Economic growth mode and total factor productivity (TFP): A literature review

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Abstract: This paper sorts out the literature related to the mode of economic growth and total factor productivity, including the theory and measurement of TFP, and the influencing factors of economic growth mode.

1. Introduction

Under the background of the new era, China's economy is turning from the stage of high-speed growth to the stage of high-quality development.

There are two ways of economic growth, one is extensive type, which mainly realizes economic growth by increasing the input of material production factors; the other is intensive type, which mainly improves the quality of production factors through technological progress and innovation, and then realizes economic growth. The connotation of total factor productivity (TFP) refers to the productivity brought by other intangible and unmeasurable factors such as technological progress after deducting the role of capital and labor in the contribution rate of output growth. Economic growth not only depends on labor and capital, but also on production factors such as innovation, institutional management and technological progress. TFP just reflects the growth rate brought by intangible factors including technological progress and system. Total factor productivity (TFP) is a key index and an important method to measure the performance of economic growth. There are some differences in the existing research results on the impact of TFP on economic growth. The main reason is that the measurement standard of TFP is inconsistent. This paper summarizes the existing literature on economic growth and TFP in China and Western countries.

2. Western Studies

2.1 The development of TFP and Economic growth mode

The theory of economic growth mode and TFP is relatively mature in foreign countries, which originated from the labor division viewpoint put forward by Adam Smith. He systematically expounded the important role of labor division in increasing national wealth and improving labor productivity. The role of labor division lies in the improvement of workers' labor proficiency. The special operation of special personnel not only saves the time and cost of production, but also improves the tools. The concept of division of labor is similar to the resource allocation part of TFP. Ricardo [1] brought the concept of technological progress to the effective improvement of capital productivity into the theoretical connotation of TFP. John Mueller thinks that the significant improvement of production efficiency can be achieved through large-scale production methods, and proposes that to some extent, the offset of diminishing returns can be achieved through technological progress and organizational innovation[2]. Marshall put forward that "knowledge is our most powerful productivity", he thought that to promote technological progress, we should improve human capital, so we must pay attention to education [3]. Schumpeter proposed that innovation is the basic driving force of economic development, emphasizing that adaptation, imitation and innovation play a decisive role in the process of economic growth.

2.2 The measurement of TFP

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Later, scholars studied more practical problems, and they made quantitative measurement of TFP. Douglas and Cobb took the lead in using the production function theory to do quantitative research on the role of productivity in economic growth(see Mode(1)-(3))[5]. The concept of TFP was first proposed by Tinbergen, who introduced time factor into Cobb Douglas production function to establish production function. Solow proposed Solow residual method to measure TFP in technology change and aggregate production function for the first time. This method estimates the residual value of TFP after excluding the contribution of capital and labor in the total growth under the assumption of complete competitive market, constant returns to scale and Hicks neutral technology [6]. Derision expanded Solow residual method(see Mode (4)-(6)) in 1950s, and took allocation resources, progressive knowledge and efficiency of scale economy as influencing factors of TFP. He determined the role of knowledge in economic growth, and introduced the variable called TFP into the production function to reflect technological progress [7]. Data envelopment analysis (DEA) was proposed by Chames&Cooper. In 1994, Fare et al. combined DEA with the index method proposed by Swedish economist StenMalmquist to measure TFP(, and decomposed it into technical progress and technical efficiency index [8]. The differences between SFA and DEA methods are compared in Fig. 1 and Fig. 2

$$Ln(Y) = Ln(A_0) + \lambda t + aLn(K) + \beta Ln(L) \quad (1)$$

$$Ln(Y|L) = Ln(A_0) + \lambda t + aLn\left(\frac{K}{L}\right) + u \quad (2)$$

$$TFPG = \triangle Y/Y - \alpha \Delta K/K - (1-\alpha)\Delta L/L \quad (3)$$

$$Y_t = A_t F(X_t) \quad (4)$$

$$\dot{Y} = \dot{A} + \sum_{i=1}^{n} \delta_n \dot{x_n} \quad (5)$$

$$TFPG = \dot{A} = \dot{Y} - \sum_{i=1}^{n} \delta_n \dot{x_n} \quad (6)$$

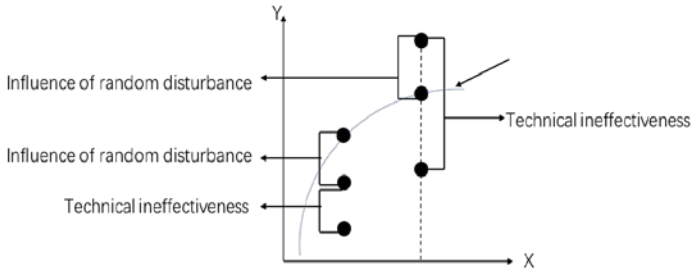

Fig.1 The influence of stochastic disturbance term and technology inefficiency in SFA

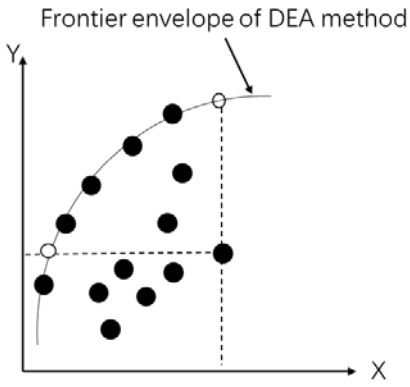

Fig.2 The structure of frontier with DEA method

2.3 Decomposition of TFP

Sylvain used the equilibrium model to study the effect of monetary policy on inflation and output volatility in the United States after 1984. The results show that the reason for the real output volatility is mainly attributed to TFP [9]. According to Cobb Douglas production function, scholars find that policy variables (such as financial development, human capital, competition policy and knowledge reserve) will affect the absorptive capacity, but will not cause permanent growth effect. Financial development and knowledge reserve have significant hierarchical effect (Visscher, 2020) [10]. Wang (2020) [11] used Malmquist -Luenberger (BML) productivity index to estimate the green TFP changes of 34 industrial sub industries in China from 2005 to 2015. The TFP of Vietnam and its determinants have been deeply analyzed. The Fare-Primont index is used in the TFP assessment and is decomposed into different components: technological change, pure technology, mixing and scale efficiency (Viet Nguyen, 2019) [12].

3. Research in China

Based on the study of foreign research methods and the actual situation of China, some scholars focus on the theory and application of TFP, some research on the mode of economic growth, while others study TFP and economic growth mode comprehensively.

3.1 On the theoretical application of TFP

Research on specific industries includes agriculture, industry, forestry and manufacturing. Liu Li and Zhang Wenai used the transcendental logarithm production function model to calculate agricultural TFP. Through analysis, it was found that agricultural TFP showed dynamic effect, positive spatial spillover effect was significant, and the overall level was growing continuously [13]. Through TFP, it is found that provinces have low non-ferrous metal industrial production efficiency, and there is no significant steady-state trend in the convergence of production efficiency. China still has severe pressure on emission reduction (Hao Rong, 2017) [14]. Scholars used DEA-M index method to measure the TFP of forestry from 2005 to 2015, and analyzed the characteristics of spatial agglomeration, and concluded that there was spatial agglomeration phenomenon and certain volatility in TFP change of forestry (Jiang Yuhe, Guan Shiyi, 2018) [15]. Based on the panel data of manufacturing industry, the study finds that independent R & D innovation, cooperative R & D innovation and non R & D innovation do not improve the TFP of manufacturing industry, but the collaborative interaction between the three and human capital has a significant promoting effect (Gu Junjian, 2020) [16].

3.2 Research on the theory of economic growth mode

In terms of theoretical research on economic growth mode, scholars mainly focus on scientific and technological progress, innovation, human capital, service and so on. Some scholars try to establish the index system of economic growth mode. Chen Hong studied the relationship between scientific and technological progress and the transformation of economic growth mode, pointed out that scientific and technological progress can mark the transformation of economic growth mode, and put forward the requirements for enterprises and the government on how to promote the transformation of economic growth mode (Chen Hong, 1999) [17].Based on the analysis of the internal meaning of economic growth, scholars have studied how to set up and establish the principles of index system for evaluating the mode of economic growth, and the signs of transforming the mode of economic growth (Hu Zongyi and Li Feng, 2002) [18]. Through the balanced analysis of the relationship between labor quality and the transformation of economic growth mode, Cheng Jianming pointed out that the way to change the mode of economic growth is to improve the quality of labor force and increase the input of human capital [19].In addition, Yang Xin and Xia Jiechang believe that under the current development environment of China, the transformation of economic growth mode can be realized with the help of service economic development [20] [21]. Chen en and Liu Jing introduced the difference of input-output efficiency based on cost difference reflected in technology and market driven by original innovation and imitative innovation in the Pearl River Delta research, established a theoretical model of endogenous economic growth driven by original innovation, and carried out quantitative analysis

on driving factors of economic growth mode [22]. Yang Shuo and Wang Aiqing believe that the scale of human capital and financial expenditure can promote TFP, thus driving the transformation of economic growth mode. However, the impact is long-term and lagging [23].

3.3 Empirical research of economic growth mode

In the empirical research of economic growth mode, there are many methods, and the mainstream research methods are Solow growth model, Gini index, SFA and DEA Malmquist index method. Based on Cobb Douglas production function(mode (1)-(3)), Li Qingji analyzes the factors affecting economic growth and puts forward suggestions on how to choose the mode of economic growth between the East and the West [24]. Zhao Wenjun and other scholars take Hicks-Moorsteen TFP index (mode (7)-(9)) as the measurement index of economic growth mode, combined with kernel density estimation and Moran index, select the change characteristics of economic growth mode of 248 cities above prefecture level in China from 2000 to 2015, and investigate the reasons for the formation of characteristics through four decomposition of the index [25]. In the relationship between TFP and the transformation of economic growth mode, some scholars use TFP to replace the transformation of economic growth mode. The DEA Malmquist index method (mode (10)-(12))is selected to measure the TFP of 30 provinces in China from 2001 to 2017. The conventional panel data analysis method is used to investigate the current and lagging effects of human capital level, human capital structure and fiscal expenditure scale on TFP (Yang Shuo and Wang AI)Qing, 2020) [23].

$$Q(y_{it}) = [D_0^{t-1}(k_{it-1}, l_{it-1}, y_{it}) * D_0^t(k_{it}, l_{it}, y_{it})]^{1/2} \quad (7)$$

$$X(k_{it}, l_{it}) = [D_1^{t-1}(k_{it}, l_{it}, y_{it-1}) * D_1^t(k_{it}, l_{it}, y_{it})]^{\frac{1}{2}} \quad (8)$$

$$TFP_{it} = Q(y_{it})/X(k_{it}, l_{it}) \quad (9)$$

$$D_i(x, y) = \max\{\rho: \left(\frac{x}{\rho}\right) \in L(y)\} \quad (10)$$

$$M_i^t\left(x_{t+1}, y_{t+1}, x_\rho, y_t\right) = D_i^t(x_{t+1}, y_{t+1})/D_i^t\left(x_\rho, y_t\right) \quad (11)$$

$$M_i^{t+1}\left(x_{t+1}, y_{t+1}, x_\rho, y_t\right) = D_i^{t+1}(x_t, y_t) \quad (12)$$

3.4 The green TFP

Some scholars have also introduced the green TFP. Considering the pressure of structural transformation, energy conservation and emission reduction, and unbalanced regional development, many scholars have begun to study the mode of economic growth based on environmental protection. Yin Chuanbin and Jiang Qijie analyzed the green development of the western region based on the perspective of green TFP, and found that the contribution of green TFP to economic growth in the western region is low, and the level needs to be improved [26]. Sun qiupeng pointed out that the quantitative and extensive growth mode emphasizes the increase of quantity and the value of goods and services that can be included in GDP, but it is difficult to measure the value of products with positive externalities, especially the value of ecological products [27].

3.5 Factors affecting TFP

In addition, some scholars do empirical research on the factors affecting TFP. Tang Weibing and others discussed the impact of technological innovation and technology introduction on the transformation of economic growth mode. Using the provincial panel data from 1996 to 2011, they found that technological innovation was negatively correlated with the level of economic growth intensification, which was not conducive to the transformation of economic growth mode, while technology introduction was more favorable [28]. Through empirical analysis, Wang Xiaowen and other scholars found that: human capital, technology introduction, opening up to the outside world, and institutional arrangement are significantly positively correlated with the level of economic growth

intensification, while technological innovation and industrial structure have no significant impact on the level of economic growth intensification; the influence effects of various factors on the level of economic growth intensity show regional differences [29].

3.6 Research on the mode of economic growth from the perspective of TFP

Using the Malmquist productivity index method of DEA, Wang Xia et al. Calculated the TFP of 17 central cities in China from 2000 to 2013. The study found that the main reason for the improvement of TFP in central cities in 13 years was technological progress. In order to realize the transformation of economic growth mode, technological innovation and industrial structure adjustment must be carried out. Central cities in the central and western regions can't achieve the optimal GDP output only by relying on urban fixed investment, and the state-owned economic investment can no longer promote the TFP of Shanghai and other eastern cities [31]. Yang Wenshuang believes that the economic growth mode of Jilin province belongs to the capital investment type, and there is a gap in the level of science and technology, growth momentum and mode among different industries. The TFP level of manufacturing industry in Jilin Province has been developed rapidly in recent years, and TFP has been improved among various industries [32]. Based on the perspective of TFP, Maya calculated the average value of TFP index in Northwest China by DEA Malmquist index method, which was mainly driven by technological progress, while technical efficiency had inhibitory effect [33].

4. Research trend and Prospect

To sum up, throughout the 20 years of TFP development, the mainstream measurement methods focus on data envelopment method, DEA Malmquist and stochastic frontier method. At present, Malmquist index method is widely used. Each method has its own advantages, disadvantages and applicability, and the method system of TFP calculation is becoming more and more mature.

After many years of exploration and research and continuous attempts of many scholars, the theoretical and computational research of TFP tends to be mature and stable, but there are still some shortcomings in the level of research objects. There are many researches on macro level TFP, involving countries, regions, provinces and cities, as well as the application fields from basic agriculture and manufacturing industry to service industry, energy and environmental protection, finance and other fields, and many subdivision fields are rapidly derived, such as green TFP, carbon emission productivity, etc. However, there are few empirical studies on the micro level, such as enterprise clusters and TFP of representative leading enterprises, which are limited by data and other factors. At the same time, there is still a blank in the research of TFP operation trend and fluctuation characteristics.

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