Research on Total Factor Productivity of High-Tech Parks Based on the Perspective of Technology Field

Taking the Zhongguancun Demonstration Zone as an Example*

Yaotong Chen
Beijing Key Laboratory of Green Data Big Decision
Making
Beijing University of Information Science and Technology
Beijing, China

Xiaofeng Wu
School of Economics and Management
Beijing Jiaotong University
Beijing, China

Zhi Zeng
Yangtze University
Hubei, China

Hua Guo
School of Economics and Management
Beijing University of Information Science and Technology
Beijing, China

Abstract—In order to clarify the economic growth dynamics of high-tech parks and the method of improving total factor productivity, this paper adds dummy variables to the stochastic frontier model method to consider the difference of total factor productivity among different economies, and combines clustering methods to verify The shortcomings of lower-economy economies and recommendations for science policy. This paper takes the six technical fields of Zhongguancun as the empirical object. The calculation results show that from the time axis, since 2002, the growth rate of total factor productivity in various technical fields of Zhongguancun has declined, but there have been signs of recovery in recent years. From the perspective of domain differences, the level of total factor productivity and the quality of economic development in the field of electronic information are the highest.

Keywords—total factor productivity; high-tech industrial development zone; technical field; random frontier

I. INTRODUCTION

In recent years, "all-factor productivity" has appeared in many important government documents such as the 19th National Congress, and the promotion of total factor productivity has become a hot topic today. Total factor productivity refers to the productivity of all resources after input [1], which can comprehensively and scientifically study the main sources of economic growth, thereby clarifying the dynamics and constraints of economic growth, and providing theoretical support for government decision-making. Many studies on China's macroscopic and microscopic multi-faceted TFP have been carried out. Wang Yuying, Zhang Hongwu, and Shen Junjun (2016) have measured the production efficiency of China's "Belt and Road" 18 provinces and cities between 2000 and 2013. The method used is beyond the logarithmic production function. Random frontier method [2]. Yang Yan (2019) used the matrix matrix estimation method to explore the relationship between the concentration of tourism industry in China and its TFP in 2007-2016 [3]. However, research results at the technical level have yet to be developed. The high-tech park is an important engine for the development of the regional economy. It has played a role in demonstration and driving in terms of personnel training and scientific research. Different economic sectors have different economic structures and different factors, and they involve a wide range of enterprises. By analyzing the characteristics and differences of the total factor productivity in different technical fields of high-tech parks, the paper promotes the high-quality development of the capital economy. It is of great significance to realize the integration of Beijing-Tianjin-Hebei at an early date.

II. ANALYSIS OF THE THEORY AND MEASUREMENT METHODS OF TOTAL FACTOR PRODUCTIVITY IN THE TECHNICAL FIELD OF HIGH-TECH ZONES

A. Theoretical Analysis

The high-tech park divides the concept of total factor productivity in the technical field. Since the establishment of the Torch Program, China's standards have defined high-tech parks as eight technical fields: electronic information, biology and new medicine, aerospace, new materials, high-tech services, new energy and energy conservation, and resources. With the field of the environment, advanced manufacturing and automation, the measurement and analysis of total factor productivity in the technical field of

high-tech parks can measure the efficiency of resource allocation in various technical fields, including people, finances and materials, and help to judge the development quality of a technical field in the new normal background, thereby providing a theoretical basis for government decision-making.

Total factor productivity theory. Total factor productivity is actually a surplus concept, which refers to the part that output will still increase without considering capital and labor. The most mainstream measurement methods are divided into parameter estimation method and non-parametric estimation method. Among them, the parameter estimation method has classical regression estimation method and stochastic frontier model method [4]; the most mature nonparametric method is the Mannquist index method based on data envelopment (DEA) method. In contrast, the DEA model has a long history of using the total factor productivity field, but the SFA is a measurement model based on the production function, which is more conducive to further analysis of the TFP cause of the empirical object. In addition, due to the late establishment of China's high-tech parks and the small amount of data, the data is highly volatile relative to countries and cities, and SFA's data quality requirements are not as strict as the DEA method. Considering this, this paper chooses the SFA method based on production function as the main measurement model.

B. Technical Field Total Factor Productivity Measurement Method — Stochastic Frontier Analysis (SFA)

The stochastic frontier method can accept the sub-item of adding technical inefficiency. In the early stage, the TFP can be roughly decomposed into technical progress and technical efficiency change [5], and then subdivided into technological progress, technical efficiency change, Scale efficiency changes and configuration efficiency changes [6]. In this paper, using the stochastic frontier model of four decompositions, the technical field of Zhongguancun Demonstration Zone is used as an empirical object, and the efficiency of optimization model is continuously adjusted from the perspective of different spatial units, different time scales and different economic structures.

The general form of the stochastic frontier production function model is:

$$lnY_{it} = f(X_{it}, t; \beta) + V_{it} - U_{it} \quad (1)$$

1) Total factor productivity based on stochastic frontier

For (1), the first derivative of time is obtained, X_{itj} represents the jth input element; ε_{itj} represents the output elasticity of the jth input element; $\dot{Y}_{it}$ represents the rate of change of output; $\dot{X}_{itj}$ represents the rate of change of the jth element. The technical change is defined as

$$TC_{it} = \partial lnf(x_{it}, t; \beta)/\partial t,$$ and the technical efficiency change is $TEC_{it} = \frac{\partial lnTE_{it}}{\partial t} = -\partial u_{it}/\partial t$. Then (1) is rewritten as follows:

$$\dot{Y} = TC_{it} + \sum_{j} \varepsilon_{itj}\dot{X}_{itj} + TC_{itY} \quad (2)$$

According to the growth kernel algorithm, Equation 3 can be obtained:

$$T\dot{F}P = \dot{Y}_{itj} - \sum_{j} \varepsilon_{itj}\dot{X}_{itj} \quad (3)$$

Where $S_{itj} = w_{itj}x_{itj}/\sum_{j} w_{itj}x_{itj}$, w_{itj}, w_{itj} represents the price of element j in industry i at time t, so s_{itj} can be understood as time t, the cost of a certain input element j in practice, In total, it accounts for the proportion and share of the total cost of the same elements in the entire industry i.

2) Using four factorization of total factor productivity based on stochastic frontier

$$T\dot{F}P = TC_{it} + TEC_{it} + SEC_{it} + FAEC_{it} \quad (4)$$

3) Setting of production function

Considering the two input factors of capital (K) and labor (L), the frontier model is set as follows based on the form of the transcendental logarithm function:

$$lnY_{it} = \alpha_0 + \alpha_T T + \alpha_{TT}T^2 + \alpha_K lnK_{it} + \alpha_L lnL_{it} + \alpha_{KK}(lnK_{it})^2 + \alpha_{LL}(lnL_{it})^2 + \alpha_{KL}lnK_{it}lnL_{it}$$
$$+ \alpha_{KT}lnK_{it}lnT_{it} + \alpha_{lt}lnL_{it}T - u_{it} - v_{it} \quad (5)$$

C. Data Source and Processing

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled. In this paper, the total income of each technical field is taken as the output variable, the total number of employees and the total assets are used as the input quantity to measure the total factor productivity, and the characteristics and changes of the total factor productivity monitoring value and relative value result are analyzed. Because the technical field classification and national standard classification of Zhongguancun Demonstration Zone are not completely unified, the Ministry of Commerce of the People's Republic of China issued the corresponding standards of the "High-tech Fields Supported by the State (2016)", and the actual situation of data collection can be considered. In this paper, the existing 11 first-level technical fields and 72 secondary fields in the Zhongguancun Demonstration Zone are merged into six first-level technical fields as research samples [7][8][9], namely: electronic information field, biology and new medicine field, new material field, new energy and energy

conservation, advanced manufacturing and automation. The data used in the models of total income, endings and total assets of various technical fields are derived from the economic development indicators of the Zhongguancun Demonstration Zones prepared by the Zhongguancun Demonstration Zone Management Committee. Based on the stochastic frontier model, this paper uses stata15.0 software to measure the total factor productivity of the six technical fields, and considers the differences among various technical fields by adding dummy variables. Finally, using SPSS21.0 software to cluster and analyze the results, the level of total factor productivity in each technical field and its causes.

III. ANALYSIS OF TOTAL FACTOR PRODUCTIVITY IN THE TECHNICAL FIELD OF ZHONGGUANCUN DEMONSTRATION BASED ON STOCHASTIC FRONTIER MODEL

In this paper, the relevant data of the six technical fields of Zhongguancun Demonstration Zone from 2001 to 2017 are brought into the stochastic frontier model for calculation. Finally, the average annual TFP results of the six technical fields are clustered.

A. Total Factor Productivity Measurement in the Six Technical Fields

The The stata software was used to calculate the total factor productivity growth rate (TFP) of the six technical

fields in the Zhongguancun Demonstration Zone from 2002 to 2017, and the four decomposition treatment was carried out. In addition, this paper adds dummy variables in the process of measurement, which is convenient for considering the differences between different technical fields.

For From the time trend, as shown in "Fig. 1", since the establishment of the park, the growth rate of TFP in the six technical fields of the Guancun Demonstration Zone has shown varying degrees of fluctuations. Especially in the early stage of construction, it is experiencing a stage of development from scratch. The overall scale of the park is small. The growth rate of TFP in various technical fields is greatly affected by changes in environmental factors, input factors and government policies, so the fluctuation is very intense; Since then, the growth rate of TFP in the six major technical fields has shown a slight downward trend. The most representative one is the advanced manufacturing field. From the high-speed level of more than 60% in the initial stage of construction, it gradually falls back to the negative position. In the past few years, in addition to the steady growth of TFP growth in new materials and application technology, the growth rate of TFP in the other five technical fields has shown signs of recovery, which may benefit from the country's vigorous promotion of innovation and development. The positive effect brought about.
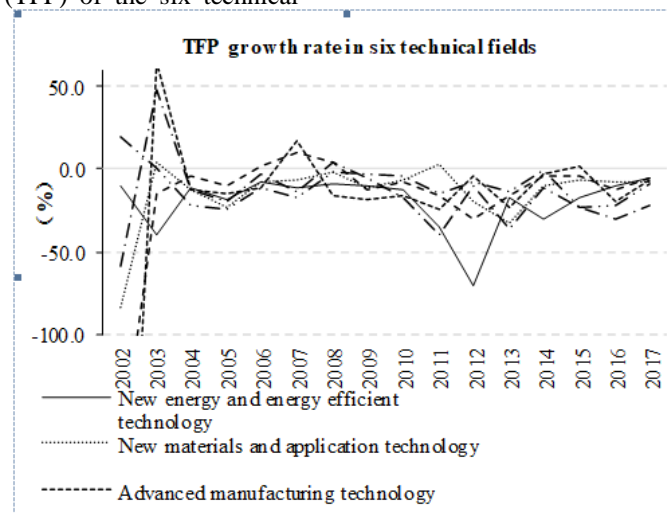

Fig. 1. TFP growth rate in six technical fields from 2002 to 2017.

The six major technical fields have been on a downward trend for a long time. The reason is that the innovation activities of most Chinese enterprises depend on their introduction from abroad. However, as developed countries strengthen their technical barriers, the advantages of Chinese enterprises are gradually weakened, and their technological progress speed. It is slow. In addition, with the sharp increase in land prices and increasing the cost pressure of enterprises, it can be seen from the data of factor allocation efficiency and scale efficiency in "Table I". On the one hand, large-scale enterprises that cannot meet the high-tech standards are highly migrating and occupy Zhongguancun resources. On the other hand, some small and micro-high-

tech enterprises have moved to areas with less land price pressure, and these conditions are common in various technical fields, which have led to a decline in the growth rate of the total factor productivity of Zhongguancun.

TABLE I.   ANNUAL AVERAGE SITUATION OF TFP GROWTH RATE AND ITS DECOMPOSITION INDICATORS IN THE SIX TECHNICAL FIELDS OF 2002-2017

Technical field	TFP growth rate	TC	TEC	SEC	FAEC
New energy and energy efficient technology	-0.2	0.01	0.04	-0.05	-0.2
New materials and application technology	-0.14	0.03	0.04	-0.07	-0.15
Advanced Manufacturing Technology	-0.27	0.07	0.04	-0.17	-0.2
Bioengineering and new medicine	-0.19	0.08	0.04	-0.08	-0.23
Environmental protection	-0.16	0.01	0.02	0.03	-0.21
Electronics and information	-1	0.09	0.03	-0.27	0.06

From the perspective of technical differences, as shown in "Table II", the average annual growth rate of total factor productivity in the six technical fields is: electronic and information (-9.6%), new materials and applied technology (-14.4%), environmental protection technology (-15.6%), bioengineering and new medicine (-18.6%), new energy and energy efficient technology (-19.8%), advanced manufacturing technology (-27.2%). The TFP growth rate in the 16-year period from 2002 to 2017 shows that bioengineering and new medicine have the most leading positions, with 12 leading positions in the top three, followed by electronic information and advanced manufacturing, each with 8 The second row is in the top three. Among them, although the bioengineering field has the highest frequency, the ranking data is 1 and 5, and the frequency is 4 times. The average ranking in the past ten years is only at the upper-middle level, and the lead is not obvious. In contrast, the level of total factor productivity in the field of electronic information has grown significantly in the past decade, and has been ahead of the other five technical fields four times.

The annual growth rate of TFP in the electronic information field ranks first in the six technical fields. On the one hand, under the background of the support mechanism and support effect of the policy of Zhongguancun tilt policy and tax incentives, the domain characteristics of electronic information make it possible to decide the six major technical fields have the highest concentration of talents, and talents are the mainstay of technological progress. The accumulation of professional knowledge and the long-term cultivation of talents can generate incremental benefits. On the other hand, the Zhongguancun Demonstration Zone accelerates structural adjustment in the region, with emphasis on encouraging each sub-park develops characteristic industries, and the electronic information field covers almost all the high-tech industries in the sub-parks. For example, Chaoyang District is committed to the development of a new generation of information technology and intelligent equipment leading industries based on the headquarters research and development, and the Haidian Park. Data and cloud computing, artificial intelligence, industrial Internet and fifth-generation mobile communications and other special industries, as well as the smart car industry of the manor, so it can be said that the electronic information field is widely distributed in the Zhongguancun demonstration area, which is more adequate than other technical fields. Take advantage of talent and policy resources.

TABLE II.   TFP GROWTH RATE TABLE OF SIX TECHNICAL FIELDS FROM 2002 TO 2017 (%)

Year	New energy and energy-saving technologies		New materials and Application technologies		Advanced Manufacturing technologies		Bioengineering and New medicine		Environmental protection technology		Electronics and Information technology	
	TFP growth rate	Rank	TFP growth rate	Rank	TFP growth rate	Rank	TFP growth rate	Rank	TFP growth rate	Rank	TFP growth rate	Rank
2002	-9.7	2	-84.3	4	-345.7	6	-175	5	-59.4	3	19.8	1
2003	-40.2	6	4.7	3	64.3	1	-14.8	5	48.7	2	0.5	4
2004	-10.9	2	-12.3	4	-11.9	3	-4.6	1	-12.3	5	-21.5	6
2005	-18.3	3	-23	5	-15.4	2	-10	1	-20	4	-24.4	6
2006	-8.1	4	-7.4	3	-11.2	6	1.4	1	-3.1	2	-10.9	5
2007	-11.1	4	-6	3	16.8	1	10.3	2	-13.8	5	-17	6
2008	-9	5	-2.3	4	-16.3	6	4.1	1	4	2	-1.4	3
2009	-9.7	3	-10.9	4	-18.9	6	-12.4	5	-4.9	2	-2.6	1
2010	-12.9	4	-6.5	2	-16.2	5	-7.5	3	-16.8	6	-4.1	1
2011	-34.9	5	2.7	1	-24	4	-16.6	3	-39.5	6	-14.6	2
2012	-70.6	6	-20	4	-4.6	1	-30.1	5	-10.3	3	-8.2	2
2013	-17.7	3	-33.2	5	-23	4	-16.4	2	-36.6	6	-13.6	1
2014	-30.4	6	-10.6	4	-3.5	2	-3.8	3	-11.4	5	-1.1	1
2015	-17.3	4	-6	3	1.3	1	-4.1	2	-23.5	6	-22.6	5
2016	-10.1	2	-7.5	1	-20	4	-12	3	-29.8	6	-21.9	5
2017	-5.6	1	-7.2	4	-6.6	3	-5.8	2	-21.4	6	-9.3	5

B. Cluster Analysis of Total Factor Productivity in the Technical Field

In order to avoid the impact of technical differences on the measurement results, this paper adds dummy variables to the measurement model to consider the development gap between different technical fields. In the case of the same input factors, the larger the value of the dummy variable, the higher the expected output level in the technical field, and the more advanced the development. The dummy variables

in the field of new energy and high-efficiency energy-saving technologies are set to 0. "Table III" shows the ranking

results of the dummy variables in each technical field from large to small.

TABLE III.   RESULTS OF VIRTUAL VARIABLES IN SIX TECHNICAL FIELDS

region	Coef.	Std/Err	z	P>|z|	[95%Conf.Interval]	
Electronics and information	0.984	0.376	2.62	0.009	0.247	1.722
Advanced Manufacturing Technology	0.121	0.105	1.15	0.251	-0.085	0.326
New energy and energy efficient technology	0	-	-	-	-	-
New materials and application technology	-0.136	0.062	-2.18	0.029	-0.258	-0.014
Bioengineering and new medicine	-0.314	0.083	-3.77	0	-0.478	-0.151
Environmental protection technology	-0.616	0.126	-4.88	0	-0.863	-0.369

As shown in "Table III", the field of electronic information is far ahead, and the fields of advanced manufacturing and new energy technologies are closely followed. The input and output rates of the other three technical fields, such as new materials and application technology, are lower than those of new energy technologies is a negative value. Therefore, it can be seen that the level of input and output rate in the field of electronic information is the highest, which is more than 7 times higher than that of the second-ranked advanced manufacturing sector. In the electronic information field of the Zhongguancun Demonstration Zone from January to November 2018, the total revenue increased by nearly 20% year-on-year. The growth level is also the first among the six technical fields. It can be seen that the overall development of the electronic information field and the level of total factor productivity are at the leading level, and their economic structure, scientific research investment and overall business environment construction have high reference value.

TABLE IV.   CLUSTER ANALYSIS CASE PROCESSING SUMMARY

Case					
Effective		Missing		Total	
N	Percentage	N	Percentage	N	Percentage
6	100	0	0	6	100

Further, SPSS21.0 software is used to cluster the optimal segmentation system for the average annual TFP growth rate of the six technical fields from 2002 to 2017. "Table IV" shows the completeness and absence of data.

The clustering results are shown in "Fig. 2". These four categories are summarized as: The first category of TFP leading areas: electronic information technology. The electronic information field, which is mainly represented by intelligence and information industry, has obvious characteristics of high-tech industries. R&D investment has obvious strength leading edge compared with other fields; the second category of TFP superior fields: new materials and application technology fields, environmental protection technology the field; the third category of TFP good areas: new energy field, bioengineering and new medicine; the fourth category of TFP general field: advanced manufacturing technology.
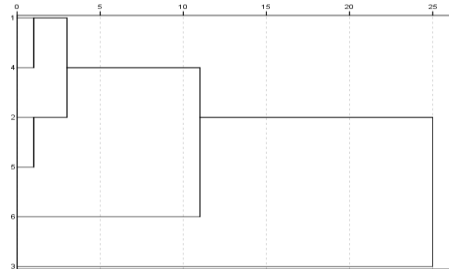

Fig. 2.   Clustering results of six technical areas.

It can be seen from the above that when using the dummy variables and cluster analysis to analyze the difference in the total factor productivity level of the six technical fields in the Zhongguancun Demonstration Zone, the results are slightly different. Among them, the results of the advanced manufacturing field have the biggest difference, and the value of the dummy variable ranks second with 0.1206, which belongs to the general field of TFP in cluster analysis. Observing similar manifestations in other fields, the areas with higher virtual factor value and higher total factor productivity have relatively low TFP. This is because the areas with low economic development have more room for growth than the "developed" fields. The base is low, so the TFP growth rate is high. In view of this, the electronic information field is the most advanced technical field in the economic development of the Zhongguancun Demonstration Zone. Its total factor productivity is still the first in the case of limited upside. It can be seen that the electronic information field has maintained high-speed and high-quality development. The flag area of the demonstration area. Scale efficiency and factor allocation efficiency are the main factors that drive down the growth rate of TFP in the Zhongguancun demonstration area. Specifically, Zhongguancun has incorporated some state-owned enterprises with low R&D investment and large volume, which is the main reason for the decline in the growth rate of total factor productivity in Zhongguancun. The rise in the value of real estate has indirectly led to an increase in the cost of various production factors. Under the effect of price volatility, corporate income has not increased in time, resulting in a steady increase in the growth rate of TFP in Zhongguancun, and a negative growth after falling below zero.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

A. Conclusion

Scale efficiency and factor allocation efficiency are the main factors that drive down the growth rate of TFP in the Zhongguancun demonstration area. Specifically, Zhongguancun has incorporated some state-owned enterprises with low R&D investment and large volume, which is the main reason for the decline in the growth rate of total factor productivity in Zhongguancun. The rise in the value of real estate has indirectly led to an increase in the cost of various production factors. Under the effect of price volatility, corporate income has not increased in time, resulting in a steady increase in the growth rate of TFP in Zhongguancun, and a negative growth after falling below zero.

B. Policy Recommendations

First, improve the efficiency of resource allocation. The economy of Zhongguancun Demonstration Zone is a factor input type growth and its location is located in Beijing. Compared with other parts of China, the capital and labor factors should be more abundant. Therefore, the efficiency of knowledge transformation should be improved as soon as possible, and the rationality of resource allocation should be improved. It is also advisable to strengthen the supervision and management of high-tech standards, and strictly enforce them, and refuse to blindly include enterprises with low quality and non-compliance. In this way, it can form a high-speed internal transformation, externally controlled and audited, and a two-pronged approach.

Second, promote talent introduction policies to create talented highlands. First of all, we must formulate preferential policies to attract talents. Then we should strengthen talent management and form a personnel flow tracking file to facilitate the best development space for talents. And set the standard professional and technical personnel selection process, select high-level technical personnel suitable for the corresponding positions on demand, help talents create greater value; finally, it is necessary to strengthen the talent reserve and increase the training subsidy for professional talents.

Third, continue to "reduce taxes and reduce burdens", focus on improving the business environment, attract high-tech foreign-invested enterprises to invest in the station, optimize the investment structure of the service industry, control the flow of foreign capital, reduce the loss of high-quality enterprises is also an important link to improve the expected output. This also needs to improve the entry and exit mechanism of enterprises, and improve the "entry threshold" to strictly control the standards of high-tech enterprises. Although this will restrict the overall economic growth rate in the short term, it will be conducive to the long-term high quality of the park economy steady growth.

REFERENCES

[1] Xue Ranzhen, Zhou Ying. Study on the Full Productivity Dynamics of China's Retail Industry Based on Three-phase DEA Model [J]. Business Economics Research, 2019(03):29-31.

[2] Wang Yuying, Zhang Hongwu, Shen Junjun. An Empirical Study on Production Technology Efficiency in China's "One Belt, One Road" Region — Based on Analysis of Stochastic Frontier Production Function [J]. Business Economics, 2016(06).

[3] Yang Yan. Tourism Industry Agglomeration Level and Total Factor Productivity Growth: An Empirical Study from Chinese Experience [J/OL]. Business Economics Research, 2019 (06).

[4] Li Xiaosheng. Measurement Method and Empirical Analysis of Total Factor Productivity under Resource and Environment Constraints [M]. Economic Science Press, 2018.

[5] Wang Wei, Yan Liangqun. Factor Mismatch, Technology Progress Bias and Total Factor Productivity Growth — Analysis of Stochastic Frontier Model Based on Sub-sector of Equipment Manufacturing Industry [J]. Journal of Shanxi University of Finance and Economics, 2018, 40(12).

[6] Kumbhakar S C. Estimation and Decomposition of Productivity Change When Production is not Efficient: A Panel Data Approach [J]. Econometric Reviews, 2000, 19(4).

[7] Ji Rui, Zhang Jian, Ge Xinquan. Characteristics and Causes of Economic Cycle Fluctuation in High-tech Parks [J]. Quantities Economics & Technology Research, 2018,35(03):132-149.

[8] Peng Lin. Measurement and Comparison of Total Factor Productivity in the Yangtze River Economic Belt. Measurement and Comparison of Total Factor Productivity in the Yangtze River Economic Belt [J/OL]. Research World, 2019 (03).

[9] Xiao Wen, Xue Tianhang. The Dynamic Evolution of Regional Productivity in China and Its Enlightenment [J]. Social Science Front, 2019 (03)