Working Paper

Nine-Quadrants of the "Endless Frontier”: Triple Helix Technological Innovation Systems [1]

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Abstract：To impel technological innovation in regional industries is key to a national strategy of innovation-driven development. This paper proposes a nine-quadrant model, delineating the relationship of the Triple Helix innovation actors with three levels of technological innovation types —— independent innovation, re-innovation after import, and technological import —— and three stages of R&D activities from basic research to applied research to experiment & development.. The framework is utilized to develop a strategy to speed up formation of technological innovation systems in the regional industries of China, Paradoxically, the Linear model and planned economy are found to be in concordance with the non-linear model and a free market economy

Key Words: innovation actors, university-industry-government triple helix for innovation, technological innovation system of regional industry, linear and non-linear innovation models, scientific research stages

Introduction:

Technological Innovation Types, Scientific Research Stages and the Actors in a Triple Helix

The technological innovation system is a concept developed within the scientific field of innovation studies which serves to explain the nature and rate of technological change (Smits, 2002). Indeed, it is held that "The innovation systems idea is an institutional conception, par excellence" (Nelson & Nelson, 2002).A Technological Innovation System can be defined as 'a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology' (Carlsson and Stankiewicz, 1991). Among them, new technological inventions with own IPRs are the key. Gregory Tassey (1991; 2012 & 2016) proposes a "technology-based economic growth strategy" and classifies technologies as fundamental, generic and proprietary technologies. These technologies are all essential in technological innovation system of regional industries,

Malaria (2002) proposed a similar conception, sectoral systems of innovation and concluded "that a sectoral system is a set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products. A sectoral systems has a specific knowledge base, technologies, inputs and demand. Agents are individuals and organizations at various levels of aggregation. They interact through processes of communication, exchange, co-operation, competition and synergy. Interactions are caused by the institutions in action. A sectoral system undergoes change and transformation through the co-evolution of its various elements" . This study, in a general sense, concentrates in "industrial system of technological innovation", rather than "sectoral system of innovation".

The core elements of a technological innovation system include actors , knowledge base, new technologies (IPRs), production process, sale mechanism and public policies. The innovation actors include industrial enterprises, universities, research institutes, as well as government agencies. however, government , university, public and private research institutes should focus on different types of

technologies and scientific research stages. Elicia Maine and Elizabeth Gurney (2006) studied "commercializing generic technology", contrast it to "radical technology". Generic technology is of interest because of its potential for value creation across a broad range of industries and applications, referring to "a technology the exploitation of which will yield benefits for a wide range of sectors of the economy and/or society" (Keenan, 2003). It makes technology import necessary and possible. "Radical technology" is defined as having "the potential for delivering dramatically better product performance or lower production costs, or both" (Utterback, 1994, p. 158). This needs independent discovery and R&D efforts.

Technological innovation types are classified as three levels —— independent innovation, re-innovation after import, and technological import, according to the degree of that innovation relies on outside resources. Independent technological innovation, relating to radical technology and technology-based economic growth strategy, is hard to get through technological import, but it is critical to pushing economic growth in knowledge-based society. Therefore, public science policy and government must play a very active role in encouraging independent technological innovation based on basic research, i.e., the research activities in "Pasteur Quantum" (Stokes, 1997). It may have another alternative: to push incremental innovation; and use 2nd mover strategy behind protection for new technologies e.g. China's Baidu and Russia's Yandox vs US Google, however, it could cost more for IPRs as globalization coming and international IPRs protection are strengthened increasingly.

 It is not that all actors act in these innovation types to the same extent. In other words, different actors play different roles in different types of innovation in a given region and era. For example, The main actors for technological import activities are firms with the help of technology transfer service agencies. It has significant policy implication to get knowledge in the relationship between technological innovation actors and the three types of innovation. This study draws four innovation actors —- government, university, research institute and industry, but put them into three actors: government (G), academia (A: including research parts of university and research institutions) and enterprise (En) to analyze the relationship, based on the triple helix innovation theory, aiming at constructing technological innovation system of a region. In addition, linear and non-linear innovation models, planned and free market economies are put together to draw a whole picture.

1. Triple Helix Innovation Model (Etzkowitz, 2008)

The interaction among university, industry and government is the key to innovation and growth in a knowledge-based economy. The triple helix as a physical device is superseded by university- industry- government interactions that have led to the venture capital firm, incubator and Science Park. These social inventions are hybrid organizations that embody elements of the triple helix in their DNA. (Etzkowitz and Leydesdorff, 2000)

The university is the generative principle of knowledge-based societies just as government and industry were the primary institutions in industrial society. (Etzkowitz and Zhou, 2007) Industry remains a key actor as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange. The competitive advantage of the university, over other knowledge producing institutions, is its students. Their regular entry and graduation continually brings in new ideas in contrast to R& D units of firms and government laboratories that tend to ossify, lacking the "flow-through of human capital" that is built-in to the university.

Universities, firms and governments each "take the role of the other" in triple helix interactions even as they maintain their primary role and distinct identity. The university takes the role of industry by stimulating the development of new firms from research, introducing "the capitalization of knowledge" as an academic goal. Firms develop training to ever-higher levels and share knowledge through joint ventures, acting a bit like universities. Governments act as public venture capitalists while continuing their regulatory activities. In contrast to theories that emphasize the role of government or firms in innovation; the Triple Helix focuses on the university as a source of entrepreneurship and technology as well as critical inquiry.

According to the triple helix model, the three spheres interact in three "regional triple helix spaces", forming dynamics and hybrid organizations. Triple helix spaces in a given region include knowledge space, consensus space and innovation space. Knowledge space consists of research institutions or knowledge production units, fundamental R&D facilities, research results and relevant practitioners. It is hard to say that a region, which doesn't have any leading research institution (university and re-

search institute), has sufficient knowledge space. A knowledge space provides the building blocks for regional growth in the form of a "critical mass," a concentration of research resources on a particular topic, from which technological ideas can be generated. When these resources reach a certain level, they may play a role in regional development. The concept of "knowledge space" was first used to describe the decentralization of government research laboratories from Mexico City to other regions of Mexico following the mid 1980s earthquake where, inserted into new surroundings, they took on a new potential. The researchers began to think of how they could use their skills and the resources of the Institute to address problems in their new locality. For example, a relocated agricultural institute took up the problems of the strawberry crop in their new locality. Then, more research institutes were relocated to give additional areas of the country the opportunity to create knowledge spaces. The decentralization of laboratories from Mexico City gave other Mexican regions a research capacity that had heretofore been lacking in most other parts of the country. These relocated research institutes still only represented a potential for regional development that will only be realized if further steps are taken.(Casas et al., 1999)

A consensus space denotes the process of getting relevant actors to work together: brainstorming, analyzing problems and formulating plans. When these actors generate a strategy and bring together the resources to realize it, the regional development process can be moved forward. An innovation space denotes an organizational invention or adaptation made to fill a gap in the regional development process, often identified during the consensus phase. The organizing effort to create a new hybrid entity is similar to a social movement, bringing together resources, people and networks across the triple helix. A consensus space is a neutral ground where the different actors in a region, from different organizational backgrounds and perspectives, can come together to generate and gain acceptability and support for new ideas to promote economic and social development. From the analysis of the knowledge resources awareness in a region can be generated of their potential. Knowledge spaces are often transformed from potential to actual sources of economic and social development through projects originating out of discussions among participants whose backgrounds cross cut institutional boundaries. The very process of including actors from these various backgrounds in the strategy review and formulation process provides access to the resources required to implement the eventual plan.

The innovation space may be visualized as a dual set of ladders with cross bars between them. One ladder is the linear model of innovation, starting form research; the other ladder is the reverse linear model of innovation, originating in societal needs. Crossbars between the ladders are represented by specific innovation mechanisms: incubator facilities, technology transfer offices, the research centers, science parks etc. Where the reverse linear side and the linear side meet, something unexpected that was not part of the original plan may result such as an incubator with research-oriented firms and close to market firms interacting with each other.

２. Technological Innovation Types of Regional Industries

According to how technologies are produced, to the extent that they are extensions of existing technique or novel, technological innovation is classified on three levels —— independent innovation, re-innovation after import, and technological import. Independent innovation, i.e., original innovation, means discoveries or inventions from basic and applied research that are achieved by researchers originally. It needs big inputs, taking much risk. Usually the results of independent innovation take the lead and fill gaps in the technological fields. For example, ancient China's four great inventions —— paper-making, the compass, gunpowder and printing —— are typical original/independent technological innovation, arising from intelligence and creativity.

Re-innovation after technological import is an innovation that is often taken by following or developing countries. It is a preparation for independent innovation, which is based on technological resources imported to digest and absorb the ideas (secrets) to develop new technologies. developing countries can use technologies imported to shorten the time to get innovative results and lowers risk in R&D investment. However, if a nation only satisfies with this innovation type, overlooking to foster independent innovation, it will fall behind and lose competitiveness worldwide.

"Pure" technological import is a strategic choice in a given historical period. For example, China followed this path in the 1950s when numbers of important technologies were imported from former Soviet Union, with a number of technicians/engineers who know the technologies and apparatus. Importing existing technologies from the outside can speed up getting technologies and avoid huge

expenditure and waste from long-term R&D process. Moreover, it can train researchers to catch up new technology wave and push economic increase in shorter time. However, this approach may cause technology dependence and loss of R&D capacity, especially in some key industrial technologies. Table 1 compares the three models through analyzing the advantages and disadvantages.

Table 1 Advantages and disadvantages of different technological innovation types in a region

Innovation model	Characteristics	Advantages	Disadvantages
Independent Innovation	Of unprecedented With • major scientific discovery • technological invention • leading technology • innovative achievements	• It belongs to the original innovation; • It has undisputed IPRs; • Key technology breakthrough can bring unexpected profit. • Can promote basic research greatly, in turn.	• It needs strong strength research units and enough basic research; • It needs huge investment in research funding; • long cycle and • big risks.
Re-innovation after technological import	• Re-innovationIn through improving (foreign) advanced technology and studying and analyzing them; • Shorter time • Fast benefits	• Decreasing R&D funding • Shorten time from research to production • Reducing errors and avoid detours	• Not original innovation; • Hard to catch the results in basic research in the given fields; • May cause "technology development path dependence".
"Pure" technological import	• It is a trans-regional/national behavior. • Higher-technologies (Applicable techs) are imported to start or upgrade manufacture. • Usually it involves mechanical equipment, technical personnel，IPRs, etc.	• Saving R&D funding • Avoid lengthy process of exploration; • Speed up existed technology upgrade and new-tech application; • fast to fill technological gaps; • good for training technical personnel. • promote regional economy in short term.	• Easy to form technology dependence on the outside resources; • may result in gaps in key technological fields; • bad for trying innovative talents and strengthening technology development.

3. Innovation-Research Nine-Quadrant Analysis on Linear Models

Scientific research is the process of exploring unknown fields, using existing knowledge, ,to get new knowledge. Technological innovation arises from applying existing or new knowledge to make new products. Although non-linear model has taken into account that contemporary science and technology have been interweaved in the frontier (Stokes, 1997), the linear model of research/ innovation, exemplified

by Vannevar Bush's, *Science—The Endless Frontier,* has important policy implications. Bush's separation of research into "basic" and "applied" domains has been enshrined in much of U.S. science and technology policy over the past seven decades. Bush argued successfully that funding basic research was a necessary role for government, with the implication that applied research should be left to the auspices of markets. A significant assumption of Bush's work, typically received without attention to the problem focused "challenges" (in contemporary innovation parlance detailed in the appendices chapters on housing, health etc. is that scientific research precedes technological innovation. Thus, the full Bush model is bi-linear: moving in two directions; from basic questions in one direction and addressing major societal issues, in the other.

This study follows the linear model from basic research to applied research to technological development, crosscut with three models of industrial technological innovation, forming a nine-quadrant figure that takes the "Full Bush" model into account rather than only its popular partial version. . Each quadrant presents an "innovation module". Figure 1.

Triple Helix innovation model argues that academia, industry and government are primary actors or "institutional spheres" in innovation. Each institutional sphere can play a role as others. The interactions among them generate "hybrid organizations" such as university science parks, incubators and spin-offs. the power for the three helices evolution is from each of them per se, and also from their interactions (Etzkowitz, 2008) . Nevertheless, we argue that, in reality, each of the spheres acts

differently in different "innovation types" from government to market. In market failure, government must play roles, to fill the gaps, rather than interfere the market. For example, in Quadrant 1 (Q1), basic research and independent innovation are the focus. It is far away from market, government should play roles; while in Q9, ideally government leaves market alone operation, to form and rely on the market mechanism.
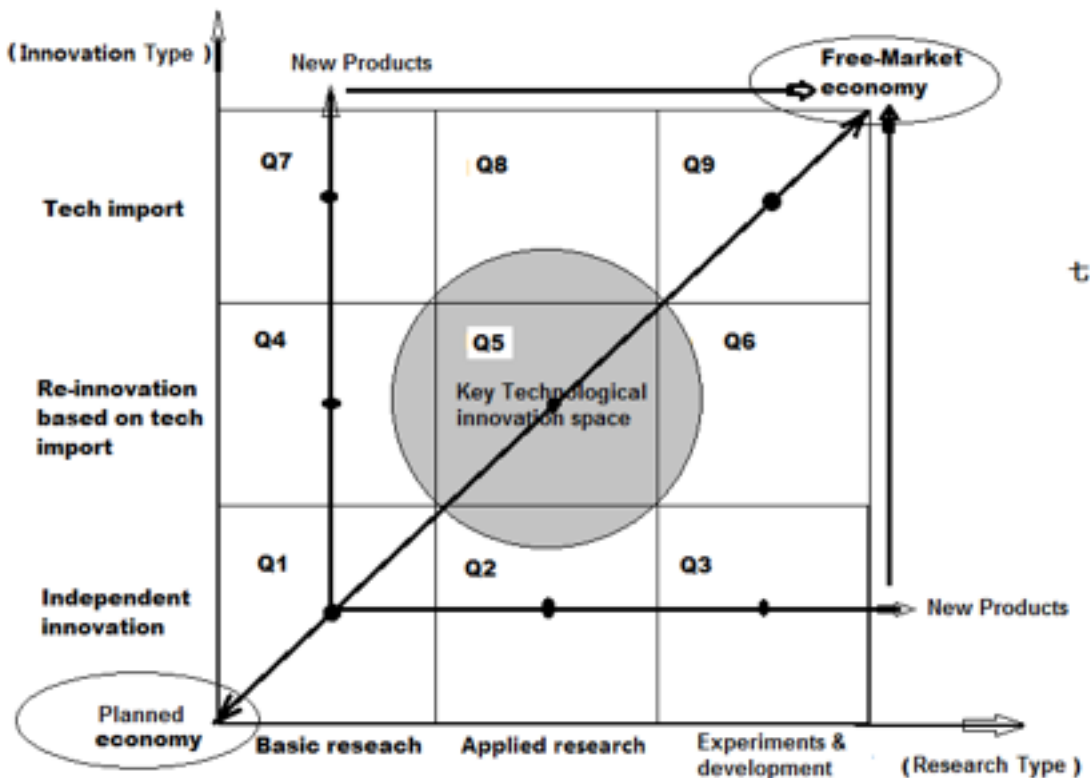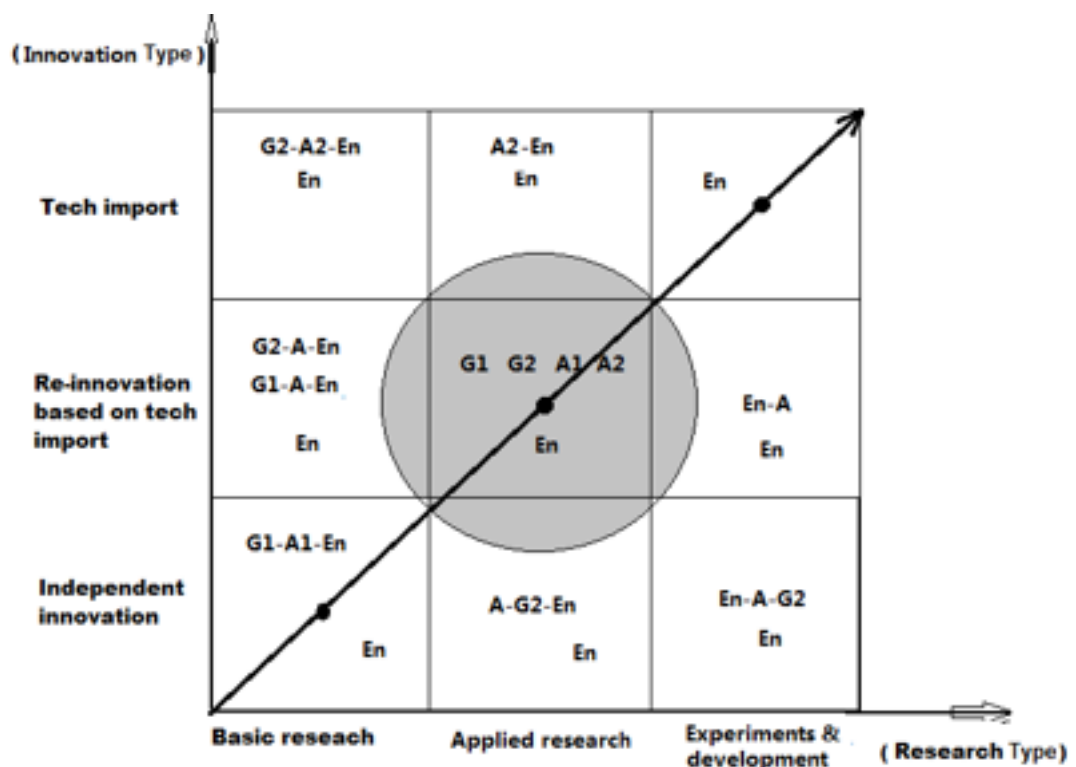

Figure 1 Research-Innovation Nine-Quadrant Picture

Q5 is in the middle of the nine quadrants. It represents re-innovation based on technologies imported in applied research stage. Since the technologies imported have been available to be applied, they are easier to be developed into new products (re-innovation). Generic technology is the focus in Q5 since it would result in fast product development. Technologies in Q6 are closer to the new products than those in Q5, but they are not easy to be imported in lower cost. The same as those in Q8. Therefore, Q5 is a key technological innovation space.

5. Refining the Relationship of the Actors with Technological Innovation Types and Scientific Research Stages based on the Triple Helix Theory

In a regional innovation system, none of the space can be missing. Academia, industry and government as three primary actors interact in the triple helix spaces and form "hybrid organizations " in "hybrid spaces" such as science parks, incubators and high-tech development zones. These hybrid organizations include venture capital firms, media agencies serving for R&D, IPRs offices, technology transfer (license) offices, academia entrepreneurial programs, etc. Some actors bias towards basic or applied research; others emphasize market demand through applied research and products development. All the actors work in innovation space to gain benefits.

Based on analyzing innovation actors above, a nine-quadrant picture with various actors is created to arrange the innovation space. In order to refine innovation actors' roles in different Modules, government is classified into two levels: central and local, called G1 and G2; academia into A1, including research university and national level research institute, and A2, teaching university and local research institute. Enterprises in industries are presented by En. Even though such an arrange seems imprinted with "planned economy", we argue that it has essential policy implication for free or mixture market economy systems. It tells the conductor how to make an innovation symphony. Figure 2.

Figure 2 Research-Innovation Nine-Quadrant Analysis with Innovation Actors

First of all, enterprise is the most primary innovation actor and to provide final results —- new products for market. En thus is put into all the nine quadrants, although innovation actors in a region should include universities, research institutes and government agencies.

Q1, Q2 and Q3 present the actors of independent innovation in basic, applied research and experiments & development stages. In Q1 independent innovation on ground of basic research is pure original innovation by inventors or scientists, involving with key scientific theories and advanced technologies breakthrough. Such "upstream" innovation activity needs strong central or federal government (G1) support through policy or direct funding, working together with key national leading academia and enterprises for specific projects. Q2 means independent innovation but in applied research stage. It needs academia (A) and G2 to work with enterprise (En), in which academia could take the lead. Q3 combines independent innovation with experiments and development, which is a research stage closer to market or final new products. It needs En-A-G2 interactions with enterprise as leading actor.

Q4, Q5 and Q6 present re-innovation based on imported technology/knowledge (re-innovation for short) in basic research, applied research, as well as experiments & development. Re-innovation refers to technology imported. It highlights further understand and analysis on the technology's structure, formula, principles, data, etc., applied these new knowledge to develop similar products or other products. Re-innovation based on technologies imported can the development of existing technology and new products through improving the product structure, process methods, materials, recipes, etc. As the most popular and primary type of innovation, re-innovation is a approach for tech catch-up and fast raising productivity worldwide. To achieve independent innovation through re-innovation in basic research, government in national and local levels must work together with academia and enterprise, i.e., G1-A-En and G2-A-En interactions in the Q4. For re-innovation in experiments & development stage, government can leave it to academia and enterprise, that is, En-A interaction in Q6. The fifth quadrant, referring to re-innovation in applied research, needs all innovation actors interaction, making a triple helix and connecting with market of the emerging products. Technology accumula-

tion through re-innovation has help China's enterprises enhance their capacity in innovation, however, it is not easy to avoid technology path dependence, resulting in key tech missing. Put differently, Q1-3 are not replaceable.

Q7, Q8 and Q9 present to obtain new technology through pure technology import in basic research, applied research and experiments & development stages. This is usually needed by large-scale enterprises in traditional industries. Nevertheless, Q7 may involve G2-A2-En; Q8 just needs A2-En interaction; while Q9 could leave to enterprises alone.

In summary, government first should focus on basic research and independent innovation; and second support re-innovation. Especially in key and core technological innovation, government's support is indispensable. Simultaneously, government should be protector and breeder for competitive mechanism in market. In the area to close market, enterprise should play games in technological innovation. Academia applies new knowledge/technology to help enterprises get new products with potential market. Figure 2 is only one example to show how to use this nine-quadrant method to guide policy and decision makers in the performance of technological innovation in regional industry. One can make own picture for specific region in different countries.

Government and academia not only help enterprise to fulfill technological innovation, but to raise its social responsibility and environment & resources realization together within "public", forming sustainable triple helix in a given region (Etzkowitz & Zhou, 2007).

6. Combination Linear with Non-linear Research and Innovation Models

Innovation embodies the total process of the application of a new idea (Schumpeter, 1911). Following Schumpeter's definition, "An innovation in the economic sense is accomplished only with the first commercial transaction involving the new product, process, system or device, although the word is used to describe the whole process." (Freeman, 1982) Freeman identified four different types of innovation: incremental, radical, technological system innovation and technological revolution or change of techno-economic paradigm (Freeman, 1986).

A uni-direction linear research model influenced by *Science: Endless Frontier* prevailed in the 1950s and 1960s (Godin, 2006) and legitimated post-war American science policy although actual policy was strongly influenced by challenges like Sputnik that produced DARPA and an expanding health research program as a partial substitute for universal health care. Correspondingly , the industrial innovation process was generally perceived as a linear progression from scientific discovery, through technological development in firms, to the marketplace (Rothwell, 1994). It neatly described the commercialization of scientific research as a process moving from scientific research→technology inventions → technology experiments & development → production → marketing products. The critique of this model is that it oversimplified the actual innovation process and did not adequately reflect the increasingly complexity of contemporary technological innovation.

The Linear Model of technological Innovation is an early model of innovation that suggests technical change happens in a linear fashion from Invention (independent technological innovation) to Innovation (technological re-innovation) to Diffusion (technological application). It also priorities basic scientific research as the basis of technological innovation, and plays down the role of later players in the innovation process. The dynamics of the linear model of innovation are often presented: "technology push" and "market pull". From the mid 1960s to the early 1970s, emerges the second-generation Innovation model, "market pull". In this model, the market was the source of new ideas for directing R&D.The` process is market demand—technology development—products manufacturing—sales. A history of the linear model of innovation may be found in Godin (2006).

Kline and Rosenberg's (1986) chain-link model of innovation depicted the innovation process as much more complex, recognizing that the academy does not produce knowledge blindly; nor are firms its passive recipients. Nevertheless, it still kept the linear order, although admitting interactions and feedbacks, reflected by a chain with arrows. The linear models are critiqued as they ignore the many feedbacks and loops that occur between the different "stages" of the process. Shortcomings and failures that occur at various stages may lead to a reconsideration of earlier steps and this may result in an innovation.

Contemporary innovation is increasingly complex with multiple starting points and approaches. Current models of innovation, e.g., open innovation and user innovation, derived from approaches such

as Actor-Network Theory or Social shaping of technology. In the face of skepticism from the military sponsors of artificial intelligence research in the mid 1970's, the head of the computing office in the Defense Advanced Research Program (DARPA) of the U.S. Defense Department concluded that it would be to the mutual advantage of all for the academic researchers to take an interest in their sponsors practical problems. "… the shift will give the university research groups an engineering arm, a marketplace, customers, users. [That] integration will strengthen the basic work because there will be more feedback from real tests of the big new ideas..." (Waldrop, 2001:405). The author of this statement, a psychologist involved in the early development of computer science as an academic discipline, the redoubtable J.C.R. Licklider of Internet origin fame, joined DARPA from MIT, after a stint at Bolt, Beranek and Newman (BBN), a consulting and research firm (Hafner and Lyon, 1996).
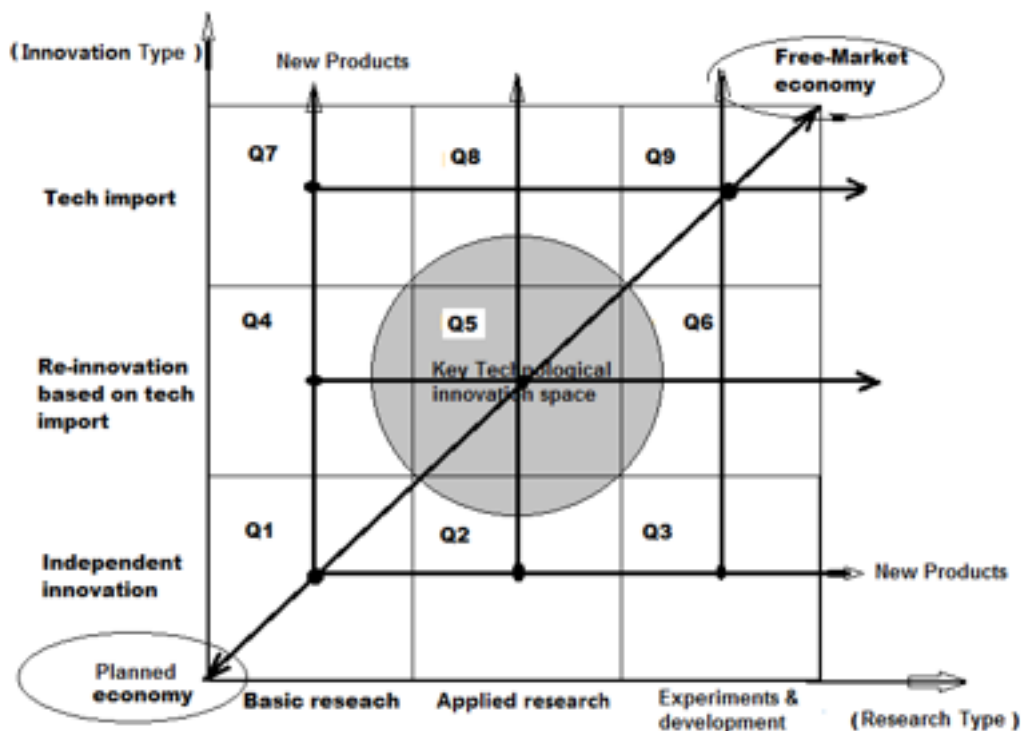
Figure3 Linear and Non-linear Model of Technological Innovation

Nine-quadrant analysis also describes a combination of non-linear and netlike innovation model in which technological innovation may begin from different starting quadrant (Q1-Q9) to the end: new products and market. Therefore, technological innovation is the mixture of all the actors' activities, which can be taken on by the same or different institutions.

6. Policy Implication: Suggestions and Measures for Making Technology Innovation System of Regional Industries in China

Technology Innovation System of Regional Industries is institutional arrangement and relationship network, formed by the connections of innovation actors (government, academia and industrial enterprise) for obtaining innovation resources and carrying on activities. (Zhang, 2013) In a specific system, the process for different system elements to co-evolve and upgrade sets a particular path of a given industry (Malerba, 2002). Technological Innovation system has developed into an eco-innovation system (Chen and Huang, 2014). It undertook the first generation focused on inner R&D, the second on the ground of coordination and integration, the third highly based on strategy and management-oriented, as well as the fourth generation forming innovation eco-system (Chen and Huang, 2014) . In summary, technological innovation system is created by triple helix actors' interactions. Following the nine-quadrant analysis, our suggestions and measures for making technological innovation system in China include:

（1）Strengthening government's role in Q1, the independent technological innovation capability, through basic research, but in both direct and indirect ways. The ability of independent innovation is the core competitiveness of the country. The construction of innovative countries/regions is not only a major strategy decided by china's government, but also an important starting point that china implements innovation-driven development strategy. To develop the capability of independent innovation is strengthening of national innovation networks and institutional interactions, from the viewpoint of triple helix theory, The synergy and competition among universities-industry-government innovation resources is the dynamics for the system to evolve. Government also plays amore role when a region is at risk (Etzkowitz, 2013).

(2) Building the interactive mechanism for different innovative elements co-evolution in Q5, which is still a week quadrant in regional industries of China. This needs sufficient triple helix interactions in the innovation spaces (Etzkowitz, 2008). According to triple helix formation mechanism, from the longitudinal view, the triple helix force presents morphological evolution, that is, every spiral is

constantly improving, seeking their own development, forming a vertical evolution characteristic in a triple helix (Park and Leydesdorff, 2010). From the lateral view, three spheres have shared functions and overlapping institutional areas (Zhou, 2014). These functions and areas consist of a number of flow forming elements, including personnel, information and products. Graduates, new technology researchers, novel ideas and other "products" of colleges and universities continue to output, which are also the most important part of making innovative elements co-evolution. Goods trade, tax, and capital of regional industrial, promote local economic and social development, and the central and local governments provide policies, regulations and funding support and security conditions. The elements must be allowed in between universities, industry and government flow or transfer, forming personnel circulation, circulation of information and product cycles. Moreover, triple Helix interaction is accompanied by three strands of longitudinal and transverse evolutionary spiral cycle implementation, forming the development of different elements positive interaction, thereby promoting technological innovation system of regional industries and its constantly improve.

(3) Focusing on Q4, re-innovation through the digestion and absorption for imported basic sciences and technologies. The generation and change of Triple Helix model occur in knowledge creation, diffusion and use, and the short-board occur in innovation elements, especially high-tech and strategic emerging technologies, we can through the knowledge diffusion and technology used to implement regional industrial technologies to upgrade. Therefore, we should pay attention to digestion, absorption and innovation, but the independent innovation ability has endogenous features. Practice has proved that the effectiveness of the introduction of technology depends largely on the ability to learn and the effort of introduce party. The stronger the ability to learn, to absorb the external technical ability is stronger, the stronger and, thus, better access to independent innovation capability. In the introduction of technology, we must pay attention to enhance learning and absorbing efforts to form an independent product development capacity, to avoid falling into the "introduction - backward - reintroduction - lag further behind" passive situation.

(4) Promoting industrial initiatives in leading innovation projects. Giving full play to enterprises to be the primary innovation actor (working with government and academia). Joint collaborative technological innovation activity is developed greatly, by the respective advantages resources and capabilities, with support of collaborative government, science and technology intermediary service

agencies, financial institutions and other relevant subjects. Enterprises and universities interact to set up technological innovation alliances, to develop industrial key and generic technology, and actively to explore investment and benefit distribution mechanism of industry with university and research institute. application and cooperation in-between planned and free-market economy. The last but equally important，it is indispensable to encourage science and technology practitioners to establish high-technology enterprises (firm-formation).

(5) Playing support roles by government in Q1, Q2 and Q4, guiding roles in Q3 and leaving enterprises alone in Q3, Q6 and Q7-Q9 . Triple helix quantitative studies also demonstrate that government plays the strongest roles in the relations. (Shapiro, 2012) at the beginning of the implementation of regional industrial technology innovation strategy, the government needs to identify the Quadrant in which it is, make its industry development plans, encourage domestic equipment purchase through procurement, establish enterprise risk investment system and create a favorable innovation environment for enterprises and other initiatives, which can guide enterprises to enhance self-development capacity, promote the growth of the industry and economy.

Conclusion

Enterprise is one of the main actors in technological innovation, but not the only actor. Academic institutions and government also play active roles. It has significant implication that these actors "should" performance actively and make contributions in which quadrants and how. It can be summarized that from basic research to applied research and then to experiments & development, government's role (planned economy) should be weaker and weaker; and the same as from independent innovation to re-innovation and to tech import. Academia's role can be depend on their capacities, institutional levels or the ownership. In one word, the actors of triple helix in a given region must be interact reasonably in promoting technological innovation. Technological innovation can start from any quadrant (Q1-Q9) and end to market and new products.

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