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Studies of Evaluative System on the Scientific and Technological Innovative and Managerial Ability -- Based On the Malmquist Productivity Index Approach

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Abstract: *This paper first sets up the evaluative system on enterprises' scientific and technological innovative performance based on the Malmquist productivity growth index, and then combined with the innovative environmental factors, such as networking effects, to build a more realistic and feasible evaluative system on the regional scientific and technological innovative performance. Finally, the paper decomposes the analysis into subcomponents of scale effect, technical effect and other relevant factors that determine the competitiveness of innovative activities. It is suggested that the scientific and technological innovative activities and innovative management of enterprises and regional development be not only of long-term strategic significance for the sustainability and development of the society, and for the enhancement of the core competitiveness of the enterprise, but of practical significance for the promotion of economic benefits as well.*

Keywords: *Innovative Management, Productivity Growth, Performance Evaluation, Malmquist Productivity Index, Total Factor Productivity.*

1. INTRODUCTION

Along with China's economy grows gradually from fast development to the direction of innovative and sustainable development, at the same time, the economy also confronted a lot of social problems, such as over-speeded economic growth, serious environmental pollution, unbalanced economic development, and insufficient core competitive capacity of industrial enterprises. All these problems are closely related to some degree with the insufficient scientific and technological innovative capability of enterprises. And poor innovative ability can affect the society's aptitude towards enterprises' operating performance, and ultimately affect the sustainable development of enterprises and even the entire society. Therefore, paying more attention to scientific and technological innovations is of great importance to improve enterprises' core competitiveness, and is a necessary way to realize sustainable development of the society.

Scientific and technological innovation refers to the process that enterprises and individual creators apply new knowledge, new technology and new craft, adopt new mode of productive or operational management method, research and develop new products, and provide new services. Scientific and technological innovation involves government, enterprises, research institutes, universities of high education, and many more other social and economic main bodies, including innovative talents, capital investment, research bases, intellectual property, policy stipulation, innovative environment, and many other factors. It is an open and complicated system that the innovative subjects, creators, and other innovative elements are closely intertwined and interacted with each other. Scientific and technological innovation generally includes knowledge innovation, technical innovation, product innovation and managerial innovation, and etc.

Scientific and technological innovation is the prerequisite of realizing sustainable development, an important way to improve efficiency of resource utilization, the dominant force in optimizing the industrial structure, which in turn is an important driving force to improve the comprehensive operating performance of enterprises. With the development and improvement of the marketable economy, scientific and technological innovation becomes enterprises' main focus, and also becomes their important means to escalate the core competitiveness, and thus to obtain competitive market advantage. Because of this, properly evaluating the level of enterprises' scientific and technological innovative capacity is of particularly importance and becomes an urgent matter at present.

The evaluation of enterprise's technological innovative performance includes evaluating the management of innovative abilities, which can be decomposed into the management of innovative inputs, the management of innovative transformation ability, the management of innovative outputs, and other relevant sub-components. Innovative managerial ability is a bridge connecting the innovative input and output. Whether inputs of research and development (R&D) achieve innovative targets depends, to a great extent, on innovative transformation and management capacities. Therefore, in this sense, it is considered to be incomplete to evaluate the enterprise's scientific and technological innovative capacity without evaluating the innovative managerial ability, which is not only of great significance to improve the enterprise's competitiveness, but playing an important role in training and bringing up a large amount of innovative entrepreneurs as well.

The scientific and technological innovation through the mechanism of innovative management ultimately contributes to increase enterprises' efficiency. No matter what perspective we may refer to evaluate the enterprise's science and technological innovative ability, it finally nails down to increase economic profit and market competitiveness of enterprises, which can be considered as a fundamental starting point and an ultimate goal as well. In short, we can use the profit growth rate of revenue and productivity growth index as measuring tools to evaluate the enterprise's scientific and technological innovative level and its innovative managerial capability.

The scientific and technological innovative activity is the key to the enhancement of enterprises' competitiveness, as well as the source to the everlasting sustainable development. However, under the situations when the economy gradually evolves into the global market, regional divergence is increasingly enlarged, and the competition among enterprises becomes forcefully fierce ever before, how to make the enterprise's innovative management combined organically with the external innovative environment, including universities of high education, scientific and technological research institutes, and governmental innovative agencies, to form a regional innovative mechanism and in turn to research and build the regional innovative evaluation system, has become both theoretical and practical issues at hand. Solutions to these questions help to promote cooperation and linkage of regional economic development, and accelerate the sustainability of macroeconomic development. Therefore, this paper first constructs the evaluation system on the enterprise's scientific and technological innovative performance based on the Malmquist productivity growth index, and then combined with the regional innovative environmental factors, such as networking elements, to build a more realistic and feasible evaluation system on the regional scientific and technological innovative performance. Finally, the paper decomposes the analysis to study the subcomponents of scale effect, technical effect and other relevant factors that determine the comprehensive ability of the scientific and technological innovative activity and management.

2. RESEARCH REVIEW

The evaluation method of scientific and technological innovation has attracted great attention since the 1990s, and after entering the 21st century, it has been used widely in the academia. According to the contents of different methodologies, there are mainly three aspects that can be researched on: the scientific and technological innovative ability, the regional innovative ability, and the national innovative ability. Methods adopted in the study of the scientific and technological innovative evaluation mainly include the balanced scorecard method (Kaplan and Norton, 1992), the data envelopment analysis (DEA) (Charnes and et al., 1978; Liang and et al., 2006; Zhong and et al., 2007), the multi-level analysis (Tang and et al., 1999; Dong and et al., 2009; Yang and et al., 2012), the network analysis (Hadjimanolis, 1999; Higgins and et al., 2002), the method of efficacy system (or Delphi method), the fuzzy comprehensive evaluation method (Xu and et al., 1997), and etc.

The balanced scorecard method first proposed by Kaplan and Norton adopts the financial and non-financial indicators of enterprises, including appraisal indicators from the auditory perspective, to combine with and contrast to the enterprise's visions and development strategies, therefore to establish the evaluation system on the comprehensive performance of the enterprise. The method of data envelopment analysis adopts the index system with non-dimensional multiple inputs and multiple outputs to measure the effect of scientific and technological innovative development. The artificial neutral network evaluation method is a kind of intelligent data processing method, which requires a large amount of sample data to perform a self-learning and self-organizing training process, so its practical usages are quite limited. On the other hand, the grey comprehensive appraisal method focuses on researching the uncertainty of the system with objective information that is partially known and partially unknown, so its applicability to evaluating the enterprise's innovative management performance is also subjected to certain constraints. The efficacy systematic method requires determining a satisfactory value as well as a non-allowance value when evaluating each indicator, then assigns a score to the index through an expertise's investigative procedure, and finally provides the comprehensive evaluation of innovative ability after aggregating the weights of these indexes. In the last method of fuzzy comprehensive evaluation, it quantifies the qualitative indexes based on hierarchical analysis to evaluate the level of enterprises' innovative management performance, to research and distinguish different enterprises' situations, and to arrange them in different positions. This method also requires to solve the value and weight of innovative factors and to rank them in a hierarchical order. Therefore, both of the last two methods are hard to overcome a serious shortcoming of arbitrary judgment.

Alternatively, the above research methods can be further summarized into two major categories: (1) the objective evaluative method, and (2) the subjective evaluative method. The empirical datasets for the objective evaluative method are mainly sourced from historical data themselves, usually come from systematic analysis of enterprises' historical input and output data, for which it includes the balanced scorecard method and the data envelopment analysis discussed above. This kind of methods focuses on efficiency-oriented evaluative research, paying much attention to the improvement situation of enterprises' innovative activities and influential power of enterprises' competitive advantage. However, such method contains less information, thus when researching on the process of enterprises' innovative activities it still retains certain limitations, but it is widely adopted in the application of the industrial and regional innovative evaluation. In the subjective evaluative method, on the other hand, empirical datasets mainly come from an expertise's scorings, for which it includes hierarchy analysis and efficacy systematic method. Such analyses focus on the process of innovative activities and the degree of participation, thus provide more information that facilitates studying thoroughly on the insight of structure and strength of enterprises' innovative activities.

From perspective of the content of research, the literature in recent years both domestically and overseas of the innovative ability evaluation largely focuses on the study of building and designing the structure of index system evaluating on enterprises' innovative ability. But the literature studying on the appraisal system for the regional and national innovative ability is much less, in addition, even for studying the process of constructing the appraisal system of innovative ability, there is little on the decomposition analysis of scale effect, technical effect, and other relevant components of the innovative ability. Zhu and et al. (2010) and Peng and et al. (2012) use the data envelopment analysis method to study the appraisal analysis of innovative ability and innovative efficient levels. But their research basically remains at the enterprise level. Fan and et al. (2002), Zhu (2004), and Wang (2010) have studied the evaluative index system of the urban and regional scientific and technological innovative ability, but their research mainly analyzes the organic structure and filtering method of the appraisal index system.

In fact, innovative efficiency is directly involved in efficient allocation of resources, which affects the function and efficacy of the scientific and technological innovative resources. That is to say, the innovative efficiency to some extent has an influential on the process of building the innovative policy scheme. In this sense, to research and evaluate on the innovative efficiency and its determinant factors is necessarily of practical importance. Therefore, based on the principle of constructing the Malmquist productivity growth index, this paper studies the appraisal system on the innovative and managerial capability of innovative enterprises, and further analyzes the appraisal system of regional scientific and technological innovative and managerial ability, as well as performs comparative analysis of innovative efficiency and its decomposition factors among different regions. As a result, these studies lead a way to escalating regional innovative efficiency and provide a theoretical basis as references to the decision-making.

In summary, the Malmquist productivity growth index measures and compares the change of efficient level among different agencies and authorities, based on the construction of multiple input and output production technology, and thus in turn the index system of comprehensive economic growth strength. As an extension, this study also provides a helpful research method to analyze the industrial and regional innovative capacity as well as the change of economic strength and market competiveness in a more broad sense.

3. RESEARCH METHOD

As early as in 1953, Sten Malmquist proposed to use distance function to build the productivity growth index, for the purpose that it can get rid of using the price of productive factors. This is because that the distance function is regarded as basic elements in defining the Malmquist productivity index, representing for the productive technology expressed as multiple inputs and multiple outputs. One obvious advantage of production technology expressed by this form is that the production set only depends on the number of input and output with no need to consider their prices. Caves and et al. (1982) and other scholars introduced and adopted the method, named the Malmquist productivity growth index after economist Sten Malmquist. Regarding the level of output as benchmark, Malmquist productivity growth index as a productivity indicator measures the production efficient level.

To define the Malmquist productivity index, we must specify two different periods, noted as t and t+1. In order to avoid choosing either period as a starting point when defining the output-based Malmquist productivity index, we must take a geometric mean of any two consecutive time periods of productivity indexes. A specific expression is shown as follows:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right)\left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}}. \tag{1}$$

On manipulating the above expression, it can be further rewritten as the following form:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}}. \tag{2}$$

By the second expression, the Malmquist productivity index can be broken down into two components: efficiency change (EFFCH) and technological change (TECHCH). The component outside the bracket represents for the efficient change, which describes the relative effect of efficient increase from backwards, or sometimes called “catch-up” effect; and the component of geometric mean of two fractions inside the bracket captures the cutting-edge change of technology between two consecutive periods, or sometimes called “technical innovation” effect. In the sense, the Malmquist productivity index can be intuitively expressed in words as follows:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = EFFCH * TECHCH. \tag{3}$$

Where, EFFCH represents for efficiency change, and TECHCH represents for technological change. Besides, the efficiency change can be further decomposed into two sub-components of scale effect and pure-technical efficiency effect. That is,

$$EFF = SCALE * PEFF. \tag{4}$$

Where, EFF represents for the efficient level and SCALE and PEFF measure the levels of scale efficiency and pure-technical efficiency in the measurement of efficient change, respectively.

Based on the above illustration of the principle of Malmquist productivity index, the study of this paper investigates and sets up the appraisal system analyzing on the comprehensive capability of scientific and technological innovative and managerial activities.

3.1. Issues of Innovative Evaluation Research

There are a lot of specialties and limitations about researches on the scientific and technological innovative and management evaluation, which are generally reflected in the following aspects: (1) the inputs and efforts of scientific and technological researchers cannot be directly observed. (2) The innovative outputs and performance cannot be directly quantified, although in the process of research and development, some indicators have been carried on a quantitative process, but still cannot eliminate the influence of subjective effect. (3) The innovative outputs of science and technology often require sparing a long period of time to realize subjective outcomes. To a large extent, they have a high level of unpredictability and thus cannot be controlled timely. Therefore, the research of scientific and technological innovative and managerial ability needs to focus more on analyzing the effectiveness of innovative investment and the integrity of evaluative system. The data envelopment analysis (DEA) is a commonly used method for evaluating efficiency that can effectively compensate for some disadvantages of current evaluative methods, and can be further used to analyze determinant factors of efficient change brought with innovative activities. Therefore, after considering that enterprises use the scientific and technological innovative resources as investment, we can apply the Malmquist productivity index with data envelopment analysis to build the appraisal system of innovative and managerial ability for enterprises, as well as to make a systematic analysis of sub-component factors, such as innovative resource allocation, technical transformation, profit performance and other elements of comprehensive competiveness.

The scientific and technological innovative performance is reflected by the efficient use of inputs and outputs. Well-performed scientific and technological innovation has a high level of efficient ratio that inputs can be produced into outputs. The influence of innovative activities on the enterprise's outputs can be divided into three categories of economic benefit, social benefit, and technical benefit. The economic benefit represents for the profitability of the enterprise's production operation, the social benefit results from the interaction between the enterprise and its external surviving environment, and the technical benefit is directly the consequence of the innovative activities, represented by new patents, new technologies, and new products and so on. In this regard, technical benefit is a kind of process performance, which can be considered as an intermediate stage of the entire innovative process that makes an important contribution to the business success. However, the enterprise's overall economic benefits also depend on the role of scientific and technological innovative and managerial capability. And most importantly, the method of efficient study with input-output analysis can effectively take these two stages into account simultaneously.

Traditional performance evaluation mainly analyzes the enterprise's net income by comparing the difference between the cost of operation and the revenue of product sales, for example the cost-benefit analysis. But in order to consider the enterprise's efficiency of utilizing production resources as well as the investment of technological innovative inputs, we may use the Malmquist productivity growth index to assess the enterprise's profit performance, referred to as "the productivity growth index of the scientific and technological innovative and managerial capability". Due to the innovative resources of science and technology as production inputs unable to use standard prices of measuring mechanism, we introduce the "input-output distance function" as basic elements to construct the "productivity growth index of scientific and technological innovative and managerial capability". For this purpose, we must first set up the "distance function of scientific and technological innovative production" before computing the productivity growth index of scientific and technological innovative and managerial ability. Then, we compare each enterprise's production to the benchmark of technological frontier, thus to calculate the innovative productivity index as a measure of the enterprise's ability of the scientific and technological innovative level. In this perspective, the distance function that reflects the scientific and technological innovative and managerial capability is the key of the issue, for which it introduces the innovative resources and innovative management skills into the production operating system as input costs, in order to set up the innovative input-output production frontier, and finally to calculate a series of innovative productivity indexes reflecting the comprehensive competiveness of the enterprise's operating performance.

When calculating the distance function of innovative ability, we apply two-stage optimization theory, that is, first to adopt a non-parametric linear programming technique to recuperate each enterprise's production technology, and then to utilize the parametric function of logarithmic variation (Translog) form to estimate a production technological frontier that is both the most smooth and appropriate to the actual experiences.

3.2. Framework of Innovative Evaluation

The evaluative system of enterprise's technological innovative ability is a very complicated project, which is involved in every branch of an enterprise and affected by many factors that are intertwined and interacted with each other, so it is necessary to completely and accurately examine each factor while researching on the evaluation of the innovative ability. In general, the innovative production process of the enterprise from innovative input investment to the output can be divided into three phases. The first phase is the investment of innovative infrastructural basis, or called the innovative input stage, for which it includes investments of research and development (R&D) personnel and the R&D expenditure, in addition to the original scale of the enterprise with labor and capital accumulation and stock of knowledge that support the innovative development. The second or middle phase of innovative process is the innovative conversion or technical transformation stage, which is a critical step that bridges the linkage between the innovative inputs and technically new products. In this stage, whether the innovative investment can achieve the anticipated goal mainly depends on the technical transformation rate and the innovative managerial ability, which can be measured by some innovative indicators such as the number of new products, new patents and technical transformation rate. But the consequence of this stage is only considered as an intermediate performance of the innovative production process. Besides, the innovative management ability has an influential effect and thus plays a decisive role in determining the innovative transformation ability in the stage, mainly including innovative incentive mechanism, property right scheme, and organization and coordination capacity. The third or final phase of the innovative process is the stage of industrialization of new products and innovative output stage, in which all sorts of innovative input elements are combined effectively with enterprise's management ability to produce profitable revenue and income with marketable new products. As a result, this stage not only reflects the innovative performance of new products, but also signifies a symbol of enterprise's successful innovative management skills. This is because, by the means of scientific and technological innovation, the enterprise raises the productive efficiency, eventually translates into increased earnings, and at the same time the competitiveness of the enterprise is increased. Simply to put, we can investigate the comprehensive economic indicators of the enterprise, such as economic benefits (i.e., profit growth rate) and market competence (i.e., market share) to reflect the final result of innovative activities.

Finally, when evaluating the regional scientific and technological innovative and managerial ability, we must also consider the support of regional innovative network, government policy, and other innovative environment that has impacts on the regional innovative ability, since these factors together with other innovative activities of enterprises, as well as the management process, will necessarily affect the innovative efficiency as well as that the innovative outputs can be transformed from resource inputs of the society. So, the main contents of innovative network include internal division and cooperation among production sectors, institutional bodies, and research agencies, and their interactive impacts with each other. Because there are many different entities within a region, their interaction has a network effect, and regional innovative ability is just the reflection of innovative network effect. On the other hand, regional innovative ability and environment have a counteractive effect on each private entity. That is to say, the collaboration among different individual bodies is an only way to achieve the integrity of regional innovative system. Generally, private entities provide the micro-basis for the regional innovative system, and government agencies provide the macro-policy support for the system, creating a well-developed innovative environment is a necessary prerequisite for setting up the regional innovative system and thus in turn creates a good external surrounding for the development of innovative capabilities.

4. EMPIRICAL RESEARCH

4.1. Data Sources

In this paper, the empirical research is mainly aimed to study China's 30 provinces and four directly affiliated municipalities, as well as the eight geographical economic zones. According to the geographical standard of division by the national bureau of statistics, the eight natural economic zones include those of the Eastern Coast region, the middle reaches of Yellow River, the middle reaches of Yangtze River, the Northeastern region, the Northern Coast, the Northwestern region, the Southern Coast, and the Southwestern regions. Basic measurements of input and output indicators for various provinces and municipalities are come from the China's Economic Statistical Yearbook, the China's Regional Economic Statistical Yearbook, and other official publications that provide records of the historical panel data. And innovative input and output indicators are come from the China's Patent Statistical Yearbook issued by the National property Office, and the China's Statistical Yearbook of Science and Technology issued by the National Bureau of Statistics and the Ministry of Science and Technology, and other official publications with relevant data sources.

Finally, we introduce the general accepted GAMS computer programming software and SPSS statistical software to process and analyze the original datasets, calculate the scientific and technological innovative productivity growth index of China's 30 provinces and four directly affiliated municipalities for recent seven years from 2006 to 2012. Besides, we also discuss the scale effect, technological effect and other internal factors that take the role in determining the change of innovative performance.

4.2. Empirical Results

After more than 30 years of reform and opening-up and the development of sustained economic growth, China's economy has gradually stepped into the stage with relatively steady growth. From the time period between 2006 and 2012, as for the nationwide 30 provinces and four directly affiliated municipalities (except Tibet province without complete datasets during the period), the Malmquist productivity index of the scientific and technological innovative and managerial ability grows at an average of 0.86% yearly for six years, much close to those of the national industrial sectors. According to China's geographical economic regions with the descending order of innovative productivity, the innovative productivity index of the eight economic zones are 1.79%, 1.35%, 1.16%, 0.89%, 0.57%, 0.49%, 0.22%, and 0.21% for the middle reaches of Yangtze River, the Southwestern region, the Southern Coast, the Northern Coast, the Northwestern region, the Northern Coast, the Northeastern region, and the middle reaches of Yellow River, respectively. The national top five provinces and directly affiliated municipalities with fastest increase in innovative productivity growth are those of Anhui (2.9%), Neimenggu (2.65%), Gansu (2.63%), Heilongjiang (2.15%), and Sichuan (2.09%), respectively. However, the top five provinces or municipalities that define the innovative frontier technology according to the innovative distance functions are those of Shanghai, Guangdong, Hainan, Hebei, and Shandong, respectively, which are different from the previous five provinces. That is to say, the innovative productivity of the previous five provinces increases much fast than the frontier and other provinces, exhibiting an obviously catch-up trend. The specific results are shown in details in Table 1 of the China's Innovative Productivity Growth Index.

Table 1: Innovative Productivity Growth in China (2006-2012)

Region	Province	Productivity Growth	Efficient Change	Technical Change	Distance (order)
Northsea	Beijing	-0.0085	0.0033	-0.0021	0.7282 (14)
	Tianjing	0.0149	0.0563	-0.0198	0.7416 (10)
	Hebei	0.0117	0.0695	0.0035	0.7782 (04)
	Shandong	0.0014	0.0363	0.0012	0.7760 (05)
Regional Average		0.0049	0.0414	-0.0043	0.7560
Northeast	Liaoning	-0.0032	0.0250	0.0055	0.6078 (28)
	Jilin	-0.0118	0.0109	0.0201	0.6122 (25)
	Heilongjiang	0.0215	0.0737	-0.0220	0.7503 (08)
Regional Average		0.0022	0.0365	0.0012	0.6567
Northwest	Gansu	0.0263	0.0854	-0.0254	0.6773 (19)
	Qinghai	0.0077	0.0463	-0.0093	0.6779 (18)
	Ningxia	-0.0161	0.0046	0.0247	0.6259 (24)
	Xinjiang	0.0047	0.0310	-0.0147	0.7203 (15)
Regional Average		0.0057	0.0418	-0.0062	0.6754
Mid-Huanghe	Shanxi	0.0099	0.0532	-0.0084	0.7621 (06)
	Neimenggu	-0.0265	-0.0178	0.0332	0.7391 (11)
	Henan	0.0140	0.0654	-0.0073	0.6994 (17)
	Shannxi	0.0111	0.0546	-0.0087	0.6088 (27)
Regional Average		0.0021	0.0389	0.0022	0.7024
Mid-Yangtze	Anhui	0.0290	0.1051	-0.0123	0.5720 (29)
	Jiangxi	0.0160	0.0788	0.0011	0.6468 (22)
	Hubei	0.0129	0.0592	-0.0107	0.7148 (16)
	Hunan	0.0137	0.0623	-0.0099	0.7586 (07)
Regional Average		0.0179	0.0763	-0.0079	0.6731
Eastsea	Shanghai	-0.0031	0.0142	-0.0071	0.9059 (01)
	Jiangsu	0.0198	0.0820	-0.0091	0.7417 (09)
	Zhejiang	0.0100	0.0490	-0.0124	0.6488 (21)
Regional Average		0.0089	0.0484	-0.0095	0.7655
Southsea	Fujian	0.0124	0.0488	-0.0191	0.7321 (13)
	Guangdong	0.0048	0.0381	-0.0072	0.8534 (02)
	Hainan	0.0175	0.0678	-0.0162	0.8022 (03)
Regional Average		0.0116	0.0516	-0.0142	0.7959
Southwest	Guangxi	0.0147	0.0712	-0.0034	0.7335 (12)
	Chongqing	0.0099	0.0577	-0.0021	0.5353 (30)
	Sichuan	0.0209	0.0941	-0.0015	0.6098 (26)
	Guizhou	0.0122	0.0522	-0.0159	0.6535 (20)
	Yunnan	0.0100	0.0555	-0.0050	0.6453 (23)
Regional Average		0.0135	0.0661	-0.0056	0.6355
Nation-wide Average		0.0086	0.0511	-0.0053	0.7020

Table 1 also exhibits the calculation of two decomposition factors of scale effect and technical effect. In terms of recent six years' innovative productivity growth, the scale effect takes a leading role in defining the average productivity growth, increases at an annual average of 5.11% growth rate, and the technological change is negative instead, declines at an annual average of 0.53%, which reflects the fact that the technological progress in the field of innovative management didn't have an obvious positive effect on promoting the productivity growth, on the contrary, somewhat a negative. It is easily understood that the recent innovative productivity growth is largely driven by resource inputs, and contrarily, the innovative outputs such as new patents consume part of factor resources to drag down the innovative productivity growth instead.

It is worth mentioning that we can further examine the sources of innovative and management productivity growth, for this purpose, this paper uses the traditional method of economic growth accounting to calculate the growth sources. Thus, the growth accounting equation of this study divides the output growth into three different sources: accumulation of labor, capital, and the change of Solow residual (i.e., technological progress or total factor productivity growth). In this case, we explain the total factor productivity (TFP) growth rate with the Malmquist innovative productivity growth rate, so we obtain the basic formula of the innovative growth accounting as the following expression:

$$TFP = \frac{\Delta y}{y} - \sum_{i=1}^{n} s_i \frac{\Delta x_i}{x_i} \tag{5}$$

Among them, TFP represents for the total factor productivity growth rate or Solow residual, y represents for the gross output, x_i is denoted for innovative inputs, s_i is denoted for share of factors in output production, that is, the marginal value of resource input. In this way, the innovative total factor productivity growth can be decomposed into contribution shares of all kinds of input factors, including increases of innovative labor input (or R&D personnel), innovative capital input (or R&D capital), and other contribution of related input elements (i.e., patents).

Table 2: Sources of Innovative Total Factor Productivity (TFP) (China, 2006-2012)

Model	Beta	T-value	Sig.
LN_RDER	0.0824	2.9694	0.0035
LN_RDCAP	0.0455	2.8790	0.0046
LN_PATENT	-0.0858	-6.5999	0.0000
	Adj R^2=0.9853;	F=3342.86	

By examining Table 2 of the regression result, it is found that the increase in investment of R&D personnel and R&D capital expenditure has played a positive role in promoting the growth rate of total factor productivity, increasing the TFP at an average rate of 8.24% and 4.55%, respectively. Namely, every 1% increase in the standard unit of R&D personnel and R&D capital spending, the innovative and managerial TFP will grow at an average rate of 8.24% and 4.55%, respectively. Same as the result of above analysis of the Malmquist innovative productivity growth index, the independent variable of patents representing for the innovative output has a negative effect on the innovative total factor productivity growth, namely, for every 1% increase of the number of new patents, the innovative and managerial TFP will drop by 8.58%, instead. It is noted that the innovative output expected to escalate the productivity growth or economic output, yet compared to the innovative investment scale, do not show any significant effect till now. It is worth to mention that the above results of regression analysis are all statistically significant at 1% interval level (see Table 2 for details).

5. CONCLUSION

The scientific and technological innovative activities and innovative management has shown obvious positive effects on the economic benefit of enterprises and regional development. It is not only of long-term strategic significance for the sustainability and development of the society, for the enhancement of the core competitiveness of the enterprise, but of practical significance as well for the promotion of economic benefits. Economic advantage, in turn, creates good conditions for new innovation and investments, and the two factors interact and complement with each other, for which it forms a well-developed circulation system. This study shows that, in recent seven years, innovative activities and innovative management of Chinese economy plays an active role in increasing the productivity efficiency, in which the innovative productivity grows at an average rate of 0.86%. However, the innovative activities and management to promote productive efficiency still rely on acquiring a large amount of innovative resource inputs. Namely, the scale effect that uses R&D labor and capital inputs extensively plays a dominant role, relative to the innovative technological change, thus it shows an obvious comparative advantage. In a nutshell, the innovative efficiency of China's enterprises is relatively low, and the contributive effort of innovative outputs to support the economic transformation is insufficient.

Therefore, in view of the current situation and insufficiency of development of innovative activities and management, it is suggested that government agencies should optimize the scientific and technological innovative and managerial policies, build the political environment with innovative incentive scheme, intensify the protection system of intellectual property rights, and improve the industrial transformation mechanism of innovative patents, as a result, provide an effective way in realizing the sustainable and healthful economic development of the society.

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