindmark, Andersson et al. 2006), so in China since the reform. Reviewing the development history of China's telecommunication industry, the term of innovation gained more attentions in last decade. Innovation in Chinese telecommunication industry can be identified two types, one is technical innovation, and the other is service innovation. Both types of innovation stimulate the economic growth at national level. According to statistics, in 2005, innovations in telecommunication industry has contributed up to 16.6% of GDP growth rate(Ma 2007).

At the end of 2005, statistics show that the subscriptions using fixed phone have reached to 350 million, and the subscriptions using mobile phone have increased up to 400 million, moreover, the subscriptions connecting with internet have risen to 100 million (Leng 2006). These numbers not only suggest that Chinese telecommunication industry has developed rapidly recently, but also imply that big potential still exists in the huge Chinese market. Since China joined the WTO, the attitude of the Chinese government to indigenous telecommunication industry is to prevent from foreign companies entering into the Chinese market. However, this situation can not last long time. For long-term development and economic growth, on one hand, Chinese government is required to continue supporting R&D activities in telecommunication industry by finance investment and policies guidance; on the other hand, improving the innovation capacities of the indigenous telecommunication enterprises is a considerable issue for both Chinese government and the enterprises.

Nowadays, China is struggling with a new technology TD-SCDMA on the launch of the third generation mobile communication in the market. TD-SCDMA is a self-developed technology in China, which has been accepted by the International Telecommunication Union (ITU) as one of the three international standards in 2000. Since TD-SCDMA has invented, China has been devoting in copying the successful experiences from Korea who formulated CDMA as the only standard when it launched 2G mobile communication

networks, resulting in prevent foreign companies take the big advantages in the market. Therefore, to develop 'indigenous innovation' [2](Yan 2006), China put off the launch of 3G repeatedly, and carried out TD-SCDMA until 2007. However, TD-SCDMA still has a long way to go before it becomes mature products available in the market. If the TD-SCDMA is finally accepted by some Chinese operators and is proven to be a successful technology, it would mark the turning of a new page in China telecommunication sector. That is to say, China increases international competitiveness in the global market by means of setting a technology policy as a strategy. At the same time, the Chinese national innovation capacity would rank high in the world.

4 Confronting the case to three approaches

Since China moves from planned economy to market economy, Nelson (1993) comments that in China, "the matter would have been different" (P.507). Researchers with different backgrounds from the west and homeland have begun to analyze the innovation system in China. One of the first foreign studies of China's national innovation system by the IDRC(1997) identifies the key stakeholders, policies, and institutions, and also reveals weaknesses in organizations and policies. And in 2001, Liu and White (2001) proposed a generic framework for analyzing innovation system in China anchored around five fundamental activities- R&D, Implementation, end-use, education, linkage, which focused on the performance implications of a system's structure and dynamics. They compared China's national innovation system under central planning and since economic reforms, and revealed the structure, dynamics and performance of these two very different innovation systems.

With the rapid development of the Chinese telecommunication industry, the studies focusing on telecommunication technologies have been increasing. In 2003, Yan and Min (2003)used national innovation system model to address the development of 3G in China within the broad context of the Chinese telecommunication equipment manufacturing industry. In this research, it concludes that the Chinese government has played a significant role in technology changes. However, this research ignored the interactions between the main actors influencing the innovation process at national level. Consequently, there are no optimal approaches to study Chinese telecommunication sector at national level currently, and nor a comprehensive insight of the telecommunication technology change and the future development for the policy makers. In this paper, we would like to apply three different approaches into the Chinese telecommunication sector, in order to further reveal the strengths of each approach when they are using.

4.1 NIS and Chinese telecom

As mentioned above, a national innovation system can perceive the economy growth and historical technology change, and it can also be regarded as a grown subsystem of the national economy (Balzat and Hanusch 2004) in social and economic context. This

[2] Indigenous innovation is a process to explore potential markets though in-house R&D activities and external knowledge acquisition. It aims to develop predominant core technologies and core products, and improve core competitive ability of the country, region or industry company.

subsystem involves various organizations, enterprises and institutions interact with and influence one another in the carrying out of innovation activity. Therefore, the NIS approach pays more attentions on the interactions on the organizational level as well as the interplay between organizations, and institutions.

According to the main actors in the NIS, the main actors in Chinese innovation system are the whole telecommunication industry, central government and the Chinese education and research organizations. Applying the NIS approach into the case, it focuses on the various stages of development of the Chinese telecommunication sector and reveals the interactions influencing the innovation process. After Chinese government launched the economic reform in 1978, the development of Chinese telecommunication sector can be divided into three stages (Yan and Min 2003); the first stage is the period of 1979 to 1983, which is characterized by full dependency upon importation. The period of 1984 to 1993 is the second stage, in this stage many foreign technologies were transferred to China via joint ventures. At the same time, the domestic enterprises began to take-off. The third stage is after 1994, when two revolutions took place in the Chinese telecommunication sector. The first revolution is the liberalization in the telecommunication market. The second one is that China formally joined the WTO in 2001 and promised to gradually open its telecommunication operations up to direct foreign investment. In this paper, we only focus on analyzing the final stage in the Chinese telecommunication sector by applying the NIS.

In 1980s, China relied on 100% imports of telecommunication equipment including telecommunication networks and products, however, in the middle 1990s, the domestic firms developed rapidly and competed with MNCs in the markets of optical transmission, data communications, and mobile communication in the new millennium (Fan 2006). The growth of major domestic telecommunication enterprises contributes a significant portion of the development of Chinese telecommunication industry. By the mid 1990s, several domestic enterprises including telecommunications equipment manufacturing and telecommunication operators were well established, among of which ZTE (Zhongxing Telecom Equipment Corporation) and Huawei (Huawei Technology Corporation) are two main domestic telecommunication equipment providers and China Mobile, China Unicom and China Telecom are main three operators.

In the final stage, domestic telecommunication enterprises have already replaced the foreign companies in the telecommunication market, and improved their innovation capacities and competitiveness by investing R&D activities. For instance, ZTE and Huawei have been concentrating on R&D activities in the last decade, and established the global R&D centers located in China and also in overseas. They have been investing a minimum of 10% of their annual revenue into R&D every year. Moreover, Huawei's R&D staff is 48% of total 68,000 employees, and 35% of total 50,000 employees dedicate to R&D in ZTE (source from Huawei and ZTE website). That is to say, in-house R&D has turned out to be the most important factor for domestic firms to improve their innovation capacity, whose main purpose is to enhance the competitive advantages in the global market.

At the national level, the main performers of the innovation activities in China are enterprises and universities. In the first two stages, most domestic enterprises prefer importing mature technologies to developing their own R&D capabilities. In the last two decades, Chinese government made the policies aiming at improving the innovation capacities as a national strategy, Chinese enterprises has changed the development of R&D's direction and established own R&D departments. For instance, 39% of total 23,267 large and medium size enterprises[3] has their own R&D departments or research facilities in 2004. Statistics show that the R&D expenditure of research institutes was 18.9% of national R&D spending, while that of enterprises was 71.1% in 2006[4]. Universities are the other performers in China, who consumed only 9.2% of the national R&D spending in 2006. China's R&D activities are mainly funding by three sources, that is, the enterprises, government and banks, whose ratios of national R&D expenditures in 2006 were 69.1%, 24.7% and 6.2%. Recently, the sources from oversea companies are increasing. In 2005, China's R&D expenditure, as a percentage of GDP was 1.3%, and the investment intensity in telecommunication industry is 1.19%[5]. And Electronic and telecommunication industry as a percentage of value added increased to 5.6%[6].

Besides R&D finance supports, Chinese government also changed the education system, resulting in that the companies can recruit graduates from any universities. And the amount of students studying overseas is increasing every year. That is to say, the free flow of talent has enhanced the knowledge exchanges and knowledge imports in the Chinese telecommunication sector. For instance, the graduates and enrolments studying engineering field in universities and other regular institutes are 5 million only in 2004, as the percentage of total number 34%[7], and this number was keeping increasing due to the expend enrolment in China.

Summarizing the statements above, at the national level, we describe the final stage of the Chinese telecommunication sector by the development of domestic telecommunication enterprises, national R&D activities and personal mobility at the national level. By applying the NIS, it reveals that the analysis focuses on studying the macro-economy growth and the national innovation capacity, which provides the clues for the comparative study between the countries in one specific sector. The NIS approach also gives a comprehensive insight of the historical evolution of a technology change or innovation for policy makers. This insight will help policy makers improve the national innovation capacity by political and finance supports, and enhances the competitiveness at the global level.

4.2 RIS and Chinese Telecom

A RIS has evolved through different technology trajectories and industry development. The RIS manifests different characteristics in different regions(Doloreux 2004) .For

[3] http://ibm.e-works.net.cn/document/200803/article4678_1.htm
[4] http://www.china.com.cn/policy/txt/2007-09/13/content_9252719.htm
[5] http://cn.chinagate.com.cn/tech/2007-09/25/content_8945525.htm 22-04-2008
[6] http://www.showchina.org/zgkj/xgsj/200701/t105222.htm 22-04-2008
[7] http://www.showchina.org/zgkj/xgsj/200701/t105222.htm 22-04-2008

instance, innovation systems in metropolitan regions are different from innovation systems in peripheral and rural regions. Technological change and innovation might occur more easily or more frequently in large cities than elsewhere(Doloreux 2004) . As Chung studied regional innovation system in Korea, he defined three categories of the Korean regional innovation systems basing on three main actors, namely university, industrial enterprises, and public research institutions. These three categories of regional innovation systems are advanced innovation systems, developing innovation systems and less developed innovation systems. An unbalance development of regional economy exists in China due to some historical reasons. According to the report of regional innovation capacities in China, Shanghai is at the first place on the list. Recently, four regional innovation groups are divided in China, namely, the first group is Beijing, Shanghai and Guangzhou, the second group is in the coastal areas including Jiangsu province, Liaoning provice and Shangdong province etc. the third group is the midland of China, the fourth group is the west of China. For instance, in 2006, R&D expenditure in the first regional innovation group as the percentage of total national R&D expenditure is 34%, while the fourth group expends as the percentage of total is only 6%[8]. When come to the Chinese telecommunication sector, ZTE and Huawei are both established in Shenzhen in Guangdong Province and set up the R&D center there. Furthermore, the headquarters of China Mobile, China Unicom and China Telecom are all in Beijing and have R&D department there. That is to say, the main R&D activities in the telecommunication sector are mainly occurred in the first regional innovation group.

By applying the RIS to the Chinese telecommunication sector, these four regional innovation groups will be analyzed individually by innovation activities inside the telecommunication enterprises, innovative interactions between industrial enterprises and R&D collaborations with universities and public research institutions in telecommunication sector. This analysis focuses on analyzing the innovation capacities in the Chinese telecommunication sector of the different regional innovation groups. The results also reveal the disequilibrium in the regional economy in China, which will hinder the future development of the national economy as a whole. To avoid the disequilibrium in the regional economic, the RIS is a useful tool to help the policy makers to prevent the problem of unfair geographical concentrations.

4.3 SIS/TIS and Chinese Telecom

In order to understand technological change, the insight in the dynamics of innovation system should be provided by the studies for the policy makers. As defined in the pervious section, SIS/TIS approach focuses on analyzing the technology flow between firms and institutions place, and studying the technology development in a specific sector. The purpose for mapping all the innovation activities that take place in the technology flow or development, normally, the foundations of innovation systems are used as a framework to analyze the generation, diffusion and the use of innovations.

Basing on the basic function of most studies in the innovation systems, namely, ‘learning’ or ‘interactive learning’ (Hekker et al. 2007), different researchers proposed

[8] http://cn.chinagate.com.cn/tech/2007-12/11/content_9371960.htm 28-08-2008

various functions from different perspectives. For instance, Liu and White (2001) address five fundamental activities at the national level from the systemic modules' perspective, which are research, implementation, end-use, linkage and education. From policy perspective, Smits and Kuhlman(2004) conclude six supporting functions, namely, manage interfaces, build and organize systems, provide a platform for learning and experimenting, provide an infrastructure for strategic intelligence, stimulate demand articulation, strategy and vision development, and stimulate and facilitate the search for possible applications. In this paper, we adapt the functions proposed by Hekkert et al. (2007), including **entrepreneurial activities, knowledge development, knowledge diffusion through networks, guidance of the search, market formulation, resources mobilization and creation of legitimacy/counteract resistance to change.**

According to Hekker et al., the application of functions of innovation system is to describe the 'events'. They define that events are what the central subjects do or what happens to them. By using these events to describe the development of TD-SCDMA, we can map its whole development process in the Chinese telecommunication sector. All the events related with TD-SCDMA are allocated to the seven functions, and are required to be reported at the system level. During the description of each function in the technology innovation system, we can identify which functions perform well and which do not. The final outcome of analysis is a storyline of the development procedure of TD-SCDMA over time.

This approach can provide a clear insight of technology change over time in the social context, and reveal the weak functions existing in the technological innovation system. This insight is likely to be highly relevant for policy. This insight is likely to be highly relevant for policy. According to an insight in the current functions of the specific technology innovation system at a national level, policy makers can determine the optimal policy strategy for the purpose of improving national innovation capacities in international competitive environment. This can be done by stimulating weak fundamental activities or remove the barriers to the successful technology development.

5 Conclusion

Confronting these three approaches to the Chinese telecommunication sector, it shows that NIS, RIS and SIS/TIS have different focuses on the analysis in the innovation system. Therefore it is difficult to identify an optimal or ideal approach of innovation system, nor talk about an optimal propensity to innovate. However, for the purpose of analysis and policy making, the best way is to compare different approaches of innovation system with one another. Comparing systems is the only means of identifying the strengths and weaknesses in the approaches of innovation system, which is very important for policy purpose(Edquist 2004). In the pervious section, we have already compared these three approaches basing on the basic elements in the innovation system. After applying them into the real case, we can summarize the strengths when they are using, see Table 2.

Approaches	Strengths
NIS	1. focuses on studying macro-economy growth and national

	innovation capacity 2. a useful tool for the comparative analysis between countries 3. provides a comprehensive insight at the national level for policy makers
RIS	1. focuses on studying micro-economy growth 2. reveals the regional innovation capacity 3. prevents the disequilibrium of regional technological and economic capacities
SIS/TIS	1. analyzes a specific technology in social context 2. provides a clear direction for policy actions 3. better understanding of the innovation system dynamics

Table 2: the strengths of three approaches

This paper studies three s approaches of innovation system, namely, national innovation system, regional innovation system and sectoral innovation system/technological innovation system basing on three basic elements (actors, interactions and institutions). By applying them to the Chinese telecommunication case individually, it reveals that they have different strengths on analyzing a specific sector. National innovation system and Regional innovation system are related with economy development and innovation capacities at national or regional level, and they mainly focus on the knowledge exchanges and learning interactions between the actors. In contrast, sectoral innovation system/technological innovation system focuses on using the events description on a specific sector or technology development to reveal the dynamics of innovation systems over time in the social context. In short, it demonstrates the technology flows among the actors. Therefore, it is not possible to identify an optimal or ideal approach. The choice of approaches mainly depends on the research scopes and research purposes of what the problems need to be solved.

There would be a possibility to combine two approaches into one basing on their different focuses, and propose a new framework to analyze a specific sector at the national level. However, it can lead to a new discussion on these approaches.

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