TOTAL FACTOR PRODUCTIVITY GROWTH OF CHINA'S SERVICES SECTOR: A MALMQUIST INDEX MEASURE BASED ON DATA ENVELOPMENT ANALYSIS

by

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Abstract

Using the Malmquist index method based on Data Envelopment Analysis and the latest provincial and industrial panel data, this paper measures the total factor productivity growth of China's services sector and its decomposed components over 2003 – 2012, namely technical efficiency change and technical progress change, where technical efficiency change can be further decomposed into pure technical efficiency change and scale efficiency change. Overall changing trend, regional differences and industrial heterogeneity are analyzed. With the Malmquist productivity index measurement result, the total factor productivity growth of China's services sector was found mainly coming from technical progress growth and has an obvious declining trend since 2006. All the provinces and industries saw their TFP growth rate peak in 2006, but after that, the overall TFP growth rate of services sector began to decline very quickly. The possible reasons may include economic overheating, global financial crisis impact and excessive investment. There are significant regional differences in services sector TFP growth performance. The worst TFP growth performance was found in the middle region, which may be due to its lower output-investment ratio compared to the two other regions. A convergence trend was found in the services sector TFP growth of the three regions. On industrial dimension, market services and non-market services have significant total factor productivity growth performance as well. The TFP growth is much higher in market services than in non-market services. The driving factors of market services and non-market services are also different. The services sector TFP growth is dually

driven by both technical progress and technical efficiency, while the one of non-market services sector is mainly driven by technical progress. The TFP growth of market services and non-market sector have shown different changing trend over the past decade. Some calculation result which is difficult to understand and explain may be due to the statistical data quality issue. The case of Public Management and Social Organizations, which has being seen unusual high TFP growth as a typical non-market services industry, is analyzed in this paper.

Chapter 1: Introduction

Since adopting reform and opening policy in 1978, China's economy has experienced significant growth over the past three decades. The average annual growth rate of Gross Domestic Product (GDP) over 1978-2012 is 9.8 per cent. More significant growth was seen in the new millennium, and the average annual growth rate of GDP for 2000-2012 is 10.1 per cent. China had kept the double-digit growth trend until 2008, in which year the global financial crisis broke out. Even hammered by the global financial crisis, China still gained a 10.4 per cent average annual growth rate of GDP over 2003 - 2012. Numerous studies have been focused on the high economic growth of China, many of which try to find the driving factors behind the outstanding economic performance. Structural reforms and stable development environment no doubt are important factors for the high growth of China's economy. In the late 1970s and the 1980s, China started a series of reform policies, including land using policy reform in rural area, state-owned enterprise reform, price system reform, etc. In 1992, China formally began to adopt market economy system. In 2001, China became a member of World Trade Organization (WTO). During the past over 30 years, most major advanced economies, including North America, Europe and Japan, also gained a stable economic development, which stimulated the exports from China to these regions, especially since China became a member of WTO. All of these factors contributed to the high economic growth of China.

Services sector has been playing an important role in the economic development of China. In 1978, the share of services sector's value-added in GDP is 23.9 per cent, and in 2012, this share is increased to 43.1 per cent. Although the share of services sector in GDP is still much lower than most developed countries, services sector of China actually has gained a quite fast growth since 1978. The average annual growth rate of services sector's value-added over 1978-2012 is 10.8 per cent, 1 percentage higher than average annual GDP growth rate over the same period. Chinese government also has paid much attention to the development of services sector, hoping that it can take the role of manufacturing and become the main engine of economic growth, as services sector can absorb more labor, rely less on natural resources and is a "cleaner" industry sector which produce less pollution to the environment than manufacturing. In 1992, the Central Committee of Chinese Communist Party and the State Council of China jointly published "Decision on Accelerating Development of Tertiary Industry", which pointed out that services sector should have a comprehensive and swift development in order to gain a better economic performance. This decision also listed out priority industries in services sector development and regulated relative policies and measures. Entering into the new millennium, more official documents and regulations on services sector development have been issued by the State Council, the Cabinet of China, to stimulate the development of services sector.

Total factor productivity is an important factor of economic growth. Total factor productivity issue has always been a research hotspot for economic growth researcher, and many different models and methodologies to measure productivity have been developed. In case of services sector, there are not as many productivity researches on it as those of total economy or manufacturing. There are also many different practices in estimating the total factor productivity for services sector. One important reason for the existing of so many different opinions and practices in services sector productivity research, is that services sector is very difficult to quantitatively measure in nature. For example, in the measurement of output for service sector, sometimes it's difficult to get the price information for some industries, or there is even no any market price for some industries, like public management. The quantity of output usually is impossible to directly get, so people have to use some indirect methods.

This paper aims to research the total factor productivity growth performance of China's service sector for the past decade, i.e. 2003-2012, focusing on the overall trend, regional differences and industrial heterogeneity. The research objective of this paper is to find the development trend and pattern of service sector productivity in China in the most recent ten years. We will examine the different productivity growth performance in different regions in order to find which regions have higher productivity growth and which regions have lower one, and what factors can explain the regional differences. We also will compare the productivity growth performance between different services industries. The services sector will be classified into 14 sub-industries and we will conduct total factor productivity calculation on the basis of sub-industries level. Detailed industrial level analysis will enable us to find more specific productivity growth characteristic for different industries. Using the latest detailed regional and industrial data is an advantage of this paper, which makes it different from other current researches on China’s services sector productivity. The methodology we use in this paper is Malmquist productivity index method based on Data Envelopment Analysis technique. The major advantage of Malmquist index is that it can decompose the total factor productivity change into technological progress change and technical efficiency change, and technical efficiency change can be further decomposed into pure technical efficiency change and scale efficiency change.

This paper will be structured as follows. Chapter 2 will review some related researches on services sector productivity. Then we will present a brief introduction of services sector development process as a background of productivity analysis in the following chapter. Chapter 4 will introduce the methodology we use in this paper, Malmquist index method based on Data Envelopment Analysis. And we discuss the data issues in Chapter 5. Main calculation result will be presented in the following chapter, and we will analyze the general performance, regional differences and industrial heterogeneity of services sector productivity in this chapter. We will summarize our main findings in the concluding section, Chapter 7. And an appendix will be given at the end of this paper to list out detailed total factor productivity growth for each industry and each province over 2004 – 2012 as a further reference.

Chapter 2: Literature Review

Since the 1960s, most advanced economies, especially the United States, have shown two important characters in their economic development, one of which is the share of services sector in economy is bigger and bigger, and the other of which is their economies' productivity growth seems having a declining trend. Hornstein and Krussell (1996) estimated the total factor productivity (TFP) of the economy of the U.S., and found that the average annual growth rate of TFP over 1954-1973 is 1.3 per cent, while the one over 1979-1993 is 0.7 per cent.

As bigger services sector share has not shown more help to the increase of productivity growth, many researchers regard that the productivity of services sector should be lower than other sectors in the economy. In 1967, Baumol published a paper on *American Economic Review*, addressing the famous Baumol's cost disease (also known as the Baumol Effect). He constructed two sectors in this paper, one called progressive sector, which can be interpreted as manufacturing, and the other called non-progressive sector, which can be interpreted as services. The progressive sector grows at a fixed rate, while the non-progressive sector keeps fixed labor productivity. With the Unbalanced Expansion Model constructed by him in this article, he concluded that: "If in the non-progressive sector productivity is constant, every rise in wages must yield a corresponding addition to costs. … If their relative outputs are maintained, an ever increasing proportion of the labor force must be channeled into these activities and the rate of growth of the economy must be slowed correspondingly.” In 1968, Fuchs also concluded that the main reason for services share increase is its relative weaker productivity, which is similar to the study result of Baumol.

Oulton (2001) expanded Baumol’s model, regarded that some services sectors should be introduced into the model as intermediate input, and concluded that the TFP will not decrease as the consequence of services sector’s stagnating, so he suggested that Baumol’s theory should be applied to the services industries which only produce final use output. As some researchers confirmed Baumol cost disease, there are also some researchers thinking that actually there is no Baumol cost disease in economic reality. Ruttan (2002) considered that the idea of services sector productivity always being lower than manufacturing productivity is a wrong hypothesis made by economists. Some researchers admit the existence of Baumol cost disease, but regard that it’s not a common phenomenon for services sector. Based on the data of OECD countries, Wolfl (2005) regarded that services sector productivity has structural differences among different industries. Labor intensive services industries usually have lower productivity, while wholesale, retail, transportation and storage industries have a higher productivity level. Rubalcaba (2007) concluded that financial services, communication services and public services have a higher productivity, while social and personal services, catering services and business services have less contribution to the total productivity growth of economy.

In the early period, services productivity research mainly focused on per capita services output, i.e. labor productivity of services sector, and after then it was expanded to total factor productivity research. Triplett and Bosworth (2002) regarded that productivity growth includes labor productivity growth and total factor productivity growth, and the total factor productivity growth is not only the main contributor to services labor productivity growth, but also the main source of the services sector productivity's accelerating. Gouyette and Perelman (1997) compared two types of total factor productivity indicator, frontier analysis and Divisia index, and estimated the services sector productivity for 13 OECD countries for 1970-1987. They found that although the productivity growth of services sector is low, their levels between different countries have a convergence trend, which is contrast to manufacturing. Mahadevan (1999) calculated services sector production efficiency for Singapore since 1970s using stochastic frontier analysis method, concluding that TFP has little contribution to services sector growth, which means that services sector growth mainly depends on resources input.

For the researches focusing on China's services sector productivity, most of them are conducted by Chinese researchers. In the early days, there were no many productivity researches using services sector as research object in China. Along with the deepened understanding and reorganization of the importance of services sector in economic development, there came more and more researches focusing on the total factor productivity of services sector in China. Research emphasis gradually transferred from purely calculating the total factor productivity for services sector to analyzing the impact of productivity change on services sector development. If we look into related researches, they can be roughly divided into three categories.

The first group uses national services sector as research object to estimate and research the total factor productivity. Using Solow residual value method, Guo (1992) estimated the average annual growth of China’s services sector TFP for 1979-1992, which he estimated being 2.58 per cent. Using Malmquist productivity index method based on Data Envelopment Analysis technique, Wang and Hu (2012) measured the growth rates of total factor productivity in China’s services industries from 1990 to 2010，which was then decomposed into technological progress，pure technical efficiency and scale efficiency． Their findings suggest that services sector TFP is still being in a increasing channel． The dominant factors leading to TFP growth have transformed from technical efficiency improvements in the 1990s to technological progress after 2000． They also found that industrial heterogeneity of TFP between services industries has increased.

The second group uses regional panel data of services sector as research object to estimate the services TFP and research productivity disparity among provinces. Gu and Li (2006) analyzed the regional difference of technical efficiency of China’s services sector using stochastic frontier production function model, and concluded that there are significant differences on services technical efficiency among east, middle and west part of China, which worsened the services development unbalance among different regions of China. With Data Envelopment Analysis method, Gu (2008) used provincial panel data to analyze efficiency and impact factors of services sector for 1992-2006, concluding that China’s services sector efficiency is still quite low and regional differences on services sector efficiency has an obvious increasing trend. Yin and Su (2009) applied Malmquist index method to calculate the total factor productivity growth of all the 31 provinces in China over 1993-2007 and found that the services sector TFP of this period in China has a reversing U-curve development process and the regional development of services sector productivity has a unbalance characteristic, the east region having an obvious development advantage compared to the west and middle region. Based on provincial panel data, Huang and Pu (2011) estimated the regional services TFP for 2003-2007 using Malmquist index, and found that there was a declining trend for regional services TFP, where technical regress was a main factor. They also found that the slowdown of China’s services sector efficiency is mainly caused by the technical efficiency regress of the middle and west regions. Also based on regional panel data and Malmquist index method, Liu (2009) estimated the total factor productivity growth of China’s services sector over 1978-2007, finding that factors input is the main contributor to the growth of services sector output, whereas the total factor productivity growth has less contribution. He also found the total factor productivity growth of services sector has a staged declining trend.

The third group uses sub-industries in services sector as research object. Yuan, Liu and Bai (2009) used provincial panel data and Malmquist index to analyze the total factor productivity changing trend of China’s productive services sector over 1997-2005. The result showed that the productive services sector TFP during this period has a descending trend. Zhang (2010) also estimated the total factor productivity of China’s productive service industries for a similar period, 1994-2004, with a different method, transcendental stochastic frontier model. What is interesting is that he got a completely contrary conclusion; showing that the productive services TFP has a quite high growth at an annual growth rate of 7.05 per cent. Wang (2013) also studied the productive services sector TFP, with Malmquist index method. The conclusion is that the productive services sector TFP has a positive growth, and at the same time the industrial heterogeneity of TFP has an ascending trend. Xu and Zhao (2009) researched the growth variation and regional convergence of China’s information services TFP and conclude that the information services TFP has a convergence trend. In addition, the aforementioned research of Wang and Hu (2012) can also be classified into this group, as they have analyzed the industrial heterogeneity of services sector TFP and found an ascending trend in it.

Chapter 3: Services Sector Development in China

During 2003-2012, the services sector of China gained a quite high growth. The real value-added of services sector saw a 10.9 per cent average annual growth rate for this decade. The development process can be seen as a reversing U-curve. Before 2008, in which year the global financial crisis burst out, China's services sector has seen an accelerating growth trend. Nearly every year the growth rates of real value-added were about two percentages higher than the previous year. The peak was seen in 2007, just before the burst of global financial crisis, at an unusually high growth rate of 16.0 per cent. The worldwide financial crisis also hammered the economy of China, which highly relied on exports. In 2008, the growth rate of services sector has a drastic slowdown compared to 2007, declining from 16.0 per cent to 10.4 per cent. And in 2009, the growth rate further dropped to 9.6 per cent. After that, the services sector gained a stable development in 2010 and 2011, but we saw a drop again in 2012. From the sub-industry perspective, the highest growth rate during the decade was seen in wholesale and retail trade and financial intermediation, both of which recorded an average annual growth rate at 13.4 per cent.

The share of services sector has also increased during this period. Before 2009, the share of services sector nominal value-added in GDP has never exceeded 42 per cent. The share jumped to 43.4 per cent in 2009 from 41.8 per cent in 2008. The main reason behind that is not that services sector had a better performance during financial crisis period than pre-crisis period, but that services sector was less affected than manufacturing by the crisis, as products of services sector mainly face domestic consumption. In 2012, the share of services sector is 44.6, which is the top record in the history of China's economic development.

Table 1: Growth rate of services sector value-added in China: 2003-2012 (%)

Industry	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average
Services Sector	9.5	10.1	12.2	14.1	16.0	10.4	9.6	9.8	9.4	8.1	10.9
Transport, Storage and Post	6.1	14.5	11.2	10.0	11.8	7.3	4.2	9.8	9.9	6.8	9.1
Wholesale and Retail Trades	9.9	6.6	13.0	19.5	20.2	15.9	12.1	14.3	12.6	10.4	13.4
Hotels and Catering Services	12.4	12.3	12.3	12.6	9.6	9.6	5.5	10.0	6.6	8.0	9.9
Financial Intermediation	7.0	3.7	13.8	25.9	27.6	13.3	18.2	10.0	7.2	10.0	13.4
Real Estate	9.8	5.9	12.2	15.5	24.4	1.0	11.3	7.0	6.7	4.1	9.6
Others	10.8	12.6	11.9	10.8	11.3	11.0	7.8	7.9	9.5	7.9	10.1

Data source: Online database of the National Bureau of Statistics of China. The average annual growth rates are calculated by author.

Within services sector, the internal structure also has had some changes during the past ten years. Some modern services industries, like banking, insurance, information technology, real estate, etc., have gained higher growth and seen a higher share in the total services sector. For example, the share of financial intermediation value-added in services sector has been increased from 8.9 per cent in 2003 to 12.4 per cent in 2012. The share of real estate saw a 1.7 percentages increase, from 11.0

per cent in 2003 to 12.7 per cent in 2012. Some new type services activity have come into emergence during this period, including electronic commerce, internet banking, etc.

Along with the development of services sector, it absorbed more labor force, which helped the performance of employment market. In 2011, in the total employment, the share of primary industry is 34.8 per cent, the share of secondary industry is 29.5 per cent, and the share of territory industry is 35.7 per cent. This is the first time in China's economic history that the share of territory industry in the total employment surpassed the share of primary industry.

In order to further develop services sector, China has adopted a number of policies to encourage the development of services sector. In 2007, the State Council issued "Several Opinions on Accelerating the Development of Service Sector", which is a very important official guiding document on the development of services sector. It points out that the development emphasis of services sector should be placed on the modern service industries, especially the service activities facing production. It also requires further structural reforms in services sector field, including lowering the market barrier, introducing the mechanism of competition, and reforming state-owned services enterprises, etc. After the publishing of this official document, many specific measures have been taken to encourage the further development of services sector. For example, Wenzhou, an important regional economic center in Southeast China, lowered the threshold of registering capital requirement for setting up services business from 100 thousand Yuan to 30 Yuan in 2009 (Rui, 2009). In 2011, a trial taxation reform for some modern services industries was conducted in Shanghai. According to the reform, some modern services industries, including designing services, advertising services, consulting services, etc., will transfer from business tax to value-added tax, which will lighten the tax burden of related services companies. In 2008, in order to tackle with the negative effect of the global financial crisis, Chinese government announced a four trillion Yuan economic stimulus plan, quite a part of which has flown into services sector.

China’s services sector has gained a significant progress during the past decade. But it still has not reached the target set up by Chinese government. In the eleventh five-year development plan, which is the national development strategy of China, the target of services sector development is that the share of services sector value-added and the share of services sector employment should be increased 3 and 4 percentages during the eleventh five-year period (2005-2010), respectively. But in 2010, the share of services sector value-added was only increased 2.5 percentages compared to 2005, and the share of services sector employment was only increased 3.5 percentages compared to 2005. In addition, the development level of China’s services sector is still quite low, not only being much lower than most advanced countries, but also lower than some developing countries.

Chapter 4: Methodology

Generally speaking, there are three main methodologies used in estimating the total factor productivity of services sector, including Solow residual value method, stochastic frontier production function method and Malmquist index method based on Data Envelopment Analysis (DEA) technique. In this paper, we use the Malmquist index method based on DEA technique as our methodology to estimate the total factor productivity growth of services sector in China, which has three main advantages in calculating TFP growth. The first one is that Malmquist index method does not need related price information, which is important to empirical analysis, because in reality the input and output information is easy to get, but factors price information usually is quite difficult to find, sometimes it is even impossible to find. The second one is that it is very useful in the total factor productivity calculation and comparison across countries (regions) and over time, which corresponds to the case of this paper. The third one is that the total factor productivity growth can be conveniently decomposed into technical progress change and technical efficiency change, where the technical efficiency change can be further decomposed into pure technical efficiency change and scale efficiency change. With the decomposition information, we can analyze the main contributors of total factor productivity growth.

Malmquist index was first constructed on the basis of the idea of Swedish economist and statistician Sten Malmquist in 1953. Caves, Christensen and Diewert (1982) first used Malmquist index to estimate total factor productivity, thus it is also called Malmquist productivity index since then. Fare, Grosskopf, Norris, and Zhang (1994) combined Malmquist productivity index method and Data Envelopment Analysis technique, and proposed the decomposition of total factor productivity growth into technical change and efficiency change. Unlike Caves, Christensen and Diewert (1982) using a theoretical index which is equivalent to Tornqvist index under certain conditions to measure total factor productivity growth, Fare, Grosskopf, Norris, and Zhang (1994) constructed Malmquist index based on distance functions using non-parametric programming method to estimate the TFP growth in 17 OECD countries over the period 1979 – 1988. They proposed the decomposition of total factor productivity growth into three components, namely, technical progress change, pure technical efficiency change and scale efficiency change. Ray and Desli (1997) improved the decomposition of total factor productivity growth, where they used a more appropriate measure of technical change when the technology does not exhibit globally constant returns to scale. Ray (2004) summarized the historical development and technical details of Malmquist productivity index based on Data Envelopment Analysis technique, and our description to the methodology in this chapter is mainly based on the introduction of Ray (2004).

Suppose we have two periods, *t* and *t+1*. T^t and T^{t+1} are the technologies of period *t* and period *t+1*, respectively. (x_t, y_t) and (x_{t+1}, y_{t+1}) are input and output vectors for period *t* and period *t+1*, respectively. d_0^t is the distance function using T^t as reference technology and d_0^{t+1} is the distance function using T^{t+1} as reference technology.

First, we construct output-oriented Malmquist productivity index M_0^t using T^t as reference technology.

$$M_0^t(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^t(x_{t+1}, y_{t+1}) / d_0^t(x_t, y_t) \quad (1)$$

Second, we construct output-oriented Malmquist productivity index M_0^{t+1} using T^{t+1} as reference technology.

$$M_0^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^{t+1}(x_{t+1}, y_{t+1}) / d_0^{t+1}(x_t, y_t) \quad (2)$$

Both M_0^t and M_0^{t+1} can be used as measures to estimate the growth of total factor productivity, but obviously they will not be equal to each other in general condition. To avoid the difference caused by choosing reference technology arbitrarily, we can use the idea in constructing Fisher ideal index. As we know, Fisher ideal index is the geometric mean of the relevant Laspeyres index and Paasche index. Laspeyres quantity index is a weighted average quantity index where the weights use base period price, while Paasche quantity index is a weighted average quantity index where the weights use current period price. Through constructing a Fisher ideal index using the geometric mean of Laspeyres index and Paasche index, we can avoid the arbitrariness in choosing weights, and on the other side, Fisher index has very good decomposition characteristic. If we use Fisher ideal index to measure nominal economic growth, it can be exactly decomposed into price inflation growth and quantity growth. Caves, Christensen and Diewert (1982) first borrowed the idea of Fisher ideal index in constructing a Malmquist productivity index M_0 as the geometric mean of M_0^t and M_0^{t+1}.

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_t, y_t)} \right]^{1/2} \quad (3)$$

As we aforementioned, d_0^t and d_0^{t+1} are distance functions, but they can also be interpreted as efficiency level. $d_0^t(x_t, y_t)$ and $d_0^{t+1}(x_{t+1}, y_{t+1})$ are efficiency levels using the current period technology as reference technology. $d_0^t(x_{t+1}, y_{t+1})$ is the efficiency level of period *t+1* using the technology of period *t* as reference technology. $d_0^{t+1}(x_t, y_t)$ is the efficiency level of period *t* using the technology of period *t+1* as reference technology.

We use M_0 to measure the total factor productivity growth. It can be larger than, equal to or less than 1. If it is larger than 1, we will say that the total factor productivity is increasing. If it is equal to 1, we will say that the total factor productivity is keeping a constant level. And if it is less than 1, we will say that the total factor productivity is decreasing or recessing.

The Malmquist productivity index we get has very good decomposition characteristic. Under constant returns to scale assumption, it can be decomposed into technical efficiency change index (TEC) and technical progress index (TC). The decomposition process can be shown as follows:

$$\begin{aligned} M_0(y_{t+1}, x_{t+1}, y_t, x_t) &= \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} \times \left[\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_{t+1}, y_{t+1}\mathrm{C})} \times \frac{d_0^t(x_t, y_t)}{d_0^{t+1}(x_t, y_t)} \right]^{1/2} \\ &= TEC \times TC \end{aligned} \quad (4)$$

TEC measures the catch-up degree of decision making unit to pursue the optimal production frontier from period *t* to *t+1*, so it is also called “catch-up effect”. Simply speaking, what TEC measures is the change of efficiency. When TEC is larger than 1, it means that the production of decision making unit is closer to production frontier, and the efficiency level is increasing. TC measures the shift of production frontier from period t to $t+1$, namely frontier-shift, which is also called “growth effect”. It can be interpreted in a simpler way as well. When the input levels keep unchanged, the ratio of efficiency level will represent the shift in production function due to technical change (Ray, 2004). When TC is larger than 1, it means that there is technical innovation or progress.

According to Ray and Desli (1997), the technical efficiency change (TEC) can be further decomposed into pure technical efficiency change (PTEC) and scale efficiency change (SEC).

$$M_0(y_{t+1}, x_{t+1}, y_t, x_t) = TEC \times TC = PTEC \times SEC \times TC \quad (5)$$

These three components, pure technical efficiency change (PTEC), scale efficiency change (SEC) and technical progress change (TC), are growing sources of productivity growth. If one of these indexes is larger than 1, it means that this index is contributing to the growth of total factor productivity. If less than 1, it means that this index is pulling down the growth of total factor productivity.

To calculate the Malmquist productivity index, we need to use the liner programming method, which is widely used in Data Envelopment Analysis to solve distance function problems. Solve the following linear programming problem, and then we will get the measure of Malmquist productivity index and its decomposed components.

$$
\begin{aligned}
&\left[d_0^t(x_t, y_t)\right]^{-1} = \max_{\phi,\lambda} \phi \\
&\text{s.t.} \quad -\phi y_{it} + Y_{t+1}\lambda \geq 0 \\
&\qquad\quad x_{it} - X_{t+1}\lambda \geq 0 \\
&\qquad\quad \lambda \geq 0
\end{aligned}
\qquad
\begin{aligned}
&\left[d_0^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi \\
&\text{s.t.} \quad -\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0 \\
&\qquad\quad x_{i,t+1} - X_{t+1}\lambda \geq 0 \\
&\qquad\quad \lambda \geq 0
\end{aligned}
$$

$$
\begin{aligned}
&\left[d_0^t(x_{t+1}, y_{t+1})\right]^{-1} = \max_{\phi,\lambda} \phi \\
&\text{s.t.} \quad -\phi y_{i,t+1} + Y_t\lambda \geq 0 \\
&\qquad\quad x_{i,t+1} - X_t\lambda \geq 0 \\
&\qquad\quad \lambda \geq 0
\end{aligned}
\qquad
\begin{aligned}
&\left[d_0^{t+1}(x_t, y_t)\right]^{-1} = \max_{\phi,\lambda} \phi \\
&\text{s.t.} \quad -\phi y_{it} + Y_{t+1}\lambda \geq 0 \\
&\qquad\quad x_{it} - X_{t+1}\lambda \geq 0 \\
&\qquad\quad \lambda \geq 0
\end{aligned}
\tag{6}
$$

Chapter 5: Data

In order to estimate the total factor productivity growth of services sector, we need the output and input data of services sector first. We choose value-added at constant prices as our output indicator. For input, we use two types of input, labor input and capital input. We choose the number of employees as labor input indicator and we construct a capital stock data series at constant prices as capital input indicator.

We use regional panel data in our analysis. There are 31 province-level regions in mainland China. The formal and official terminologies used for these regions' name are different. For example, Beijing, Shanghai, Tianjin and Chongqing are called "Municipality". Inner Mongolia, Tibet, Xinjiang, Ningxia and Guangxi are called "Autonomous Region". All the other regions are called "Province". But for simplicity, we will call all the regions as provinces. For the analytical convenience, we will group the 31 provinces into three divisions mainly according to their geographical position but also considering their economic development level at the same time, namely, the eastern region, the middle region and the west region. This grouping method is commonly used in the regional economic researches of China. Generally speaking, the east region is more developed than the middle and west regions. The west region usually is regarded as the least developed part of China. The data for Taiwan, Hong Kong and Macao are not included in our analysis.

Table 2: The East, Middle and West Regions Grouping

The East Region (11 provinces)	Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan.
The Middle Region (8 provinces)	Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan.
The West Region (12 provinces)	Sichuan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Guangxi, Inner Mongolia.

The period we use to analyze is from 2003 to 2012. One reason we choose it as our analyzing period is that China gained the rapidest economic growth during this period, as we have mentioned in the introductory part of this paper. We want to see what has happened to the productivity growth as China's economy grew so fast during this period. Another very important reason is that we can obtain comparable and consistent data series for detailed sub-industries over this period. With the detailed industrial data, we can compare different productivity growth performance between different services industries. Before 2003, China's economic surveys and national accounts were based on *Chinese Industrial Classification 1994*. From 2003, China's economic surveys and national accounts began to adopt *Chinese Industrial Classification 2002*[1]. So the industrial data before 2003 are not comparable with the data after 2003. Under this industrial classification standard, services sector are classified into 14 one-digit sub-industries. Using the sub-industrial data, it is possible for us to estimate the total factor productivity growth from a more detailed level, which is better for productivity analysis, because different services industries actually have different productivity growth patterns. But unfortunately, the value-added data

[1] In 2012, the employment statistics and investment statistics of China began to use a new classification standard, *Chinese Industrial Classification 2011*. There is no difference on one-digit industrial level between *Chinese Industrial Classification 2002* and *Chinese Industrial Classification 2011*, so our data will not be affected by this change of industrial classification standard.

for 14 sub-industries on provincial level is not available for 2003, as the regional GDP accounting of China began to adopt *Chinese Industrial Classification 2002* from 2004, which is the year of the first National Economic Census of China. So for the sub-industrial total factor productivity analysis, we can only use data for 2004-2012.

Table 3: Sub-industries in China's Service Sector

Code	**Sub-industry**
F	Transport, Storage and Post
G	Information Transmission, Computer Services and Software
H	Wholesale and Retail Trades
I	Hotels and Catering Services
J	Financial Intermediation
K	Real Estate
L	Leasing and Business Services
M	Scientific Research, Technical Services and Geologic Prospecting
N	Management of Water Conservancy, Environment and Public Facilities
O	Services to Households and Other Services
P	Education
Q	Health, Social Security and Social Welfare
R	Culture, Sports and Entertainment
S	Public Management and Social Organizations

All the data we use in this paper are get from the online database of the National Bureau of Statistics of China.[2]

5.1 Output

In estimating total factor productivity, there are usually two types of output which can be used. One is gross output, and the other is value-added, which can also be interpreted as net output. Time series data of gross output is not available in China, so we use value-added at constant prices as our output indicator.

[2] The website address is http://data.stats.gov.cn

In China's national and regional GDP accounts, the value-added at constant prices for services industries are estimated and published on different price base periods. For the data of 2003-2005, the base year is 2000. For the data of 2006-2010, the base year is 2005. And for the data of 2011-2012, the base year is 2010. In order to obtain a comparable data series, we have to transform the data over 2003-2012 based on different based on different base years into a new data series based on a universal base year. We choose 2005 as the universal base year. Then for 2005, the value-added at current prices will be equal to the value-added at constant prices, as we are using 2005 as our price base period. For 2006-2010, the published value-added at constant prices are already based on the base year of 2005, so they can be directly used. Based on the level data of 2005 and published growth rate data of 2004 and 2005, we can calculate the real value-added data for 2003 and 2004 using 2005 as price base year. And based on the level data of 2010 and published growth rate data of 2011 and 2012, we can calculate the real value-added data for 2011 and 2012 using 2005 as price base year.

There is an exception for real estate service industry. In the value-added of real estate, the major part is an imputed value, the owner-occupied housing service, which is the housing service produced by the residents' own residences. For the national level data of 2004, the owner-occupied housing service accounts for 56.6 per cent of real estate value-added. For this part of value-added, there is no corresponding employment and investment statistics, so it should be excluded from the analysis of total factor productivity. But we cannot separate the owner-occupied housing service from real estate value-added for regional data, so in case of the data being "polluted", we delete the real estate industry from the whole calculation and analysis.

5.2 Labor input

Strictly speaking, an ideal labor input should consider several different factors, including the number of employees, working hours and labor quality (efficiency). But the working hours statistics are not available in China, and there is no detailed labor quality information either. So we cannot get the quality adjusted working hours as labor input indicator. Then we use the number of employees as a proxy indicator for labor input.

5.3 Capital input

In productivity analysis, capital stock is usually used as capital input indicator. But currently there is no existing capital stock information in China, so we have to estimate it by ourselves. Perpetual Inventory Method (PIM) is the mostly used method in the estimation of capital stock, which is now widely used in OECD countries. In related economic researches of China, as there is no official capital stock statistics, many researchers have calculated capital stock of China by themselves. Chow (1993) measured the capital formation and their contribution to the economic growth of China over 1952-1980, which became a benchmark for the later capital stock researches. Zhang et al. (2004) researched the capital stock estimation of China, which have been cited by many other relevant researches. Cao and Liu (2008) and Yang (2008) estimated the capital stock for China's services sector. In China's services sector TFP researches, many researchers have used Perpetual Inventory

Method to calculate the capital stock for services sector.

The formula of the Perpetual Inventory Method is:

$$K_{i,t} = (1-\delta_{i,t}) \times K_{i,t-1} + I_{i,t} = (1-\delta_{i,t})^{t} \times K_{i,0} + \sum_{j=1}^{t} I_{i,j} (1-\delta_{i,t})^{t-j} \qquad (7)$$

where $K_{i,t}$ and $K_{i,t\text{-}1}$ are the capital stock of industry i for period t and $t\text{-}1$, respectively, and $K_{i,0}$ represents the capital stock for base year. $I_{i,t}$ is the capital formulation at constant prices of industry i for period t, and $\delta_{i,t}$ is the capital depreciation rate of industry i for period t. The meaning of formula (7) is straightforward. The capital stock of current period is equal to the capital stock of previous period plus the new capital formulated in current period minus the depreciation of previous period.

There are four factors we should know in formula (7) if we want to calculate the capital stock of current period, including capital stock of base year, capital formulation of current year, depreciation rate and deflators of fixed capital formulation.

As of capital stock of base year for provinces, usually there are two ways to estimate. One is to estimate the national data first, then allocate the national data into 31 provinces by some indicator, like gross capital formulation or fixed assets investment. The other is to divide the capital formulation of base year by some specific number. The specific number used by Zhang et al. (2004) is 10%. There are also some researches using the average annual growth rate of fixed investment for some period as the specific number. In this paper, we follow the method of Zhang et al. (2004), which means that the capital stock of base year will be equal to the capital formulation of base year multiplying 10.

For the capital formulation of current period, the most ideal way is to use the detailed Gross Fixed Capital Formulation (GFCF) data in national accounts. But for regional level data, the Gross Fixed Capital Formulation data by industry is not available. What we can get is the fixed assets investment by region and by industry. We multiply the detailed fixed assets investments data by the ratio of total fixed assets investment to total gross fixed capital formulation, to simulate the fixed capital formation by region and by industry. One point we should note here is that the fixed assets investment should be deflated first before being used.

As of the depreciation rate, most researches use 4%, which is actually quite reasonable, because in the practice of national accounts compilation, the national accountants of China use 4% as depreciation rate in most services industries. So this paper also uses 4% as the depreciation rate.

For deflators of fixed capital formulation, as we don't have detailed information on regional fixed capital formulation by industry, we cannot get relevant deflators either. Since our estimation of fixed capital formulation is based on fixed assets investment, we use the fixed assets investment price indexes as a proxy indicator.

Chapter 6: Main Findings: Overall Trend, Regional Differences and Industrial Comparison

Using *DEAP 2.1* (Data Envelopment Analysis Programming 2.1) software, we calculated the Malmquist productivity index and its decomposed components of China's services sector over 2003-2012, and analyzed the overall trend, regional differences and industrial comparison.

6.1 Overall trend

As shown in Table 4, over the past decade, the average annual growth rate of China's services sector TFP is 3.1 per cent, among which the average annual growth rate of technical efficiency is 0.7 per cent, and the average annual growth rate of technical progress is 2.4 per cent. We can see the growth of China's services sector TFP is mainly from the growth of technical progress. The contribution of technical efficiency to the total factor productivity growth of China's services sector is quite slight. And among the slight growth of technical efficiency over this period, the major contribution comes from pure technical efficiency growth, whose average annual rate is 0.7 per cent. The scale efficiency has an inefficient performance during this period, which has a negative annual growth rate of -0.1 per cent. Over the past ten years, the average annual growth rate of China's services sector is 10.9 per cent, much higher than the 3.1 percentages annual growth rate of total factor productivity, which implies that the high growth of China's services sector is mainly from factors input, not from total factor productivity growth. This can also be seen from the average contribution of total factor productivity growth to the growth of services sector during this period, which is only 28.5 per cent.

Table 4: The Malmquist Productivity Index and Decomposition of China's Services Sector (2003-2012)

Year	TEC	TC	PTEC	SEC	TFPC	Growth rate of services sector (%)	Contribution of TFP (%)
2003-2004	1.017	1.037	1.016	1.002	1.055	10.1	54.5
2004-2005	0.993	1.056	1.008	0.986	1.049	12.2	40.2
2005-2006	1.003	1.090	1.006	0.997	1.093	14.1	66.0
2006-2007	1.015	1.040	1.016	0.999	1.055	16.0	34.4
2007-2008	1.019	1.014	1.019	1.000	1.033	10.4	31.7
2008-2009	1.016	1.001	1.015	1.001	1.017	9.6	17.7
2009-2010	1.013	0.990	1.010	1.003	1.003	9.8	3.1
2010-2011	1.006	0.991	0.997	1.009	0.997	9.4	-3.2
2011-2012	0.979	1.005	0.980	0.999	0.985	8.1	-18.5
Mean	1.007	1.024	1.007	0.999	1.031	10.9	28.5

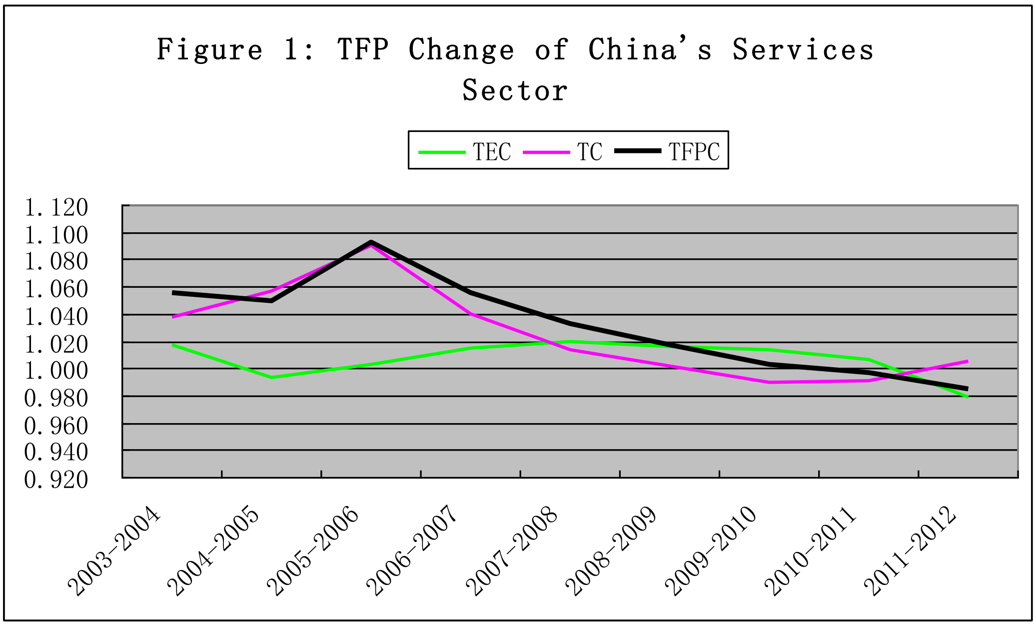
Note 1: TEC is technical efficiency change; TE is technical progress change; PTEC is pure technical efficiency change; SEC is scale efficiency change; and TFPC is total factor productivity change.

Note 2: TFPC = TEC*TC = PTEC*SEC*TC. TEC = PTEC*SEC.

Note 3: The mean value of 2003-2012 is based on the geometric mean of each period.

The average annual growth rate of services sector estimated by this paper is actually very close to the calculation result of Wang and Hu (2012), which is one of the most important and latest existing researches focusing on China’s services sector TFP change. They found the average annual growth rate of the TFP for services sector in China is 4.2 per cent over 2004 – 2010. If we shorten our data sample range to 2004 – 2010, the average annual growth rate of services sector TFP will be 4.1 per cent. But they did not find a very important trend in the most recent years as we found using the latest data, which is the continuous declining trend of services sector TFP growth since 2006, and can be very clearly seen from Figure 1. And their paper mainly focuses on industrial heterogeneity analysis based on national data, different from this paper focusing on regional difference analysis and detailed provincial industrial comparison.

From 2003 to 2007, the total factor productivity growth of services sector had kept a good performance, nearly all the years having growth rates above 5 per cent. And the peak was seen in 2006 with a TFP growth rate of 9.3 per cent. The main reason for the good performance of this short period may be behind the structural changes in services sector since China becoming a member of WTO in 2001. China lowered the entering threshold and opened the market to foreign capital in many services industries after 2001, which stimulated the development of services sector.



Although we saw a peak in 2006, the services sector TFP growth began to enter into a continuous declining channel since the same year. Slowdown of the TFP growth in the first stage may be due to the overheating of the Chinese economy around 2006 and 2007. The GDP growth rate of China for 2006 and 2007 are 13.3 per cent and 14.6 per cent, respectively. Services sector grew even faster than GDP, 14.1 per cent in 2006 and 16.0 per cent in 2007. Economic researches have shown that the overheating of economy may cause numbers of negative effects, one of which is the slowdown of total factor productivity growth. In 2008 and 2009, the worldwide financial crisis originated from the United States also hammered the economy of China, as the Chinese economy highly depends on exports. Economic growth declined during this period, which contributed to the further declining of total factor productivity growth in China’s services sector. Another important reason which may be able to explain the decreasing of services sector TFP growth is the economic stimulus package announced by Chinese government at the end of 2008, which was supposed to deal with the negative effects of the global financial crisis, and the size of the stimulus package reached a quite high level – four trillion Yuan. Resulted from the economic stimulus plan, the fixed assets investment of services sector reached an unreasonably high level, 33.8 per cent in 2009 and 25.2 per cent in 2010, much higher than the growth of output during the same periods, which caused the further continuous declining of total factor productivity growth. After 2010, the investment growth in services sector had a drastic declining, being 11.9 per cent in 2011, 13.3 percentages lower than in 2010. But the declining trend of TFP growth has not stopped. It could be one of the negative consequences caused by the 4-trillion economic stimulus package, which had pushed the capital stock up to a quite high level.

As we mentioned before, technical progress is the main driver of the total factor productivity growth in China's services sector for 2003-2012. So the slowdown of total factor productivity growth is mainly from the decreasing trend of technical progress growth, but the effect of technical efficiency change was also very important. The peak of technical progress growth was also seen in 2006, just as total factor productivity growth. Since 2006, technical progress growth has had a drastic declining, from 9.0 per cent in 2006 down to 4.0 per cent in 2007, further down to 1.4 per cent in 2008. During 2006 – 2008, technical efficiency change had an up-forward trend, which countered some downward effects of technical progress. In the most recent two years, technical progress change has stopped the declining trend, but total factor productivity growth continued to decline, which was caused by the decreasing of technical efficiency change. And at the same time, the slowdown of technical efficiency change was mainly caused by the declining of pure technical efficiency. Compared to pure technical efficiency change, scale efficiency change is a minor driver to technical efficiency change, which shows that the services sector of China doesn't have the characteristic of scale economy, still in an extensive development mode.

Along with the slowdown of total factor productivity growth, its contribution to the services sector growth also declined. In the most recent two years, 2011 and 2012, the total factor productivity had a negative growth, causing a negative contribution to services sector growth. In the year 2012, the contribution even reached -18.5 per cent, which clearly showed that the high growth speed of China's service sector was mainly built on factors input. And it is another significant evidence that China's services sector is still being in extensive development mode, not intensive development mode.

6.2 Regional differences

The economic development of China has an obvious characteristic, which is the imbalanced regional development level between different regions. For example, the highest per capita regional GDP in 2012 was seen in Tianjin at 93173 Yuan, and the lowest was seen in Guizhou at 19710 Yuan. The highest is almost five times higher than the lowest. On the total factor productivity growth of services sector, we can also find the imbalanced regional development characteristic.

Over 2003-2012, all the three regions have gained positive total factor productivity growth in services sector. The east region is seen the highest average annual growth rate at 4.4 per cent, 1.3 percentages higher than national average level. The second highest is seen in the west region at 3.7 per cent, 0.6 percentages higher than national average level. The lowest is in the middle region at 0.6 per cent, 2.5 percentages lower than national average level. This result is somewhat astonishing, as the least developed part in China is the west region, not the middle region. In 2011, the per capita regional GDP for the west region is 27731 Yuan, being lower than the middle region, which is 30154 Yuan. The main reason for the middle region having the worst productivity growth performance may be that this region relies more on investment than other regions. From 2003 to 2012, the average annual growth rate of services sector value-added of the east, middle and west region is 13.0, 12.2 and 13.0 per cent, respectively. While the average annual growth rate of services sector fixed assets investment of the east, middle and west region is 21.2, 26.3 and 22.5 per cent, respectively. As we can see here, the middle region has the lowest value-added growth with the highest investment growth.

The highest three provinces in average annual TFP growth over the past decade are all seen in the east region, which are Tianjin (10.0 per cent), Jiangsu (8.7 per cent) and Zhejiang (7.9 per cent). There is only one province in the east region having negative TFP growth, which is Liaoning (-2.1 per cent). Like the national average situation, the TFP growth of the east region mainly comes from the growth of technical progress. In the 4.4 percentages growth rate of TFP, 3.8 percentages are from technical progress growth, and only 0.6 percentage is from technical efficiency. Among all the five provinces which have negative TFP growth, three are seen in the middle region, which are Shanxi (-1.7 per cent), Jilin (-0.8 per cent) and Henan (-1.1 per cent). And the middle region is also the only region which saw a total negative technical efficiency growth, meaning in this region technical progress growth was the main driver of TFP growth as well. Guangxi in the west region had the lowest TFP growth among all the provinces, which is -0.5 per cent. Unlike the east and middle region, the TFP growth of the west region was driven both by technical progress and by technical efficiency. For the west region, the average annual TFP growth rate is 3.7 per cent, 2.4 percentages of which are from technical progress growth and 1.3

percentages of which are from technical efficiency growth.

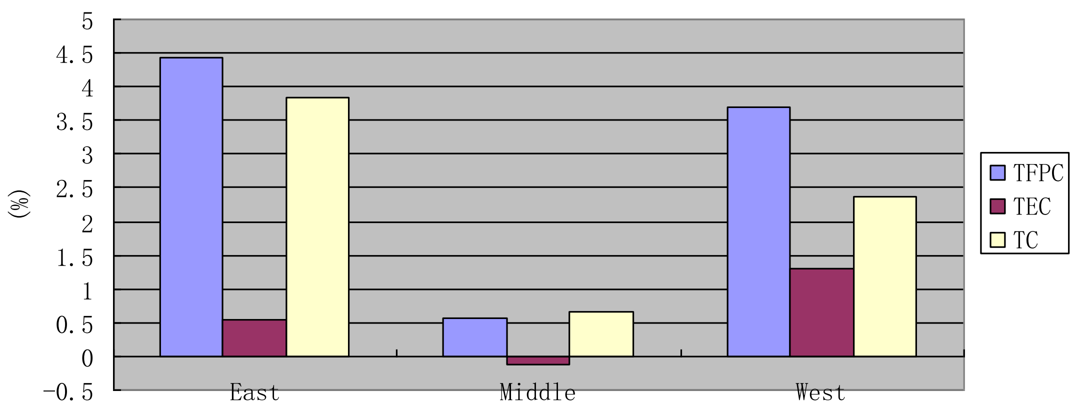
Table 5: The Average Annual Growth of Regional Malmquist Productivity Index of China's Services Sector (2003-2012)

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.000	1.003	1.000	1.000	1.003
Tianjin	1.006	1.094	1.009	0.996	1.100
Hebei	1.023	1.040	1.023	1.000	1.064
Liaoning	0.971	1.008	0.970	1.002	0.979
Shanghai	1.000	1.055	1.000	1.000	1.055
Jiangsu	1.018	1.068	1.016	1.001	1.087
Zhejiang	1.005	1.073	1.008	0.998	1.079
Fujian	1.002	1.043	1.003	0.999	1.045
Shandong	1.009	1.020	1.014	0.996	1.029
Guangdong	0.996	1.016	1.000	0.996	1.012
Hainan	1.032	1.007	1.031	1.001	1.040
Mean of East Region	**1.006**	**1.038**	**1.007**	**0.999**	**1.044**
Shanxi	0.982	1.001	0.976	1.006	0.983
Jilin	0.985	1.007	0.982	1.004	0.992
Heilongjiang	1.010	1.008	1.012	0.998	1.018
Anhui	1.003	1.007	1.002	1.000	1.010
Jiangxi	1.021	1.006	1.022	0.999	1.028
Henan	0.981	1.008	0.980	1.001	0.989
Hubei	1.006	1.008	1.006	1.000	1.014
Hunan	1.004	1.008	1.003	1.000	1.012
Mean of Middle Region	**0.999**	**1.007**	**0.998**	**1.001**	**1.006**
Inner Mongolia	1.036	1.039	1.038	0.998	1.076
Guangxi	0.944	1.007	0.940	1.005	0.950
Chongqing	0.987	1.083	0.987	1.000	1.070
Sichuan	1.013	1.007	1.012	1.001	1.020
Guizhou	1.058	1.005	1.059	0.999	1.063
Yunnan	0.991	1.008	0.990	1.001	1.000
Tibet	1.008	1.016	1.000	1.008	1.023
Shaanxi	1.044	1.008	1.043	1.001	1.052
Gansu	1.048	1.008	1.054	0.994	1.057
Qinghai	1.006	1.008	1.009	0.998	1.014
Ningxia	0.981	1.094	1.000	0.981	1.073
Xinjiang	1.046	1.006	1.048	0.998	1.053
Mean of West Region	**1.013**	**1.024**	**1.014**	**0.999**	**1.037**

Note: The mean value of region is based on the geometric mean of each province related.

For the further decomposition of technical efficiency growth, the east and west region have the same pattern, which is different from the one of the middle region. For the east and west region, both of them have a negative scale efficiency growth, so their technical efficiency growth can be seen as totally coming from pure technical efficiency growth. For example, the average annual technical efficiency growth rate of the east region is 0.6 per cent, as pure efficiency growth rate being 0.7 per cent and scale efficiency growth rate being -0.1 per cent. The middle region has an opposite pattern, whose pure technical efficiency saw a negative growth while scale efficiency saw a positive growth.

Figure 2: The TFP Growth and Decomposition of Three Regions



From Table 6 and Figure 3, 4 and 5, we can see the changing trend of each region's TFP growth and the decomposed components over time. All the three regions have seen an overall declining trend since 2006. And another point being worth noted is that all the three regions have recorded a negative TFP growth for the most recent year, 2012. The declining trend for the east and west region is very obvious, which is somewhat like a straight line. For the most recent years, the declining trend does not have a sign to stop, and the TFP growth performance continues to worsen. While for the middle region, the most recent two years actually saw a concussive change in TFP growth, which maybe mean that the declining trend has stopped.

Table 6: The Regional Malmquist TFP Growth of China's Services Sector

	Year	**TEC**	**TC**	**PTEC**	**SEC**	**TFPC**
East Region	2003-2004	0.985	1.080	0.995	0.990	1.064
	2004-2005	1.000	1.065	1.008	0.992	1.064
	2005-2006	1.037	1.085	1.039	0.999	1.125
	2006-2007	1.003	1.065	1.003	1.000	1.069
	2007-2008	1.010	1.024	1.005	1.006	1.034
	2008-2009	1.014	1.018	1.009	1.005	1.032
	2009-2010	1.024	0.998	1.020	1.004	1.022
	2010-2011	1.007	0.998	1.005	1.002	1.004
	2011-2012	0.970	1.018	0.976	0.993	0.987
Middle Region	2003-2004	1.046	0.983	1.027	1.019	1.028
	2004-2005	0.974	1.045	0.990	0.984	1.018
	2005-2006	0.945	1.100	0.942	1.003	1.039
	2006-2007	1.018	1.009	1.017	1.001	1.027
	2007-2008	1.009	1.001	1.013	0.996	1.010
	2008-2009	1.004	0.981	1.008	0.996	0.985
	2009-2010	1.003	0.975	1.002	1.001	0.978
	2010-2011	1.006	0.980	0.996	1.010	0.986
	2011-2012	0.989	0.993	0.987	1.002	0.982
West Region	2003-2004	1.028	1.036	1.027	1.001	1.065
	2004-2005	1.000	1.055	1.019	0.981	1.055
	2005-2006	1.013	1.087	1.021	0.993	1.102
	2006-2007	1.023	1.038	1.028	0.995	1.062
	2007-2008	1.033	1.013	1.036	0.998	1.047
	2008-2009	1.025	0.999	1.025	1.000	1.024
	2009-2010	1.010	0.993	1.008	1.002	1.003
	2010-2011	1.005	0.993	0.990	1.015	0.997
	2011-2012	0.981	1.003	0.978	1.003	0.984

We can also see a convergence trend in the TFP growth of the three regions over the past decade. All of the three regions have their growth rate peak for TFP in 2006, but their TFP growth rates in 2006 are quite different from each other. The TFP growth rate for the east region is 12.5 per cent in this year; for the middle region it is 3.9 per cent; and for the west region it is 10.2 per cent. In 2012, their TFP growth rates are much closer to each other, with the east region being -1.3 per cent, the middle region being -1.8 per cent and the west region being -1.6 per cent.

For the technical progress growth, we can see a same pattern for all the three regions since 2006. They all have a continuous declining trend during 2006-2010 on technical progress growth. While since 2010, the three regions all have stopped to decline and begun to increase. Until 2012, the east and west regions have seen a positive technical progress growth. But the middle region is still in a negative growth situation. And for the technical efficiency growth, there is a different temporal changing pattern. Before 2010, all the regions had a concussive changing trend, and after 2010, all of them have seen a declining trend. This means that before 2010, the declining of TFP growth were mainly from the declining of technical progress growth, and after 2010, the main factor was changed into technical efficiency growth.

Figure 3: TFP Change of the East Region's Services Sector

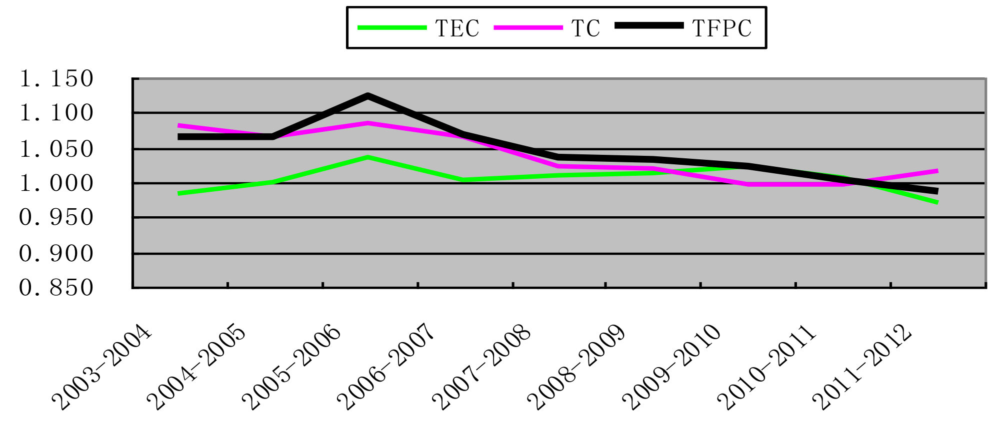


Figure 4: TFP Change of the Middle Region's Services Sector

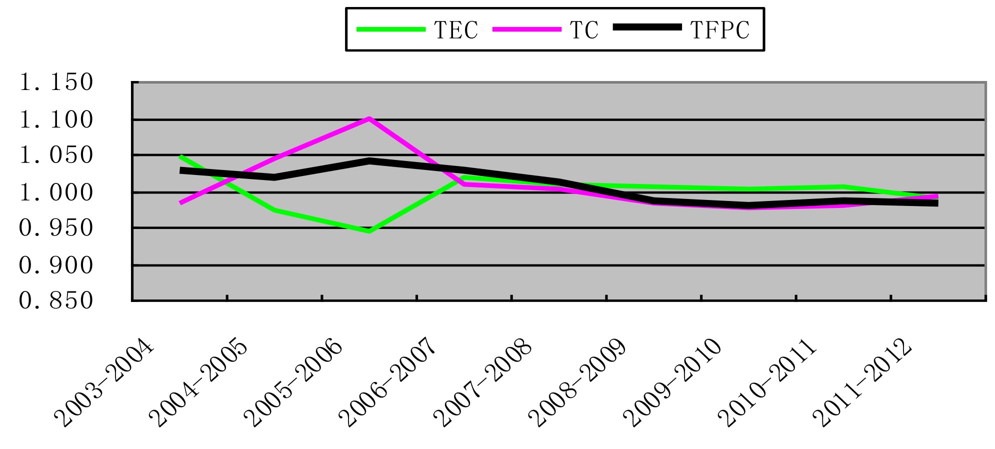
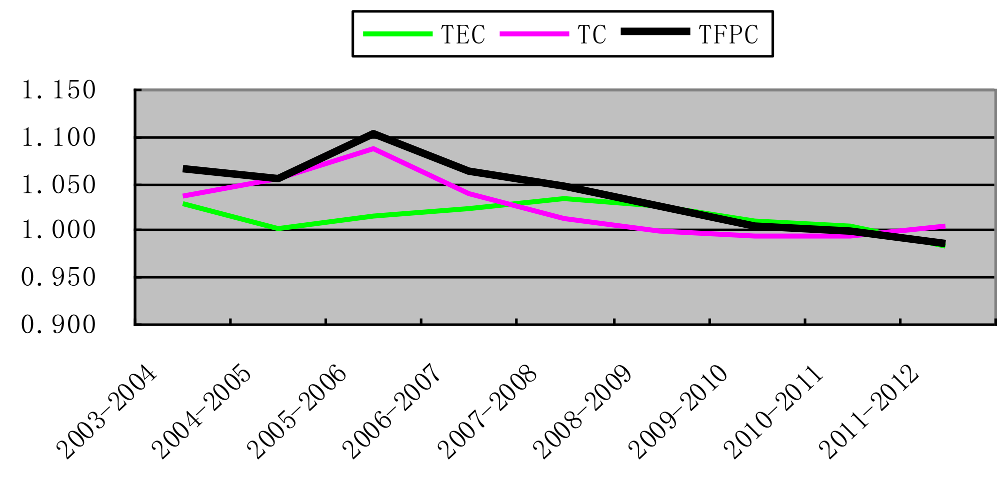


Figure 5: TFP Change of the West Region's Services Sector



6.3 Industrial comparison

Table 7: The Average Annual Growth of Industrial Malmquist Productivity Index of China's Services Sector (2004-2012)

Industry	TEC	TC	PTEC	SEC	TFPC
Transport, Storage and Post	0.987	1.076	0.993	0.995	1.062
Information Transmission, Computer Services and Software	1.014	1.069	1.013	1.001	1.083
Wholesale and Retail Trades	1.031	1.053	1.030	1.001	1.085
Hotels and Catering Services	1.003	1.000	1.014	0.990	1.003
Financial Intermediation	1.092	1.011	1.081	1.011	1.104
Leasing and Business Services	1.057	1.008	1.058	0.999	1.065
Services to Households and Other Services	1.015	1.022	1.006	1.009	1.037
Culture, Sports and Entertainment	0.979	1.092	0.990	0.989	1.069
Mean of Market Services	**1.022**	**1.041**	**1.023**	**0.999**	**1.063**
Scientific Research, Technical Services and Geologic Prospecting	0.990	1.055	0.986	1.003	1.044
Management of Water Conservancy, Environment and Public Facilities	1.017	0.983	1.011	1.006	0.999
Education	1.016	1.031	1.005	1.010	1.048
Health, Social Security and Social Welfare	1.007	1.005	1.005	1.002	1.012
Public Management and Social Organizations	0.994	1.086	0.998	0.996	1.080
Mean of Non-Market Services	**1.005**	**1.031**	**1.001**	**1.003**	**1.036**

Note: The mean value of market or non-market services is based on the geometric mean of each industry related.

For analytical convenience, we classify all the 13 services industries[3] into two groups in this section, market services and non-market services. Market services include Transport, Storage and Post, Information Transmission, Computer Services and Software, Wholesale and Retail Trades, Hotels and Catering Services, Financial Intermediation, Leasing and Business Services, Services to Households and Other

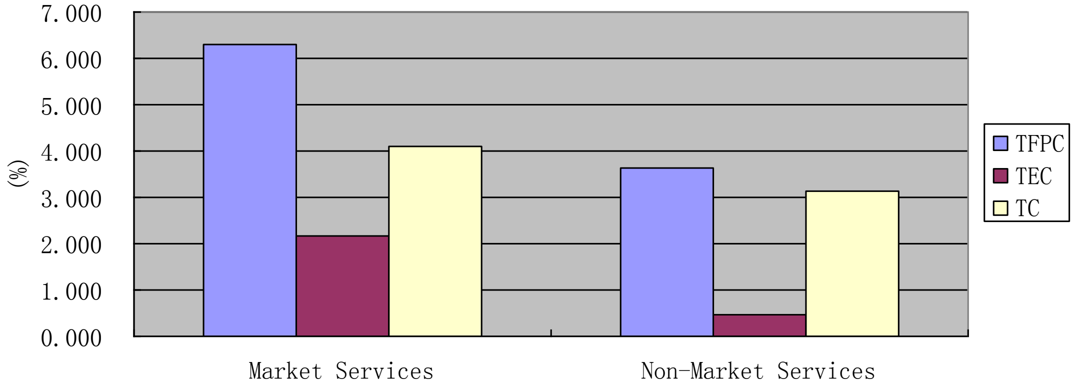
[3] Real estate has been excluded here, and the reason for that we explained in Chapter 5.

Services, and Culture, Sports and Entertainment. Non-market services include Scientific Research, Technical Services and Geologic Prospecting, Management of Water Conservancy, Environment and Public Facilities, Education, Health, Social Security and Social Welfare, and Public Management and Social Organizations. And as we are lack of detailed industrial value-added for 2003, all the analysis in this section will be over 2004-2012.

As we can see from Table 7, over 2004-2012, the average annual TFP growth rate of market services and non-market services are 6.3 and 3.6 per cent, respectively. The productivity growth of market services is higher than the one of non-market services, which corresponds to the general conception of non-market services usually having slower productivity growth. For market services, almost all the industries have an average annual TFP growth above 6 per cent, except Services to Households and Other Services and Hotels and Catering Services. Financial Intermediation was seen the highest annual growth rate at 10.4 per cent, which implies the fact that financial services are the most benefited field in the services sector reform during the past decade. Wholesale and Retail Trades and Information Transmission, Computer Services and Software also saw a quite high TFP growth rate above 8 per cent. And their high growth of productivity can be due to the widely used information and telecommunication technology in related businesses. The lowest growth rate of market services was seen in Hotels and Catering Services, the average annual TFP growth rate only being 0.3 per cent. Among non-market services, almost all the industries have a TFP annual growth rate below 6 per cent, except Public

Management and Social Organizations. Management of Water Conservancy, Environment and Public Facilities is the only industry which has a negative TFP annual growth. Public Management and Social Organizations saw the fastest TFP growth in non-market services at 8 per cent. We will analyze possible reason for that at the end of this section.

Figure 6: The TFP Growth and Decomposition of Two Industry Groups



From Figure 6, we can see that for non-market services, the TFP growth is mainly driven by technical progress. Among the 3.6 percentages of non-market services TFP annual growth rate, 3.1 percentages are from technical progress growth. In the case of market services, the main driver of TFP growth still is technical progress, but at the same time the effect of technical efficiency cannot be neglected. The annual growth rate of market services TFP is 6.3 per cent, 4.1 percentages of which are from technical progress growth and 2.2 percentages of which are from technical efficiency growth.

For technical progress, most industries saw positive growth and only one industry had negative growth, which shows again that technical progress is the main driver of the TFP growth of China's services sector. Most market services industries had a high technical progress growth rate, but there are still some industries having quite low one, among which the lowest is Hotels and Catering Services. The annual growth rate of the technical progress in this industry is 0 per cent, meaning there is no technical progress over the nine year from 2004 to 2012 for Hotels and Catering Services. The main reason may be behind the operating nature of this industry as for hotels and restaurants it is quite difficult to gain real technical progress. In China, most restaurants covered by Catering Services sector are small scaled ones, making it even harder to gain technical progress. According to the Second National Economic Census (2008) result in China, in 2008, 78.3 per cent of Catering Services' gross output is generated by the restaurants whose annual income is below 5 million Yuan. Compared to the average annual growth rate of market services technical progress, which is 4.1 per cent, the one of non-market services is 1 percentage lower at 3.1 per cent. What surprises us is that a quite high technical progress growth rate is found in Public Management and Social Organizations. This is not easy to understand and we will analyze possible reasons at the end of this section. And for technical efficiency, there are four industries having negative growth and only three industries having an average annual growth rata over 2 per cent, which means that most services industries still have quite big space to improve on technical efficiency.

Table 8: The Industrial Malmquist TFP Growth of China's Services Sector

	Year	TEC	TC	PTEC	SEC	TFPC
Market Services	2004-2005	1.049	1.039	1.053	0.996	1.090
	2005-2006	1.031	1.087	1.031	1.000	1.121
	2006-2007	1.007	1.083	1.004	1.003	1.091
	2007-2008	1.016	1.049	1.012	1.004	1.066
	2008-2009	1.030	1.018	1.033	0.998	1.049
	2009-2010	1.019	1.030	1.028	0.991	1.050
	2010-2011	1.018	1.012	1.017	1.002	1.030
	2011-2012	1.004	1.009	1.003	1.001	1.013
Non-market Services	2004-2005	1.078	0.995	1.052	1.025	1.072
	2005-2006	1.020	1.076	1.030	0.990	1.098
	2006-2007	1.021	1.049	1.011	1.010	1.071
	2007-2008	0.992	1.078	0.999	0.993	1.069
	2008-2009	0.966	1.037	0.978	0.988	1.002
	2009-2010	0.978	1.015	0.976	1.002	0.992
	2010-2011	0.970	1.031	0.969	1.001	1.000
	2011-2012	1.017	0.975	0.998	1.019	0.992

From Table 8, Figure 6 and Figure 7 we can see that, the TFP growth of market services sector has a significant declining trend since 2006, only having a slight rebound in 2010. The year 2006 saw a market services TFP growth peak at 12.1 per cent, but after six years' continuous declining, the TFP growth rate has decreased into 1.3 per cent in 2012. Compared to market services, although non-market services have an overall declining trend on TFP growth since 2006 as well, the change of it in most recent years is much more stable. Actually, the TFP growth of non-market services has been keeping a stationary fluctuation since 2009.

For the driving factor of the declining trend, market services and non-market services also have different characteristic. As seen from Figure 6 and 7, the declining of market services TFP growth over 2006 – 2012 is mainly driven by the slowdown of technical progress growth, while the declining of non-market services sector TFP growth over 2006-2009 is mainly driven by the slowdown of technical efficiency growth. As we mentioned here, the TFP growth of non-market services stopped the declining trend since 2009, which can be mainly due to the rebound of technical efficiency growth.

Figure 7: TFP Change of Market Services Sector

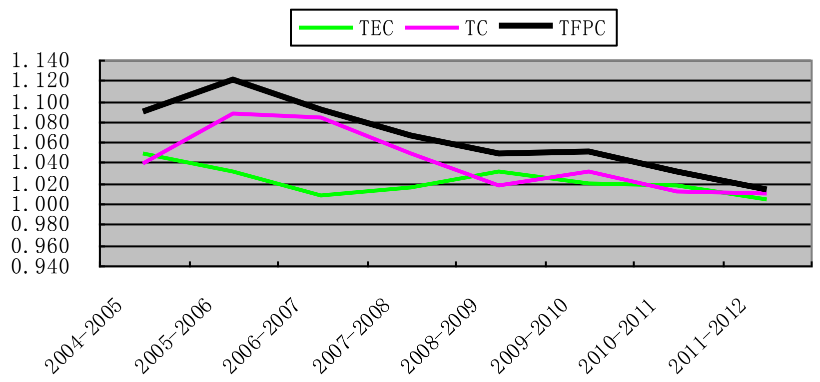
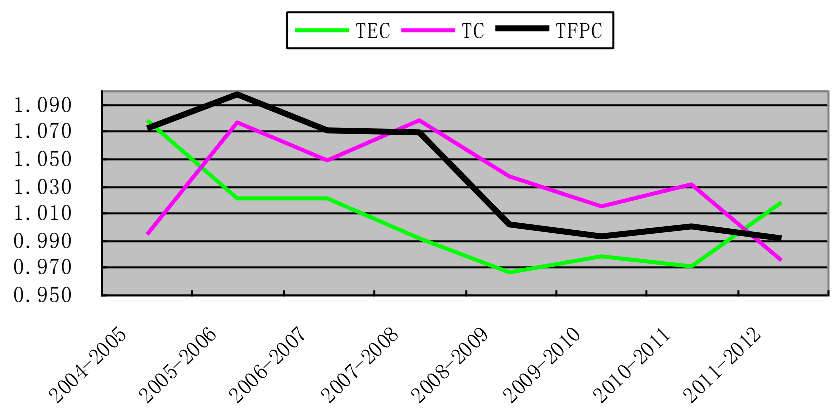


Figure 8: TFP Change of Non-market Services Sector



As we aforementioned is this section, the TFP and technical progress growth rates of Public Management and Social Organizations are quite high, not only much higher than any other non-market services industry, but also higher than many market services sector, which is very difficult to understand and explain. Public Management and Social Organizations is a typical non-market services industry, and according to common economic knowledge, it should have a very slow productivity growth or even a zero productivity growth. The growth of its output should be mainly from the growth of labor input. But if we compare the growth of output and growth of labor input of Public Management and Social Organizations over this period, we will find an opposite situation. Over 2004 – 2012, the average annual growth rate of the value-added at constant price for Public Management and Social Organizations is 12.4 per cent, while the average annual growth rate of the number of employee is only 3.2 per cent, the latter being much lower than the former, which may imply the data quality problem existing in this industry. So the output having been overestimated could be the possible reason for the unusually high TFP growth of Public Management and Social Organizations.

Before 2008, in China's national accounting practice, the real value-added growth rate of Public Management and Social Organizations is mainly based on the growth of deflated current expenditures, while the deflator usually being the price index for service items in CPI. This method may significantly overestimate the real growth of this industry. For example, when the number of employees keeps constant but their salaries, which are the major part of current expenditures of governmental organizations, are improved at a much higher growth than CPI, the real growth of value-added should be kept constant as well. But using the method we just mentioned, the estimated growth of real value-added will be much higher than zero. The National

Bureau of Statistics (NBS) of China, the national accounts compiling agency of China, realized this problem through international cooperation projects with some other official statistics agencies from advanced countries. So after 2008, the NBS began to use a new methodology in estimating the value-added of Public Management and Social Organizations and some other non-market services industries. With the new method, the growth of real value-added will be based on the average value of the growth rate of deflated current expenditure and the growth rate of the number of employees. The historical data have not been revised according to the new method. From our TFP calculation result, we can see a significant drop before and after 2008, which can be due to the change of value-added estimation methodology. Over 2004-2008, the average annual growth rate of Public Management and Social Organizations TFP is 11.3 per cent, while the one over 2009-2012 is 4.9 per cent.

Chapter 7: Conclusion

In this paper, using the latest provincial and industrial data, we calculated the Malmquist total factor productivity index of China's services sector and its decomposed components based on Data Envelopment Analysis technique over the past decade. We analyzed the regional and industrial difference on the services sector TFP growth with the Malmquist productivity index calculation result. Our main findings are as follows.

1. The total factor productivity growth of China's services sector is mainly from technical progress growth. Over 2003 – 2012, the average annual total factor productivity growth rate of China's services sector is 3.1 per cent, among which 2.4 percentages come from technical progress growth, and only 0.7 percentages come from technical efficiency growth. From the regional and industrial analysis, we can see similar situation as well.

2. The total factor productivity growth of China's services sector has an obvious declining trend since 2006. All the provinces and industries saw their TFP growth rate peak in 2006, but after that, the overall TFP growth rate of services sector began to decline very quickly. In 2011 and 2012, we saw a negative growth rate of China's services sector TFP, meaning the total factor productivity is recessing. The possible reason behind the continuous declining of services sector TFP may be due to a combination of economic overheating, global financial crisis impact and excessive

investment.

3. The regional differences on services sector TFP growth performance are significant. The east region has recorded the highest average annual growth rate at 4.4 per cent over 2002-2012. The second highest average annual growth rate is seen in the west region at 3.7 per cent. The lowest is in the middle region at only 0.6 per cent. The worst TFP growth performance of the middle region can be due to its lower output-investment ratio compared to the two other regions.

4. There is a convergence trend in the services sector TFP growth of the three regions for the period of 2003 – 2012. In the year 2006, the services sector TFP growth rates of the east, middle and west region are 12.5, 3.9 and 10.2 per cent, respectively, which are quite different from each other. And in the most recent year 2012, the TFP growth rates of the east, middle and west region are -1.3, -1.8 and -1.6 per cent, respectively, much closer to each other than in 2006. Besides that, on the temporal changing trend, the middle region is the only one which has stopped the declining trend on services sector TFP growth.

5. Market services and non-market services have significant total factor productivity growth performance over 2004 - 2012. The average annual TFP growth rates of market services and non-market services are 6.3 and 3.6 per cent, respectively, which corresponds to the general conception of non-market services usually having slower productivity growth than market services. The driving factors of market services and non-market services are also different. The services sector TFP growth is dually driven by both technical progress and technical efficiency, while the one of

non-market services sector is mainly driven by technical progress.

6. The TFP growth of market services and non-market sector have shown different changing trend over the past decade. Market services TFP growth had a straight line declining since 2006 and the declining trend doesn’t have a sign to stop in the most recent year, while non-market services TFP has been keeping a stationary fluctuation since 2009, although it also had a declining trend between 2006 and 2009.

7. Some calculation result which is difficult to understand and explain may be due to the statistical data quality issue. We analyzed the case of Public Management and Social Organizations, which has being seen unusual high TFP growth as a typical non-market services industry. After reviewing the output estimation methodology used in China, we conjectured that the unusual high TFP growth of Public Management and Social Organizations could be caused by the overestimated output.

China has been paying much attention to the development of services sector. The central government of China published the services sector development plan for the twelve five-year period (2010-2015) in 2012, which set the development targets as both services sector value-added share in GDP and services sector employment share in total employment being 5 percentages higher in 2015 than in 2010. But there is no productivity goal set in this development plan. And in the economic reality in China, both on theoretical analysis and on policy making, the productivity issue of services sector has not been paid enough attention. With a declining trend in productivity growth, especially under the situation of negative growth in 2011 and 2012, the services sector of China cannot gain high quality development. Deeper research and analysis should be done and more attention should be paid to the services sector productivity issue in China.

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Appendix: The detailed Malmquist productivity index by industry and by province (2004-2012)

Table A1: Transport, Storage and Post

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.007	0.979	1.006	1.001	0.986
Tianjin	0.965	1.131	0.969	0.996	1.091
Hebei	1.006	1.075	1.003	1.003	1.082
Shanxi	1.012	0.986	1.008	1.004	0.998
Inner Mongolia	1.011	1.131	1.011	1.000	1.143
Liaoning	0.995	0.979	0.993	1.002	0.974
Jilin	0.978	0.988	0.967	1.011	0.966
Heilongjiang	0.977	0.979	0.975	1.001	0.956
Shanghai	0.962	1.063	0.949	1.013	1.023
Jiangsu	0.991	1.131	1.002	0.989	1.120
Zhejiang	0.945	1.131	0.961	0.984	1.069
Anhui	1.001	1.064	1.015	0.986	1.065
Fujian	0.936	1.131	0.936	1.000	1.058
Jiangxi	1.000	1.102	1.011	0.990	1.102
Shandong	1.000	1.022	1.000	1.000	1.022
Henan	0.964	1.104	0.959	1.005	1.064
Hubei	0.998	1.052	0.999	0.999	1.050
Hunan	1.012	1.091	1.014	0.998	1.104
Guangdong	0.981	1.083	1.000	0.981	1.062
Guangxi	0.962	1.058	0.963	0.999	1.018
Hainan	0.988	1.087	1.010	0.977	1.074
Chongqing	1.014	1.075	1.019	0.995	1.090
Sichuan	0.936	1.097	0.935	1.000	1.026
Guizhou	1.087	1.128	1.091	0.996	1.226
Yunnan	0.943	1.131	0.943	1.000	1.066
Tibet	1.025	1.131	1.000	1.025	1.159
Shaanxi	1.017	1.083	1.021	0.995	1.101
Gansu	1.044	1.027	1.071	0.975	1.072
Qinghai	0.953	1.131	0.994	0.959	1.078
Ningxia	0.968	1.107	1.000	0.968	1.072
Xinjiang	0.953	1.106	0.964	0.988	1.053
Mean	**0.987**	**1.076**	**0.993**	**0.995**	**1.062**

Table A2: Information Transmission, Computer Services and Software

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.053	1.079	1.007	1.045	1.136
Tianjin	0.994	1.052	0.996	0.998	1.046
Hebei	0.998	1.077	0.999	0.999	1.075
Shanxi	1.023	1.078	1.031	0.993	1.103
Inner Mongolia	0.950	1.086	0.958	0.991	1.032
Liaoning	0.957	1.077	0.961	0.996	1.031
Jilin	0.965	1.096	0.979	0.985	1.058
Heilongjiang	1.011	1.048	1.009	1.002	1.059
Shanghai	1.000	1.056	1.000	1.000	1.056
Jiangsu	1.008	1.074	0.997	1.010	1.082
Zhejiang	1.022	1.078	1.029	0.994	1.102
Anhui	0.975	1.080	0.984	0.991	1.053
Fujian	1.042	1.050	1.043	0.999	1.094
Jiangxi	1.026	1.048	1.026	1.000	1.075
Shandong	0.997	1.074	0.998	0.999	1.071
Henan	1.020	1.071	1.018	1.002	1.093
Hubei	0.991	1.071	0.992	0.999	1.061
Hunan	1.010	1.077	1.015	0.995	1.088
Guangdong	1.043	1.051	1.000	1.043	1.096
Guangxi	1.006	1.062	1.008	0.998	1.069
Hainan	0.960	1.076	0.965	0.995	1.032
Chongqing	1.012	1.053	1.012	1.001	1.066
Sichuan	1.050	1.075	1.045	1.004	1.129
Guizhou	1.103	1.067	1.107	0.996	1.177
Yunnan	1.040	1.063	1.041	0.998	1.105
Tibet	0.956	1.042	1.000	0.956	0.997
Shaanxi	1.023	1.091	1.043	0.981	1.116
Gansu	1.062	1.082	1.062	1.000	1.149
Qinghai	1.090	1.095	1.000	1.090	1.193
Ningxia	1.044	1.064	1.068	0.978	1.111
Xinjiang	1.010	1.042	1.013	0.998	1.053
Mean	**1.014**	**1.069**	**1.013**	**1.001**	**1.083**

Table A3: Wholesale and Retail Trades

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.102	1.013	1.077	1.023	1.117
Tianjin	1.032	1.029	1.032	1.001	1.063
Hebei	1.014	1.112	1.009	1.006	1.128
Shanxi	1.108	1.017	1.100	1.007	1.127
Inner Mongolia	1.036	1.113	1.036	1.000	1.153
Liaoning	0.985	1.113	0.986	1.000	1.096
Jilin	1.073	1.103	1.074	0.999	1.183
Heilongjiang	1.107	1.035	1.109	0.998	1.145
Shanghai	1.012	1.007	1.000	1.012	1.019
Jiangsu	1.007	1.082	1.000	1.007	1.090
Zhejiang	0.987	1.027	0.988	0.999	1.014
Anhui	1.069	1.028	1.070	0.999	1.099
Fujian	0.972	1.023	0.971	1.001	0.995
Jiangxi	1.009	1.045	1.010	0.999	1.055
Shandong	1.014	1.113	1.043	0.972	1.128
Henan	1.028	1.028	1.016	1.012	1.057
Hubei	1.031	1.054	1.027	1.005	1.088
Hunan	1.027	1.086	1.028	0.999	1.115
Guangdong	1.000	1.020	1.000	1.000	1.020
Guangxi	1.009	1.030	1.010	0.999	1.039
Hainan	0.971	1.011	1.000	0.971	0.982
Chongqing	1.030	1.029	1.031	0.999	1.060
Sichuan	1.060	1.034	1.062	0.998	1.095
Guizhou	1.116	0.994	1.119	0.998	1.109
Yunnan	0.997	1.027	0.996	1.001	1.024
Tibet	1.026	1.096	1.000	1.026	1.125
Shaanxi	1.099	1.061	1.099	1.000	1.166
Gansu	1.060	1.066	1.064	0.997	1.131
Qinghai	1.019	1.067	1.021	0.998	1.087
Ningxia	0.964	1.108	0.960	1.004	1.068
Xinjiang	1.004	1.101	1.004	0.999	1.105
Mean	**1.031**	**1.053**	**1.030**	**1.001**	**1.085**

Table A4: Hotels and Catering Services

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.139	0.914	1.109	1.027	1.041
Tianjin	0.962	0.939	0.962	1.000	0.904
Hebei	0.958	1.005	0.955	1.003	0.963
Shanxi	0.981	0.918	0.982	0.999	0.901
Inner Mongolia	1.000	1.050	1.000	1.000	1.050
Liaoning	0.982	1.045	1.010	0.973	1.026
Jilin	1.064	0.997	1.060	1.004	1.061
Heilongjiang	1.000	0.944	1.000	1.000	0.944
Shanghai	1.011	0.960	1.029	0.982	0.970
Jiangsu	0.968	0.995	1.008	0.961	0.963
Zhejiang	1.029	0.975	1.047	0.983	1.003
Anhui	0.972	1.055	0.971	1.001	1.025
Fujian	0.973	0.993	0.989	0.984	0.966
Jiangxi	0.935	1.106	0.951	0.983	1.035
Shandong	0.940	0.996	0.992	0.947	0.936
Henan	0.980	0.993	1.000	0.980	0.974
Hubei	1.032	0.999	1.045	0.988	1.031
Hunan	1.028	0.990	1.026	1.002	1.018
Guangdong	0.985	0.966	1.000	0.985	0.952
Guangxi	1.003	0.994	1.010	0.993	0.997
Hainan	1.007	1.060	1.013	0.994	1.068
Chongqing	1.032	0.993	1.032	1.000	1.025
Sichuan	0.998	0.992	1.000	0.998	0.989
Guizhou	1.125	0.960	1.116	1.008	1.080
Yunnan	0.961	0.966	0.977	0.983	0.928
Tibet	1.028	1.052	1.000	1.028	1.082
Shaanxi	1.053	0.994	1.063	0.991	1.046
Gansu	1.003	0.983	1.012	0.992	0.986
Qinghai	0.956	1.055	1.000	0.956	1.009
Ningxia	1.011	1.104	1.058	0.956	1.117
Xinjiang	1.019	1.027	1.025	0.993	1.046
Mean	**1.003**	**1.000**	**1.014**	**0.990**	**1.003**

Table A5: Financial Intermediation

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.011	0.947	1.000	1.011	0.957
Tianjin	1.063	0.975	1.060	1.003	1.036
Hebei	1.092	0.988	1.060	1.030	1.079
Shanxi	1.241	0.932	1.240	1.001	1.157
Inner Mongolia	1.103	1.050	1.103	1.000	1.159
Liaoning	1.088	1.050	1.052	1.034	1.143
Jilin	1.056	1.050	1.057	0.999	1.109
Heilongjiang	1.226	1.003	1.228	0.998	1.229
Shanghai	1.000	0.927	1.000	1.000	0.927
Jiangsu	1.101	1.005	1.034	1.064	1.106
Zhejiang	1.081	1.029	1.059	1.021	1.112
Anhui	1.114	0.986	1.117	0.998	1.099
Fujian	1.063	1.046	1.063	1.000	1.112
Jiangxi	1.034	1.050	1.035	0.999	1.086
Shandong	1.084	1.030	1.016	1.067	1.116
Henan	1.171	0.970	1.111	1.054	1.136
Hubei	1.131	1.050	1.133	0.999	1.188
Hunan	1.064	0.993	1.056	1.007	1.056
Guangdong	1.028	1.049	0.991	1.038	1.079
Guangxi	1.117	1.050	1.117	1.001	1.173
Hainan	1.150	1.050	1.134	1.014	1.208
Chongqing	1.081	1.010	1.079	1.002	1.092
Sichuan	1.112	0.918	1.089	1.021	1.021
Guizhou	1.108	1.034	1.115	0.993	1.145
Yunnan	1.063	1.036	1.069	0.995	1.101
Tibet	1.102	1.050	1.000	1.102	1.158
Shaanxi	1.100	1.016	1.102	0.998	1.118
Gansu	1.070	0.982	1.081	0.990	1.051
Qinghai	1.052	1.024	1.111	0.947	1.078
Ningxia	1.090	1.006	1.138	0.958	1.097
Xinjiang	1.107	1.050	1.107	1.000	1.162
Mean	**1.092**	**1.011**	**1.081**	**1.011**	**1.104**

Table A6: Leasing and Business Services

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.242	0.940	1.168	1.063	1.168
Tianjin	1.089	1.057	1.089	1.000	1.151
Hebei	1.000	1.053	0.999	1.001	1.052
Shanxi	1.041	0.846	1.043	0.998	0.881
Inner Mongolia	1.025	1.040	1.024	1.001	1.066
Liaoning	1.059	1.051	1.066	0.993	1.113
Jilin	1.069	1.045	1.068	1.001	1.118
Heilongjiang	1.027	1.028	1.026	1.001	1.055
Shanghai	1.000	0.940	1.000	1.000	0.940
Jiangsu	1.072	1.039	1.072	1.000	1.114
Zhejiang	1.017	1.018	1.042	0.976	1.036
Anhui	1.132	1.037	1.131	1.001	1.174
Fujian	1.075	1.028	1.080	0.995	1.105
Jiangxi	1.007	1.036	1.004	1.002	1.043
Shandong	1.011	1.040	1.022	0.990	1.051
Henan	1.099	1.016	1.099	1.000	1.116
Hubei	1.197	1.043	1.202	0.996	1.248
Hunan	1.072	1.040	1.079	0.993	1.115
Guangdong	0.969	1.014	1.000	0.969	0.982
Guangxi	1.062	1.012	1.062	1.000	1.075
Hainan	1.034	1.001	1.036	0.998	1.035
Chongqing	0.924	1.020	0.921	1.003	0.942
Sichuan	1.075	1.030	1.074	1.001	1.108
Guizhou	1.242	0.973	1.256	0.989	1.209
Yunnan	0.997	0.945	1.001	0.996	0.942
Tibet	1.090	1.027	1.000	1.090	1.119
Shaanxi	1.051	1.053	1.050	1.001	1.106
Gansu	1.135	1.025	1.135	1.000	1.163
Qinghai	0.983	0.977	0.974	1.009	0.961
Ningxia	0.995	0.938	1.099	0.906	0.934
Xinjiang	1.040	0.961	1.049	0.991	1.000
Mean	**1.057**	**1.008**	**1.058**	**0.999**	**1.065**

Table A7: Scientific Research, Technical Services and Geologic Prospecting

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.065	1.037	1.000	1.065	1.104
Tianjin	1.000	1.015	1.000	1.000	1.015
Hebei	0.948	1.112	0.946	1.002	1.054
Shanxi	0.938	0.922	0.917	1.024	0.865
Inner Mongolia	0.974	1.110	0.989	0.985	1.082
Liaoning	0.983	1.111	0.998	0.986	1.092
Jilin	0.992	1.109	0.993	0.999	1.101
Heilongjiang	0.965	1.024	0.949	1.017	0.988
Shanghai	1.008	1.035	1.000	1.008	1.043
Jiangsu	0.977	1.112	0.975	1.002	1.086
Zhejiang	1.004	1.053	1.016	0.988	1.057
Anhui	0.861	1.072	0.863	0.998	0.923
Fujian	0.974	1.087	0.975	0.999	1.059
Jiangxi	0.967	1.046	0.973	0.994	1.011
Shandong	0.943	1.112	0.940	1.003	1.048
Henan	1.003	1.095	0.992	1.010	1.098
Hubei	1.002	1.095	1.007	0.994	1.097
Hunan	1.007	1.104	1.007	1.000	1.112
Guangdong	0.936	1.112	0.970	0.965	1.041
Guangxi	0.917	1.016	0.916	1.001	0.932
Hainan	1.104	0.946	1.000	1.104	1.044
Chongqing	1.061	1.013	1.065	0.996	1.075
Sichuan	1.006	1.058	1.002	1.004	1.064
Guizhou	1.054	0.974	1.052	1.001	1.026
Yunnan	1.046	0.983	1.039	1.007	1.028
Tibet	0.925	1.094	1.000	0.925	1.012
Shaanxi	1.016	1.111	1.015	1.000	1.129
Gansu	1.018	1.052	1.021	0.997	1.071
Qinghai	1.032	1.008	1.016	1.016	1.040
Ningxia	1.024	1.031	1.000	1.024	1.055
Xinjiang	0.966	1.103	0.971	0.994	1.065
Mean	**0.990**	**1.055**	**0.986**	**1.003**	**1.044**

Table A8: Management of Water Conservancy, Environment and Public Facilities

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.099	0.979	1.098	1.001	1.076
Tianjin	1.094	1.033	1.098	0.997	1.130
Hebei	1.062	0.956	1.049	1.012	1.016
Shanxi	1.039	0.947	1.036	1.003	0.983
Inner Mongolia	1.042	0.980	1.042	1.001	1.022
Liaoning	0.993	0.947	0.997	0.996	0.941
Jilin	1.025	0.945	1.021	1.004	0.968
Heilongjiang	1.041	0.949	1.045	0.996	0.988
Shanghai	0.952	1.012	0.954	0.998	0.963
Jiangsu	1.032	1.039	1.022	1.010	1.072
Zhejiang	1.019	1.035	1.019	1.000	1.055
Anhui	0.997	0.953	0.998	0.999	0.950
Fujian	0.951	0.983	0.949	1.002	0.935
Jiangxi	1.064	0.985	1.062	1.001	1.048
Shandong	1.018	0.975	1.012	1.006	0.993
Henan	1.051	0.972	1.040	1.011	1.022
Hubei	1.026	0.960	1.007	1.020	0.985
Hunan	0.997	0.961	0.987	1.010	0.958
Guangdong	0.988	0.996	0.992	0.996	0.985
Guangxi	0.932	0.984	0.930	1.002	0.918
Hainan	1.035	0.952	0.990	1.046	0.985
Chongqing	0.997	1.041	0.998	0.999	1.038
Sichuan	0.992	1.005	0.989	1.004	0.997
Guizhou	0.911	0.986	0.906	1.005	0.898
Yunnan	1.060	0.987	1.057	1.003	1.046
Tibet	1.014	1.046	1.000	1.014	1.061
Shaanxi	1.008	0.978	1.006	1.001	0.986
Gansu	1.063	0.944	1.028	1.033	1.003
Qinghai	1.043	0.978	1.026	1.017	1.020
Ningxia	0.938	0.981	0.944	0.994	0.920
Xinjiang	1.070	0.982	1.070	1.000	1.051
Mean	**1.017**	**0.983**	**1.011**	**1.006**	**0.999**

Table A9: Services to Households and Other Services

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.106	0.973	1.037	1.066	1.076
Tianjin	0.893	0.927	0.881	1.014	0.827
Hebei	1.014	1.023	1.002	1.012	1.037
Shanxi	1.000	0.952	1.000	1.000	0.952
Inner Mongolia	1.080	1.022	1.093	0.988	1.104
Liaoning	0.884	1.022	0.937	0.943	0.903
Jilin	1.034	1.032	1.039	0.996	1.067
Heilongjiang	1.008	0.986	0.990	1.017	0.993
Shanghai	1.132	1.001	1.109	1.021	1.134
Jiangsu	1.041	1.032	1.011	1.030	1.074
Zhejiang	1.098	1.068	1.084	1.013	1.173
Anhui	0.933	1.012	0.940	0.992	0.944
Fujian	1.085	1.015	1.089	0.996	1.102
Jiangxi	1.037	1.037	1.051	0.987	1.075
Shandong	0.933	1.021	0.977	0.955	0.952
Henan	0.960	1.011	0.969	0.990	0.970
Hubei	0.993	1.017	0.993	1.000	1.010
Hunan	1.000	0.995	1.000	1.000	0.995
Guangdong	1.055	1.003	1.000	1.055	1.058
Guangxi	0.927	1.024	0.916	1.011	0.948
Hainan	1.080	0.975	1.000	1.080	1.053
Chongqing	0.998	1.010	0.995	1.003	1.008
Sichuan	1.059	1.040	1.051	1.007	1.101
Guizhou	1.165	1.001	1.134	1.028	1.166
Yunnan	1.011	1.000	1.011	1.000	1.011
Tibet	0.845	1.270	1.000	0.845	1.073
Shaanxi	0.952	1.029	0.949	1.003	0.979
Gansu	0.991	1.042	0.964	1.029	1.033
Qinghai	0.963	1.010	0.779	1.237	0.973
Ningxia	1.193	1.164	1.160	1.029	1.389
Xinjiang	1.114	1.004	1.121	0.994	1.118
Mean	**1.015**	**1.022**	**1.006**	**1.009**	**1.037**

Table A10: Education

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.021	1.034	1.010	1.010	1.056
Tianjin	1.058	1.065	1.064	0.995	1.127
Hebei	1.031	1.028	1.012	1.018	1.060
Shanxi	0.960	1.020	0.957	1.004	0.980
Inner Mongolia	0.971	1.027	0.968	1.003	0.997
Liaoning	1.022	1.031	1.019	1.003	1.053
Jilin	1.072	1.031	1.072	1.000	1.105
Heilongjiang	1.080	1.033	1.074	1.005	1.115
Shanghai	1.000	1.049	1.000	1.000	1.049
Jiangsu	1.057	1.037	1.000	1.057	1.096
Zhejiang	1.087	1.054	1.047	1.038	1.146
Anhui	0.986	1.027	0.985	1.002	1.013
Fujian	1.048	1.031	1.047	1.001	1.081
Jiangxi	1.003	1.031	1.002	1.000	1.033
Shandong	1.057	1.035	1.018	1.039	1.094
Henan	1.047	1.027	1.020	1.027	1.075
Hubei	0.977	1.031	0.964	1.013	1.007
Hunan	0.998	1.023	1.000	0.999	1.021
Guangdong	1.030	1.035	1.000	1.030	1.067
Guangxi	0.941	1.020	0.940	1.001	0.960
Hainan	1.048	1.028	1.024	1.024	1.078
Chongqing	0.996	1.032	0.995	1.001	1.028
Sichuan	1.007	1.031	0.981	1.026	1.039
Guizhou	1.046	1.020	1.042	1.004	1.067
Yunnan	0.981	1.021	0.978	1.003	1.001
Tibet	0.984	1.036	1.000	0.984	1.019
Shaanxi	1.057	1.032	1.043	1.013	1.090
Gansu	1.038	1.024	1.034	1.004	1.063
Qinghai	0.929	1.025	0.914	1.017	0.953
Ningxia	0.926	1.028	0.922	1.004	0.951
Xinjiang	1.060	1.028	1.058	1.002	1.090
Mean	**1.016**	**1.031**	**1.005**	**1.010**	**1.048**

Table A11: Transport, Storage and PostHealth, Social Security and Social Welfare

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.026	1.041	1.030	0.996	1.068
Tianjin	0.988	1.091	0.990	0.998	1.078
Hebei	1.035	1.008	1.034	1.001	1.043
Shanxi	1.036	0.946	1.044	0.992	0.980
Inner Mongolia	0.993	1.063	0.993	1.000	1.056
Liaoning	1.061	0.952	1.050	1.010	1.010
Jilin	1.057	0.969	1.060	0.997	1.024
Heilongjiang	1.024	0.959	1.030	0.994	0.981
Shanghai	1.000	1.053	1.000	1.000	1.053
Jiangsu	1.015	0.998	1.005	1.010	1.012
Zhejiang	1.021	1.062	1.016	1.004	1.084
Anhui	0.974	0.943	0.981	0.993	0.918
Fujian	0.939	1.017	0.941	0.998	0.954
Jiangxi	0.987	1.080	0.988	0.999	1.066
Shandong	0.997	0.995	0.982	1.015	0.991
Henan	1.001	0.966	0.965	1.037	0.967
Hubei	1.043	0.979	1.036	1.006	1.021
Hunan	1.003	0.990	1.003	1.000	0.993
Guangdong	1.006	1.008	1.000	1.006	1.014
Guangxi	0.951	0.978	0.955	0.996	0.930
Hainan	0.977	0.989	0.934	1.046	0.966
Chongqing	0.999	1.047	1.005	0.994	1.046
Sichuan	0.999	0.971	0.985	1.014	0.969
Guizhou	1.056	1.000	1.073	0.985	1.056
Yunnan	0.998	0.972	1.003	0.995	0.970
Tibet	0.987	1.077	1.000	0.987	1.063
Shaanxi	1.039	0.973	1.042	0.998	1.011
Gansu	1.027	0.985	1.036	0.991	1.011
Qinghai	0.978	0.985	0.965	1.014	0.964
Ningxia	0.975	1.042	0.975	1.000	1.015
Xinjiang	1.038	1.034	1.046	0.992	1.073
Mean	**1.007**	**1.005**	**1.005**	**1.002**	**1.012**

Table A12: Culture, Sports and Entertainment

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	1.017	1.014	1.000	1.017	1.032
Tianjin	1.021	1.159	1.018	1.003	1.184
Hebei	1.003	1.156	1.010	0.993	1.159
Shanxi	0.986	0.997	0.979	1.008	0.983
Inner Mongolia	0.959	1.168	0.958	1.000	1.119
Liaoning	0.972	1.162	0.969	1.003	1.129
Jilin	1.004	1.075	0.999	1.004	1.079
Heilongjiang	0.982	1.098	0.986	0.996	1.079
Shanghai	0.910	1.159	0.913	0.996	1.054
Jiangsu	0.956	1.159	0.981	0.974	1.108
Zhejiang	1.033	1.139	1.068	0.967	1.176
Anhui	0.894	1.108	0.897	0.996	0.990
Fujian	1.045	1.103	1.043	1.002	1.153
Jiangxi	0.963	1.078	0.968	0.995	1.038
Shandong	0.943	1.160	0.983	0.960	1.094
Henan	0.955	1.051	0.957	0.997	1.004
Hubei	1.036	1.069	1.002	1.034	1.107
Hunan	1.000	1.148	1.000	1.000	1.148
Guangdong	0.919	1.161	0.999	0.919	1.066
Guangxi	0.930	1.018	0.934	0.995	0.947
Hainan	1.016	1.159	1.026	0.990	1.178
Chongqing	0.920	1.131	0.905	1.016	1.040
Sichuan	0.951	1.148	0.951	1.000	1.092
Guizhou	1.045	1.066	1.062	0.984	1.113
Yunnan	0.963	1.026	0.966	0.996	0.988
Tibet	0.962	1.026	1.017	0.946	0.987
Shaanxi	1.046	1.094	1.050	0.996	1.143
Gansu	1.054	0.991	1.084	0.972	1.044
Qinghai	0.974	0.991	1.000	0.974	0.965
Ningxia	0.894	1.005	0.944	0.947	0.898
Xinjiang	1.036	1.077	1.053	0.984	1.116
Mean	**0.979**	**1.092**	**0.990**	**0.989**	**1.069**

Table A13: Public Management and Social Organizations

Province	TEC	TC	PTEC	SEC	TFPC
Beijing	0.979	1.089	0.976	1.003	1.067
Tianjin	1.028	1.086	1.033	0.995	1.116
Hebei	0.992	1.094	1.005	0.987	1.085
Shanxi	1.000	1.086	1.000	1.000	1.086
Inner Mongolia	1.038	1.087	1.031	1.007	1.128
Liaoning	0.974	1.089	0.966	1.008	1.061
Jilin	1.089	1.089	1.084	1.005	1.186
Heilongjiang	1.015	1.088	1.007	1.007	1.104
Shanghai	1.000	1.084	1.000	1.000	1.084
Jiangsu	1.008	1.089	1.000	1.008	1.099
Zhejiang	0.985	1.090	1.000	0.985	1.074
Anhui	1.033	1.089	1.025	1.008	1.125
Fujian	1.017	1.089	1.013	1.005	1.108
Jiangxi	1.004	1.088	1.014	0.990	1.092
Shandong	0.966	1.089	0.989	0.976	1.052
Henan	0.987	1.084	0.996	0.991	1.070
Hubei	0.993	1.079	0.974	1.019	1.072
Hunan	0.969	1.083	0.967	1.001	1.049
Guangdong	0.967	1.092	1.000	0.968	1.056
Guangxi	0.895	1.089	0.918	0.974	0.974
Hainan	0.954	1.080	0.964	0.990	1.030
Chongqing	0.984	1.089	0.984	1.000	1.072
Sichuan	0.982	1.083	1.000	0.982	1.064
Guizhou	1.020	1.081	1.021	0.999	1.103
Yunnan	0.973	1.075	0.971	1.002	1.046
Tibet	0.977	1.089	0.948	1.031	1.064
Shaanxi	1.064	1.086	1.040	1.023	1.155
Gansu	1.003	1.090	1.001	1.002	1.093
Qinghai	0.995	1.089	1.021	0.975	1.084
Ningxia	0.947	1.078	1.000	0.947	1.020
Xinjiang	1.002	1.081	1.018	0.985	1.083
Mean	**0.994**	**1.086**	**0.998**	**0.996**	**1.080**