

# On the Mechanism of Technological Innovation: As the Drive of Industrial Structure Upgrading

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**Abstract** Under the background of international industrial restructuring and transfer, the optimization and upgrading of industrial structure is taken as a primary objective to achieve a new round of economic growth. From the technical point of view, this paper mainly describes the existing problems of industrial structure in China, compares the advantages and disadvantages of various mechanisms concerning industrial structure upgrading. Moreover, it elaborates on technological innovation with an aim to find out an effective path to improve industrial structure. Finally, some related suggestions to enhance the ability of technological innovation are proposed from three perspectives of country, industry and enterprise.

**Key words** industrial structure, technological innovation, mechanism

## 1 Introduction

In the era of knowledge-based economy, technological innovation has brought enormous development to national economy, which is a fundamental mean to improve products structure, increase products' added value, and strength the competitiveness of enterprises. So it is the main cause to upgrade the industrial structure, as well as the fundamental source of economic growth. The theoretical point of view of technological innovation was firstly proposed by J. A. Schumpeter in the "Economic development theory" in 1912. Since then, the theory of innovation in economic growth had been concerned widely. C. Freeman(1974) established a complete system in "Industrial Innovation Economics," containing a new macro-economics and micro-economics of innovation. It has been selected as a textbook by many universities in Europe and America so far. After Schumpeter, researchers in this field, from different angles and levels, conducted a series of profound studies, and they developed this research into two separate branches: one is the technological innovation theory, mainly consisting of technological innovation and market innovation, another is the organization innovation theory, mainly consisting of organizational change and organizational form.

In the 1990s, more researches on technological innovation have been introduced into China. Liu Yulin (1993) published the first work of "technological innovation economics" in Chinese, starting an in-depth study on technological innovation. With the continuing expansion of the research, Chinese scholars rapidly changed from a purely translation work of the technological innovation theory to empirical research on innovative activities of China's enterprises and the role which these activities will play in the up-grading of industrial structure. Zhou Li (2003) pointed out that technological progress is the leverage of the productive development, and would inevitably cause the industrial structure upgrading. Its role of leverage is reflected in causing demand changes, promoting new industries and technological transformation of existing industries, increasing labor productivity, changing the pattern of international division of labor, and so on. Xiao Yun (2005), Kazuyuki Motohashi (2005) combined the relation of industry development and science and technology with the research of innovation system. They also observed that from 1996 to 2002, the transitional stage of China's innovation system, some enterprises significantly improve their innovative ability, which also played a leading role significantly in the up-grading of industrial structure, through the coordination with universities and public research institutions. Zhao Yulin (2006), in his monograph -"Innovation economics", briefly introduced the history of innovative research, the meaning of innovation, and the basic types and characteristics of innovation. Besides, he analyzed the process mechanism of technological innovation, including process model, evolution mechanism, as well as the driving force of technological innovation;

At present, the researches on technological innovation mainly focus on qualitative analysis, many studies of the relationship between industrial structure and technological innovation are staying on the surface level. Although qualitative analysis contributes to the understanding to the possibilities of certain technological innovation policies, after which we can make corresponding adjustments. However, the theoretic analysis on the Mechanism of the Industrial Structure Upgrading Driven by Technological Innovation is also of great significance to clear the important role that the former plays in upgrading industrial structure.

## 2 The Status Quo in the Evolution of Industrial Structure in China

### 2.1 The Characteristics of the Evolution of Chinese Industrial Structure

During the past 20 years, with the driving of the new tendency of international industrial transfer and sustained high economic growth, the adjustment of industrial structure has made remarkable achievements:

In view of the changes in the ratio of production value accounted for GDP (the revenue structure) within the three industries, an obvious decline has occurred from 28.2% in 1978 to 11.7% in 2006 in the First Industry, while this ratio has been increased rapidly to 39.4% in 2006 in the Third Industry; In view of a change in the structure of labor force distribution, the employment structure tends to become more reasonable: the proportion of labor force in the First Industry declines continuously, accompanied with a steady increase in the Second and the Third Industry; In view of the industrial contribution rate to GDP, a sharp decrease occurred from 41.7% in 1990 to 5.6% in 2006 in the First Industry, while a continuous increase in the Third Industry from 17.3% to 38.8%. However, after having experienced a high growth rate from 1990 to 1995 in the Second Industry, this rate gradually came down to 49.7% in 2002, then rose steadily.

From the three major changes above, we can see that, basically speaking, the overall tendency of the evolution of industrial structure in China is in line with some same general features which can be found in other countries of the world. Besides, we have some other features as follows:

The evolution of industrial structure has been taking the same rhythm as that in the process of industrialization, which means the industrial proportion continually declines in the First Industry, while steadily rises in the Second Industry and rapidly increases in the Third Industry. Because of the different growth rate and contribution rate between different industries, the developments of structure within industries are imbalance.

### 2.2 The Existing Restraining to the Evolution of Industrial Structure in China

Despite of a growing tendency towards rationalization and advancement during recent decades, problems which cause some negative effects on the further evolution of industrial structure still remain:

(1) Level of the industrial structure is low, as well as a structural deviation among the three major industries. In 2003, the proportion of Production Value to GDP regarding the three industries is respectively 14.4%, 52.2% and 33.4%; while an average of 24.1%, 27.4% and 48.5% in low-income countries in the same year. Deviation of industrial structure is gradually becoming the most urgent problem which widely influences economic and industrial development of China. A primary cause for this conflict is that the development of technology lags behind industrial process, which leads to a lack of necessary technical support to the resources and factors transfer from the First and Second Industry to the Third.

(2) The inner structure of industry is unreasonable, which results a structural contradiction. Take the Third Industry as an example. Table 1 lists the Value Added and some formations in the Third Industry in 2005. The datum tell that the development of the Third Industry still mainly based on the traditional service industries, rather than the modern ones. Especially the share of Information Transmission, Computer Services, Software Industry, Scientific Research, together with Technical Services, which play an important role in the industrial advancement, is still low, accounting 3.5% only. Inefficient structure of traditional service industries is unable to meet the needs of industrial upgrading; unbalanced structure of technology deteriorates structural confliction.

**Table 1 The Value Added and Some Formation in the Third Industry in 2005**

The Third Industry	value added ( Billion )	formation ( % )
	7343.29	40.0
Transport, Storage and Postal Industry	1083.57	5.9
Information Transmission, Computer Services and Software Industry	476.80	2.6
Wholesale and Retail Trade Industry	1353.45	7.4
Financial Industry	630.72	3.4
Leasing and Business Services Industry	291.24	1.6
Scientific Research, Technical Services	205.06	0.9

Source: China Statistical Yearbook 2006

(3) There is not sufficient motivation of technology innovation causing a lack of power in sustainable growth. On the one hand, not only does industrial structure based on traditional industries lacks demand for innovation of technology and institution, but also impedes resources from transferring to industries with comparatively high interests; On the other hand, the proportion of Technology-Intensive Industry and the degree of processing, as well as technical level is not high enough. The evolution of industry is confronted with insufficient momentum.

All of the preventing factors above, direct and indirect can be summed up as the imbalance of technical structure and a weak power of Technological Innovation. If we do not actively promote Technological Innovation, the adjustment and upgrading of industrial structure would only be carried out at a low level.

### **3 The Dynamic Mechanism of the Optimization and Upgrading of Industrial Structure**

#### **3.1 The Pulling Mechanism of Demand and Supply**

This mechanism mainly refers to two supporting mechanisms : (1) the mechanism of adjustment of demand structure and demand pull. (2) The balance mechanism between demand and supply<sup>[1]</sup>.

The pulling mechanism of demand and supply provides an adjustment of demand structure and a balance between demand and supply. It can explain the objectives and causes of industrial upgrading. However, it ignores to analyze whether this process can be achieved, and thus fails to clarify its way to realization. Meanwhile the structure of demand is restricted by technology. Even if there are reasonable demands, as long as products that can meet the need are technically unavailable, new industries still won't appear.

#### **3.2 The Driven Mechanism of Comparative Interests**

In this paper, we only take the First Industry as an example to examine the influences of comparative interests on the industrial structure evolution. Comparing with the Second and Third industry, the comparative interests of the First industry are a bit low, which determines the ratio of income to labor force input to be reducing. The lower income elasticity of agricultural products renders diminishing returns of scale. So with the driven of comparative interests, agricultural factors will transfer largely to other industries<sup>[2]</sup>.

The driven mechanism of comparative interests mainly focus on the changes in relative price (cost) of industrial products, and how the transformation of relative advantages and disadvantages will affect industrial structure as a result of these changes. It can explain the direction and tendency of structural evolution. However, such a mechanism has not fully explored whether this process is reasonable. And the efficiency of transferring comparative interest, to some extents, depends on the speed of technical progress<sup>[3]</sup>.

#### **3.3 The Pmechanism of Policies and Institutions**

The realization of this mechanism lies in a reasonable and effective adjustment of industrial policies and regulating mechanism of industrial structure. On the macro level, it mainly refers to improving the performance of industrial environment; on the industrial level, coordinating industrial structure; on the micro level, adjusting industrial organization, guiding enterprises to achieve economies of scale and effective competition as well.

The promoting mechanism of policies and institutions reflects guidance and a macro-adjustment of government, which provides policy protection over the upgrading of industrial structure. However, there exists a lack of analysis regarding the factors inner industry. Moreover, only when policies satisfy the need of demand as well as improve effectively the flow of technology, can it promote the upgrading of industrial structure.

#### **3.4 The Leading Mechanism of Technological Innovation**

This mechanism mainly explores a tight inter linkage between technical structure and industrial structure. From the view of technical progress, it concentrates on how innovative activities to improve technical structure of traditional industries on the base of a new combination of production factors. A more detailed analysis will be conducted in the next part.

### **4 The Path in Which Technological Innovation Improves the Industrial Structure**

#### **4.1 Technological Innovation Stimulates Market Innovation, So As to Conduct and Change the Structure of Supply and Demand**

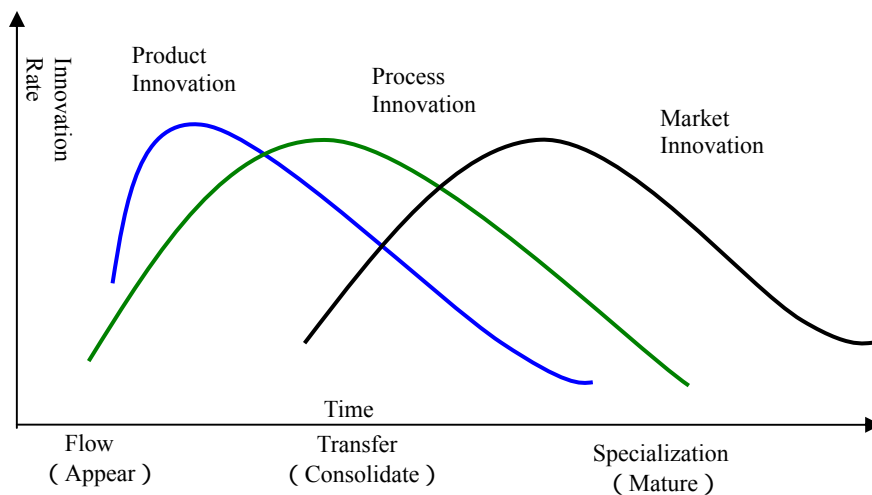
Processes and products being innovated through innovative technologies, thereby creating a market,

Technological Innovation is a process of commercialization of new market factors that are transferred from resources and knowledge. Figure1 describes the relations between Market Innovation and Technological Innovation<sup>[4]</sup>.

Market is a sum of supply and demand. While product innovation and process innovation create a new supply, they conduct and affect demand by creating new markets and changing the market structure.

(1) Technological Innovation creates new demand to upgrade the industrial structure. Technological Innovation may lead to economic growth, industrial development and the people's living standards improvement, thus brings about a new pressure to demand. On the one hand, introducing new technologies and recombining existing technologies can reduce production cost. And technical progress is also conducive to lowering consumptions of resources, increasing the availability of alternative resources and therefore changing the demand structure of production. On the other hand, product innovation tends to upgrade consumer goods, thus changes demand structure for consumption.

(2) Technological Innovation varies supply to upgrade industrial structure. Firstly, from an overall point of view, Technological Innovation leads to the improvement of social labor productivity, thus constantly deepens the industrial division of labor. An optimization in technical structure can relieve internal structural contradictions effectively as well. Secondly, Technological Innovation promotes the transfer of resources among industries. It enhances the efficiency of the uses of resources and brings changes in comparative interests among industries. Resources being flowing from the industrial sectors with a low comparative interest to those with a high comparative interest, industrial transfer receives efficient technical support. Meanwhile, reconstruction of the factors among industries, such as labor, equipment, capital, etc. will create new values, as a result of which the structural deviation of the three major industries can be meliorated. Thirdly, Technological Innovation can change the means of production, promote the division of labor, and change labor structure.



**Figure 1 The Relations Between Market Innovation and Technological Innovation**

From the analysis above, we can see that Technological Innovation impacts on the input and output condition of an industry at both sides of the supply and demand, as well as the allocation of production factors, together with conversion efficiency, and, thereby effectively improves industrial structure toward advancement.

#### **4.2 Technological Innovation Requires Institutional Innovation to Achieve Policy Adjustment**

The promote mechanism of policies and institutions mainly relies on institutional innovation. While institutional innovation and Technological Innovation are highly related: benefits of Technological Innovation are obtained through the application and spread of technology; institutional innovation is trying to improve the operating efficiency of technology, which determines the effectiveness of incentive mechanism.

The interactive process of Technological Innovation and institutional innovation consists of three main aspects: Firstly, institutional arrangements create good conditions for Technological Innovation. Varieties of formal or informal institutions provide incentive measures and a good policy protection to Technological Innovation with. Rational institutional arrangements also accounts for flow of

information and transfer of factors that originate technical progress, which can lessen uncertainties during the process of Technological Innovation. Secondly, not only does Technological Innovation require companies to adjust institution, but also it requires industry's institutional innovation. Institutional arrangements of industry will help to remove the technological transfer obstacles, and to improve the flow efficiency of technology. Thirdly, Technological Innovation, together with institutional innovation, promotes industrial growth. At every stage of enterprise's growth and industry's development, never can it be separated from technological advances and institutional policies.

Technological Innovation provides a foundation for institutional innovation through the accumulation of knowledge and technology; the later creates a perfect institutional mechanism and a liberal policy environment for the evolution of industrial structure. Therefore we can say that it is the interaction mechanism of Technological and institutional innovation that promotes further development of industrial structure adjustment.

#### **4.3 An Overflow and Spread of Innovative Technology Induces the Transfer of Comparative Interests**

Overflow and spread of innovative technology, either from Imitative Innovation or Independent Innovation, is a course of replacement in which old technologies are substituted by the new. When an innovative technology is being comprehensively commercialized, it will be inevitably accompanied with a spillover of innovation and the transfer of comparative interests. The externality of Technological Innovation is just manifested by these effects. The spillover and diffusion effect of Technological Innovation plays the role in two ways:

Firstly, this effect is evident when innovative activities of upstream industries deliver an impact on downstream industries. Normally, if institutional innovation can ensure a highly effective transfer of technology, then innovative activities of upstream industries can contribute to improving the existing technology and production process of downstream industries, which will bring about the rise of comparative advantage, too.

Secondly, this effect mainly operates as high-tech performance conducts technical reforms on traditional industries, which can be realized through learning, technology transfer and other supporting effects like relation and infiltration. Let's analyze this in detail:

Learning effect of traditional industries to high-tech industries refers primarily to a process that traditional industries with a relatively good technical foundation gradually learn and absorb technologies spilt over from high-tech industries. However, if these technologies are too complex and difficult for the former to grasp, that is to say the technology gap is difficult to bridge, and then learning effect won't be easily obtained. This also forms as a bottleneck in the development of traditional industries in China.

Technology transfer from high-tech industries to traditional ones refers to the fact that the former, by some means, transfers proprietary technologies to the latter, so as to realize commercial value of technology. Through this transfer, traditional industries are usually able to share R&D and technology accumulation with high-tech industries at a lower cost, thereby optimize technical structure.

The effect of relation and infiltration between traditional industries and high-tech industries makes it possible for innovative technologies and products to infiltrate into the former. Through introducing new technologies, new processes and new equipments, the former can improve more effectively production conditions, resulting remarkable changes in product structure, technology level, even in industrial structure<sup>[5]</sup>.

The transfer of innovative technologies brings about the transfer of comparative interests within and outside industries. This spillover and diffusion effect of Technological Innovation elevates comprehensively the overall level of technology in a certain industry; technical progress thus upgrades comparative interests, figured by the improvement of competitiveness. Subsequently, industrial structure will evolve towards a higher level.

#### **4.4 Technological Innovation Improves the Core Competitiveness of Enterprises Within Industry**

Technological Innovation highly relies on the qualities and conditions of enterprises and takes effects ultimately through the improvement of core competitiveness of enterprises within industry. On the one hand, Technological Innovation improves supply source for an enterprise. Product innovation achieves the development of new products, improves existing products, and optimizes product structure of variety; process innovation improves quality, increases the technical content and added value, as well as optimizes the product structure of quality; reorganizing production factors improves productivity, and creates new market. At the same time, technical progress enables enterprises to provide high-quality products with a lower cost, so as to better meet profound changes in structure, level and content of social

needs. On the other hand, the improvement of Independent Technological Innovative Ability of an enterprise will effectively promote comprehensive capacities such as access to information as well as organization and management.

The enhancement of Technological Innovation Ability can effectively help enterprises to cultivate core competitiveness. Therefore, from the objective perspective, Technological Innovation can be considered a primary means for a modern enterprise to improve its competitiveness and pick up sustainable development, which serves as a direct impetus for the optimization and upgrading of industrial structure.

To sum up, it is a result of interaction of many factors for Technological Innovation to upgrade industrial structure: on the one hand, the expansion of social needs is the base of formation of industry, and also sets forth new requirements on Technological and Institutional Innovation; Any adjustments of policies and institutions made to the conditions of new demands can effectively improve the mobile efficiency of innovative technologies among industries; Transfer of comparative interests, supported by policies and institutions, guide the direction of technology transfer. On the other hand, Technological Innovation has an effect on the structure of supply and demand, policies and institutions and comparative interests as well. Based on relationship and interaction among these factors, industrial structure evolves towards a higher level<sup>[6]</sup>.

## 5 Conclusions

It's an interactive system for Technological Innovation to upgrade industrial structure. Technology Innovation, coordinated by Institutional Innovation, will improve validly the transfer efficiency of technologies among industries, reconcile the structural deviation of the three major industries, and improve industrial level. Structural optimization of technology is an effective way to ease the internal structural contradictions and help to realize industrial structure advancement. In addition, the upgrading of Technological Innovation Ability will also be favorable for alleviating the so called "Insufficient Effective Demand" caused by the problem that development of industry lags behind consumption and production, and eventually enhances the economic benefits of industrial structure.

Under new situations, Chinese government takes readjustment of industrial structure as a primary aim of realizing a new economic growth and a Leapfrogging Industrial Development. The optimization and upgrading of industrial structure is of great significance for enhancing competitiveness of enterprises, industries and the overall nation. Therefore, governments should establish a National Technological Innovation System to provide technical foundation and institutional protection for Technological Innovation. Industries should construct an Open Technological Innovation System to promote generation, transfer, renewal and transformation of new knowledge or new technology within industries. Meanwhile, we should join in the Global Production Networks, and create knowledge-sharing and interactive learning opportunities to provide a much broader range of resources for Independent Innovation. Enterprises should set up an interactive mechanism of "Integration of Imitation Innovation and Independent Innovation" and "Demand-Led Innovation and Innovation-Recreated Demand"<sup>[7]</sup>. By utilizing Public innovation Platform, we share benefits of spillover and diffusion of innovative technology to improve a comprehensive competitiveness.

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