Following the Approach of National Innovation System: Evidence from National Innovation Platform in China

Xudong GAO[1], Jizhen LI[1], Wei YUAN[2] and Yuntao HE[2]

[1] Research Center for Technological Innovation, Tsinghua University, Beijing, 100084, P.R.China
[2] National Science & Technology Infrastructure Center, Beijing, 100862, P.R.China

Abstract: *Derives from the National Innovation System (NIS) approach, and based on some prominent weakness in China's National Innovation System (NIS), this paper argues that China's National Innovation Platform (NIP) program places more emphasis on the infrastructure of innovation and can be seen as an early stage to form a completed innovation system, and aims at combining the efforts and resources of enterprises, universities, research institutes, government etc to support innovation in certain industries in China and promote the translation of scientific and technological advances into practical productive forces. Therefore, NIP Program in China is a good practice following NIS approach, NIP effectively accomplishes, what is emphasized in NIS theory, the interaction and cooperation among different actors and it encourages the flow of knowledge in the process of innovation.*
Keywords: *National Innovation System; National Innovation Platform; China; innovation and interactive learning*

Introduction

The National Innovation System (NIS) concept first appeared in the mid-1980s in the context debates over industrial policy in Europe. Remarkably, this concept has been rapidly diffused and widely used in both academic circles and policymaking content, both in developed and developing countries.

For historical reasons, enterprises in China generally lack the awareness and capability of innovation. Since 1949 when the People's Republic of China was established technology development in China has been characterized by imitation rather than creation (Xie and White, 2006). Still after China's entry into WTO in 2001, most Chinese firms focus on developing manufacturing capability by utilizing low-cost labor force and exploiting resources while less attention is given to improvement of innovative capability. Many Chinese firms lack core technological competences and in most high technology fields foreign firms dominate in terms of intellectual property rights. As a result, Chinese firms are at a disadvantage in the global competition.

Therefore, the innovative capability of the main actor (i.e. enterprise) in China's NIS (compared with developed countries) is very weak. Using patent application number to indicate the output of

innovation, it is obvious that although proportion of innovation generated by enterprises has increased sharply since the late 1990s, a gap still exists between China and the world. Most enterprises in China lack intellectual property rights of core technology. Hence, to improve innovative capability of enterprises it is an urgent problem faced by Chinese government. At the same time, China has not developed a mature channel for interaction and cooperation among actors. Innovation resources in universities and research institutes can not easily be shared by enterprises. A large number of research conducted by universities and research institutes are not consistent with the demand from enterprises and thus not easily translated to production.

In the light of this, a new concept of National Innovation Platform (NIP) has been brought forward by Chinese government. In March 2008, in his report on Chinese Government work in the next five years, the Chinese Premier, Jiabao Wen, announced that China will put into effect a program of "National Innovation Platforms (NIP)" to strengthen China's science and technology infrastructure and support technological innovation of enterprises, especially SMEs (Small and medium enterprises).

National innovation system

The National Innovation System (NIS) concept first appeared in the mid-1980s in the context debates over industrial policy in Europe (Sharif, 2006). Today, OECD, European Commission, UNCTAD, and the World Bank have incorporated the concept of NIS as an important part of their analytical perspective while countries in Scandinavia, Western Europe, Asia, and Latin America also show their special interest in NIS approach when making innovation policies (Lundvall, 2002, 2007).

For an innovation system, activities or functions are important. Liu and White (2001) argued that early studies focusing on actors, policies and institutions of NIS may cause "the lack of system-level explanatory factors". Therefore, they identified five fundamental activities in their framework for analyzing innovation system, i.e., research (basic, developmental, engineering), implementation (manufacturing), end-use (customers of the product or process outputs), linkage (bringing together complementary knowledge) and education.

Although there is no consensus as to which activities or functions should be included in NIS, it is clear that NIS itself is far extended beyond traditional R&D systems and innovation in NIS approach is also a much broader concept not only referred to market introduction of new combinations but also include its diffusion and use. Edquist (2005) argued that the overall function of an innovation system is to pursue innovation process, i.e. to develop, diffuse and use innovation.

The crucial contribution made by NIS scholars is that they have developed a new analytical framework that places learning and innovation at the center of the focus. Unlike standard economic theory which assumes that all agents have equal access to technologies and are equally competent in developing and utilizing them, NIS approach assumes that organizations and agents have a capability to enhance their competence through searching and learning and that they do so in interaction with other agents. In NIS approach, innovation is no longer categorized as a one-way, linear flow from R&D to new products. It is seen as a systemic process involving multiple interactions between different actors and types of learning. NIS approach also adopts a holistic perspective and tries to encompass a wide array of important determinants of innovation (including economic, social, political, organizational, and institutional factors) for consideration.

Therefore, NIS approach is more appropriate for policy makers to take full account of factors when designing innovation policies. Its comprehensive-perspective and national-focus make NIS approach feasible and popular. That's why many counties have adopted NIS approach in policy making content. As will be introduced in the next section, the recent NIP-program in China is also a practice following NIS approach.

Lundvall (1992) pointed out that learning-by-interacting, involving users and producers in an interaction, results in product innovation. In a recent research, Lundvall (2007) identified two models of innovation according to different types of knowledge. One is called the Science, Technology and Innovation (STI) mode, which is based on the production and use of codified scientific and technical knowledge. The other, called the Doing, Using and Interacting (DUI) mode, relies on informal processes of learning and experience-based knowledge. Both STI and DUI modes are typically embedded in organizational framework and institutional arrangements that support different kinds of interactions and accelerate exchange of both codified and tacit knowledge among actors.

In summary, NIS approach provided us a systematic and holistic framework for analyzing innovation and learning. NIS approach highly emphasizes interaction and cooperation, which can be accomplished through a series of organizational designs and institutional arrangements. Bridging agencies in NIS encourage the flow of codified and non- codified knowledge and make interactive learning between actors easily happen. Government support and cooperation among actors respectively decreases the macro-level and micro-level risk of innovation.

Now we would like to raise an important question "how to shape an effective NIS". As far as we know, few NIS researches are concerned with system building. Edquist (2005) argued that innovation system evolves over time in a largely unplanned manner and even we know all the determinants of innovation processes in detail, we can not design or build innovation system. Liu and White (2001) presented a less fatalistic and more normative view that the evolutionary process and outcomes can be managed or at last constructively influenced. E.g. consciously designed government policy can change the behavior of individual actors and in aggregate change the system structure, dynamics, and performance. Lundvall (2007) also emphasized the significance to turn to system construction and system promotion when applying NIS approach to the South.

National innovation platform

NIP is a new concept introduced by the Chinese government seen in the light of China's integration into the global competition. In October 2007, Jintao Hu, the National chairman of PRC, announced that China needs to enhance its capacity for independent innovation and become an innovative country in his report to the Seventeenth National Congress of the Communist Party of China. It is also emphasized that China will speed up forming a national innovation system and support basic research, research in frontier technology and technological research for public welfare. China will accelerate the process to establish a market-oriented system for technological innovation, in which enterprises play the leading role and which combines the efforts of enterprises, universities and research institutes, and guide and support the concentration of factors of innovation in enterprises.

On March 5, 2008, the Chinese Premier, Jiabao Wen, announced in his report on Chinese Government work at the First Session of the 11th National People's Congress that China will build

a number of national innovation platforms to strengthen China's science and technology infrastructure, support technological innovation of enterprises, especially SMEs, and promote the development of the national innovation system.

The concept of NIP is not only a political statement; it has already been put into effect. The program is supported by Ministry of Science and Technology and Ministry of Finance. As there is no appropriate mode that can be imitated directly from other countries[1], China is applying this learning-by-trying method to build NIP. National innovation platforms of textile industry, integrated circuit industry and Tibetan pharmaceutical industry are selected as the first batch of pilot projects to develop. Central government has subsidized each platform with approximately 30 million USD by now.

What is NIP

Although we can not find the accurate definition from the government policy or academic research, we can give a descriptive interpretation according to the three pilot projects. Generally speaking, the National Innovation Platform has been developed to improve innovation and linked to sectors based on the generic and crucial demands of enterprises in the specific sectors. NIP integrates the innovation resources (e.g., knowledge, facilities, and skilled people), which are present in enterprises, universities, and research institutes, as well as the Platform guides the concentration of factors of innovation in enterprises. It is a supporting program that mainly promotes application oriented innovation of a sector national wide.

Why NIP

NIP is proposed as a public policy strategy which aims at improving innovative capability of specific industries. There are several underlying reasons why Chinese government initiates this program. In fact, it is expected to solve some problems generated by the reform of China's R&D-system as well as to overcome some weakness of China's NIS.

China has implemented R&D system reform since 1985 in the context of its market reform and opening to the world. During this reform, a large amount of research institutes used to be run by government has changed their business type to be a part of enterprise or become profitable firms. However, some of the research institutes engaged in activities with strong positive externalities, such as R&D for generic technology, have also been pushed to the market, leading to market failure.

In a word, NIP is introduced for the purpose of supporting R&D for generic technology, improving innovative capability of enterprises, and forming cooperation and interaction among enterprises, universities, and research institutes. It is also an attempt to integrating the existent programs in regional and national levels.

Basis of NIP

China already has some national and regional programs to support innovation before the concept of NIP is proposed.

(1) National S&T Infrastructure Platform

[1] As far as we know, U.K., Holland, and EU also put the concept of 'platform' into practice to support innovation. However, the mechanisms of those platforms are not the same and also vary from case in China. It is clear that copying experience from other countries will probably lead to failure in policy making. China should develop NIPs in its own way.

China's National S&T Infrastructure Platform is under construction to enhance the basic research from 2004. National lab, scientific equipment, technological information system, and scientific database are established and shared. Although the National S&T Infrastructure Platform focuses on basic research rather than application oriented research and thus not able to transfer technology directly to enterprises, it helps to concentrate the innovation resources and form an atmosphere of sharing.

(2) Innovation Relay Center

China's Innovation Relay Center is a technology transfer network for the purpose of accelerating the knowledge transfer from research to enterprises. It first collects information from enterprises, universities, and research institutes to know both the demand and supply of knowledge. Then it publishes the information and helps to match the 'demand' and 'supply'.

(3) National Key Technology R&D Program

China's National Key Technology R&D Program is led by the Ministry of Science and Technology and Ministry of Finance. It aims at solving the key technical problems, which are related to several regions or sectors and significant to the economic development. The Ministry of Science and Technology calls for proposals of research programs from the whole society, especially from enterprises and local governments. The proposals are then discussed by experts and approved as part of the final programs. Finally, the implementer of each program is identified. The Ministry of Science and Technology assumes the responsibility to supervise the implementation of the programs. Programs are funded in different forms, including free financing, subsidized loans, repayable funding, and venture capital.

(4) Regional programs

Besides the national programs, local governments have also developed programs to support regional innovation. For example, many innovation platforms supported by local government have been developed. Some of these platforms also link to sectors and aim at driving the economic development of the whole region through enhancing the innovative capability of the specific sector. Unlike NIP, regional platforms integrate resources and provide services within the regional boundary, but not nation-wide.

All the existent national and regional programs form the foundation of NIP. Integrating innovation resources provided by these programs can help to enhance effectiveness in supporting innovation and also reduce the cost of developing NIP.

How to build

So far, there are no common instructions on the details of how to build up a NIP and one important reason may be the fact that differences among sectors are huge. The implementation plans of the three pilot projects are drafted by main actors/implementers involved in relevant NIP and then sent to Ministry of Science and Technology of China for approval. Chinese government has proposed some guidelines for NIS which are listed as follows:

- NIP aims at improving innovative capability of specific sectors, and should be built based on the demand of enterprises.
- Integrate the existent innovation resources, especially the regional innovation platforms to build NIP.
- Devise appropriate institutions (rules and regulations) and mechanisms.
- Let government play a guiding role and attract more actors.

- Determine rights and responsibilities of each actor clearly and encourage them to actively engage in innovation.

Relationship between NIP and NIS

Compared with the concept of 'innovation system', 'innovation platform' places more emphasis on the infrastructure of innovation and can be seen as an early stage to form a completed innovation system. To have a deep understanding, we will go a step further to find the relationship between NIP and NIS in substance and in detail.

NIP is an experiment under the guidance of the NIS approach. First of all, NIP accomplishes interaction and cooperation among different actors, which is the key factor highly emphasized in NIS approach. NIP-program in China forms organizational and institutional linkage among universities, research institutes, enterprises, government and other actors. Because of NIP, innovation resource is shared among actors or concentrated for crucial innovation which is beneficial to the whole industry but hard to achieve by a single enterprise. Interaction between knowledge producer and user is also supported since one guideline of NIP is to build based on the demand of enterprises. Feedback from enterprises is a driving force for the collaborative innovation process. Besides, NIP reflects government industry policy so that is supported by central and local government. Second, NIP achieves basic functions or activities of NIS. As we will prove in the third and fourth section, NIP can accelerate the flow of both codified and tacit knowledge like bridging agencies as well as create new knowledge. In addition, it also guides the direction of innovation, influences deployment of resources, supplies fund for innovation, creates positive externalities through R&D activities for generic technology, and provides technological services to enterprises etc.

NIP is a possible way to shape China's NIS. We admit that the outcome of NIS is the cumulative and integrative effect of system's components (actors and institutional set-ups) along with exogenous factors (such as change in the international environment). Although NIS can not be planned or designed with a definite objective, we still believe it can be affected or at least shaped to some extent. Consciously designed government policies and actions can change actors' incentive mechanism and/or their relationships (organizational or institutional), leading to a change in actors' behavior. If changes in individual actor are in the same direction and strong enough, the cumulative effect should be a change in the performance of NIS. As to the case of NIP, it forms new relationships (interaction and cooperation) among different actors and encourages these actors to engage in innovation process based on the crucial and generic demand of industry by policy. In other words, NIP-program affects the components of NIS, i.e. both actors and institutional set-ups. If NIP is implemented felicitously, it is reasonable to make an optimistic forecast that the resulting NIS will form stronger domestic links and interactions among knowledge producers, users and the government. The technological infrastructure and supportive institutions for enterprises will be developed. Besides, NIP is a good complement to China's National S&T Infrastructure Platform. The former is application oriented. It supports innovation in enterprises and helps them apply new technology to production while the latter provides a national support to basic research. As shown in Fig. 1, it may be possible to form a 'starting point' of China's NIS by refining and integrating different NIPs as well as China's National S&T Infrastructure Platform.

We have discussed the feasibility to shape China's NIS by building NIP but it is still not clear why NIP links to sector not region. NIP in China is following sectoral approach not regional approach in terms of two reasons.

First, regional development can be driven and stimulated by supporting its prior industry, which plays an important role in regional economy.

Second, China can adjust its industrial structure by a sectoral approach. The Chinese government has established goals to develop new- and high-technology industries, reinvigorate the equipment manufacturing industry, upgrade traditional industries and accelerate the development of service industries. By implementing several NIPs to accelerate innovation of specific industries, China can accomplish its objective.

Fig. 1 China's NIP within the NIS

Framework for analyzing NIP

The three pilot NIPs in China, i.e. national innovation platforms of textile industry, integrated circuit industry, and Tibetan pharmaceutical industry differ from each other in operational details. NIPs may have different forms because they are built for different sectors. It is unrealistic to expect one detailed instructions adapted to all China's NIPs. However, it is meaningful to look into the mechanism behind and explain how NIP accelerates the innovation process. In this study, we will develop the framework for analyzing the mechanism for NIP to promote innovation.

As shown in Fig. 2, NIP consists of a group of actors, who are related by flows of influence, knowledge, funds, service etc, subject to the institutional arrangements.

Actors involved in NIP

Innovation is an interactive process. This means that innovations are new combinations of knowledge and reflect new combinations of interacting individuals and organizations specialized in different fields of knowledge. Graf (2006) depicted a stylized innovation system with three core elements, i.e. scientific pole, technical pole, and market pole. Foxon et al. (2005) divided the actors in innovation systems into three categories in his research of UK's innovation system for new and renewable energy technologies. These include: actors involved in creating and/or sharing

knowledge; actors disseminating and using knowledge; and actors setting the framework conditions. In the case of China's national innovation platforms, actors include innovators, users/customers, and the government.

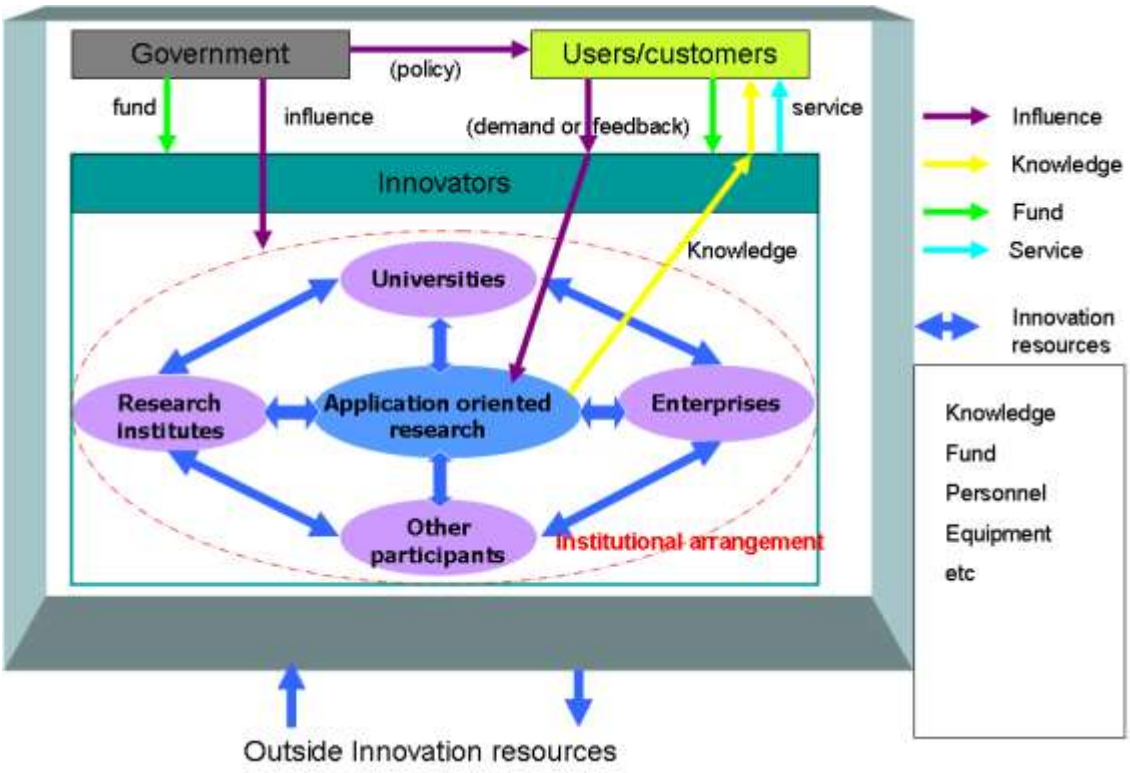

Fig. 2 Framework for national innovation platform

Innovators are those involved in creating and/or sharing knowledge, including universities, research institutes, enterprises, and other public or private participants. Here 'knowledge' both refers to codified knowledge and tacit knowledge, including know how of process, product, generic technology of the sector as well as data, information etc. Universities and research institutes can provide codified knowledge of both basic research and application research for industry. Enterprises also participate in the process of creating knowledge. Experience based knowledge is mainly accumulated and diffused in firms. Technical labs and cooperative research centers in advanced firms help to generate new knowledge. Pilot plants which design, develop, and transform artifacts for specific purposes (e.g. models, prototypes, pilot projects) shorten the time for research. The rest of the innovators who share the current knowledge base and affect the generation of new knowledge are all referred to as other public/private partners. Take Industry Associations can be mentioned as an example. They set industry standards, provide test equipment, establish database, share information, promote the application of new technologies in enterprises etc.

All enterprises, including large firms and SMEs within the sector, are the users and/or customers of the platforms. They apply new knowledge created by innovators and enjoy the services supplied by platforms.

The government acts as a guiding body, supporter, and supervisor of those platforms. It has formulated several guidelines for the establishment of all NIPs. Each of NIP's implementation

plans should finally be approved by the Ministry of Science and Technology. Currently, a majority of fund for NIP is raised through fiscal allotment from local and central governments. The government also oversees the implementation of each NIP.

Institutional arrangements

In NIPs, innovators are embedded in a series of institutional arrangements, which are understood as a set of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between actors. Different forms of institutional arrangements will set different conditions for innovation processes since they will establish patterns of cooperation and interaction. Institutional arrangements in China's NIP are formed both by the government and the innovators. The government influences the institutions by setting policies, rules and laws (e.g. industry policy, Intellectual Property Law). The innovators themselves draft the implementation plans of the platforms, establish the technology-transfer institutions, hold conferences and trade fairs, as well as they develop the culture of cooperation. All these institutional arrangements influence the modes of interaction and flows of innovation resources (including knowledge, funds, equipment, personnel, etc) on the platform.

Types of 'flows'

As to the platforms, there are types of 'flows' among government, users, and innovators, such as knowledge flow, fund flow, service flow, influence flow etc. 'Flows' reflect the relationships among the three kinds of actors. The graphical representation of the framework depicts the 'flows' related to the platforms (see Fig. 2). We make a simple interpretation:

The government sets laws, policies and guidelines to influence the institutional arrangements which organize the innovators as a whole. It also supports a majority of research funds and running expenses of platforms, especially at the early stage.

Besides, government can affect the demand of users by policies. For example, China's top legislature passed a recycling law to promote circular economy recently, which came into force on Jan 1, 2009. The aim of the law is to implement the policy of sustainable development through energy saving and reduction of pollutant discharges. Industrial enterprises are required to introduce resource-saving technologies, install energy-saving equipment in new projects, and recycle the waste materials. Companies that employ technologies, equipment and material that are prohibited will face fines from RMB 50,000 yuan to 200,000 yuan. Therefore, government policy has influence on the users and thereby affects their demand of knowledge (new environment-friendly technology in this case).

The relationship between users and innovators is a little complicated in NIP. Users obtain knowledge from innovators and receive services (e.g. product design, quality inspection, staff training, promotion of new technology etc). In return, users will pay annual fees, service fees, technology transfer fees, etc. Payment from users is another source of funds other than fiscal allotment from the government and accounts for a large proportion of total fund especially in the mature stage. As mentioned earlier, the platforms are application oriented. The research projects are based on the demand of users and related to the key and common technical issues that enterprises in the sector face. Therefore, users' demand of knowledge influences the target of the innovation process. In the whole process, users constantly compare the current knowledge generated by innovators with their actual need, which may be changing, and gives feedback to the

innovators. Thus, feedback from users continually pushes innovators to create new knowledge and supply new services.

All the innovation resources (e.g. knowledge, fund, equipment, personnel etc), which are useful to generate new knowledge or service, can flow among the innovators according to the institutional arrangements. Innovators share and/or provide the knowledge, funds, equipment, personnel, and other infrastructural facilities for the application oriented research. Of all the innovation resources, knowledge has the strongest mobility and is sometimes intangible. Therefore, we will especially discuss the knowledge flow among the innovators. In the case of China's NIP, the notion of knowledge flow comprises the transfer of knowledge between scientists, researches and engineers through the formalized research co-operations regulated by contracts and other institutional arrangements such as working groups, trade fairs, conferences, and informal meeting. Scientific publications and shared databases are the carriers of codified knowledge while the face-to-face communications and interpersonal networks are considered as important channels for the diffusion of tacit knowledge. Therefore, knowledge can flow easily among innovators.

Lastly, NIP is open to innovation resources outside the platform and to new inspiration from abroad. Each NIP receives the innovation resources supplied by other national, regional, and sectoral programs (such as China's National S&T Infrastructure Platform, NIPs linking to other sectors, regional programs etc). It also incorporates knowledge from global scientific and technological Research Technological Development (RTD) and innovation network. Meanwhile, it is also an exporter of innovation resources.

Based on the framework described above, the mechanisms illustrating that NIP promotes innovation can be seen in six aspects.

First, Innovation is a cumulative process drawing upon knowledge and creating new knowledge. This implies that it is fundamental to understand the current knowledge-base of the industry and to connect it to new sources of new knowledge. In the case of China, each NIP integrates the current regional platforms, National S&T Infrastructure Platform, as well as innovation resources from other related regional and national programs in order to generate new knowledge.

Second, Innovation is an interactive process. This reflects that new knowledge is created from a combination of interacting individuals and organizations specialized in different fields of knowledge. This implies that it is fundamental to map intra- and inter-organizational relationships. In NIPs, the innovators (i.e. universities, research institutes, enterprises, and other participants) are related by the institutional arrangements set by the government and the innovators themselves. The framework for coordination, cooperation, and interaction is clearly regulated.

Third, innovation is an uncertain process. Both macro-level risk and micro-level risk lead to the uncertainty. NIP is supported by Chinese government (policy and funds), which helps to reduce the macro-level risk. It also overcomes the micro-level risk by the institutions and organizational forms that bolster cooperation.

Fourth, innovation may be seen as a process starting from radical technical change and ending with the broad diffusion and use of new technology. Economic performance of a sector depends on the whole chain of events and especially on the feedbacks from the later stages to the early ones. Innovation on the platforms is based on the need of end-users. Innovators continually get feedback from users and make improvement.

Fifth, In order to transform new ideas into efficient production and attractive products, the

competence of all employees is fundamental. The more competent the workers are the more can tasks be decentralized and the more quickly can the organization develop and absorb new ideas. Therefore education and training should be seen as a source of innovation. One kind of services NIP provides is training, which helps improve the quality of works in enterprises and thereby make them more independent and creative.

Lastly, bridging intermediaries in transferring knowledge are considered important in NIS approach. In the case of NIP, both codified scientific knowledge and tacit experience based knowledge can flow easily among innovators due to the sharing mechanism and the institutional arrangements. NIP achieves the function of bridging intermediaries and accelerates the flow of knowledge.

Conclusion

National innovation platform (NIP) is a new concept brought forward by Chinese government. It aims at improving innovative capability of a specific sector. NIP is a good practice under the guidance of NIS approach. It effectively accomplishes interaction and cooperation between different actors and encourages flow of innovation resources by setting institutional arrangements and organizational structures. NIP is application-oriented and based on the demand of enterprises.

China has already several national and regional programs to support innovation, which form the foundation of NIPs. It may be possible to form a ‘starting point’ of China’s NIS by refining and integrating different NIPs as well as China’s National S&T Infrastructure Platform.

Actors involved in NIP include government, innovators (i.e. universities, research institutes, enterprises, and other participants), and users. Actors are related by flows of influence, knowledge, funds, service etc, subject to the institutional arrangements.

As there is no direct use for reference, China adopts learning-by-trying methods to develop NIPs. Three pilot projects are selected. NIP of Chinese textile industry sets an example as to the detailed operational issues. It is suggested that implementers of platform should have special innovation resources. Generic and crucial demands of enterprises in the specific sector/industry should be identified first. Actors from different regions and fields need to be regulated and coordinated in order to contribute to a proper organizational structure. The Government acts as a guiding body, as supporter and supervisor of NIP. In current situation, NIP in China can not be implemented without support of government.

We also refer some potential weakness of this new program. It is suggested that enterprises should gradually be the main force of innovation via NIP-program. Complementary policies need to be set by the government.

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