Analysis on the Contribution of Zhejiang Economic Growth Factors Based on Solow Residual Method

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Abstract. Based on Cobb Douglas production function, this paper uses Solow residual method and SPSS software to calculate the economic growth index of Zhejiang Province from 2003 to 2019. The results show that from 2003 to 2019, the average contribution rate of labor input to economic growth of Zhejiang Province is 70.82%, the contribution rate of capital input to economic growth is 33.00%, and the contribution rate of total factor productivity growth to economic growth is - 3.82%. It shows that the economic growth of Zhejiang Province is still a typical factor input driven economic growth mode.

Keywords: Solow Residual Method · Economic Growth · Total Factor Productivity (TFP) · Contribution Rate · Zhejiang Province

1 Introduction

Economic growth is the source of social development. Judging from the history and trend of economic and social development of various countries, the era of relying on capital and natural resources for competition has gradually transformed into relying on the quality of labor force and its determined science and technology for competition. How to change the extensive economic growth based on high input and high consumption and improve the quality of economic growth has been paid more and more attention by the government and scholars. Economic history shows that the level of total factor productivity (TFP) can largely explain the success or failure of a country's economic development. The comparison of development performance before and after China's reform and opening up also shows the key role of improving total factor productivity. In the report of the 19th National Congress of the Communist Party of China, it is proposed for the first time to improve the total factor productivity by relying on technological progress, production efficiency and the effective use of resources to promote sustainable economic growth, rather than relying on the input of capital, labor and other factors. This paper uses Solow residual method to measure the total factor productivity of Zhejiang Province based on the economic data from 2003 to 2019, and studies the contribution of total factor productivity to the economic growth of Zhejiang Province.

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2 Theoretical Review

The source of economic growth has always been a hot issue for economists. Economic theory holds that the source of economic growth mainly includes factor input and the improvement of total factor productivity. However, because the factors have the law of diminishing marginal returns, total factor productivity is the driving force of sustained economic growth. At the same time, TFP is also the core index to measure the quality of economic growth in a region. It is generally believed that the greater the contribution of TFP to economic growth, the higher the quality of economic growth.

Productivity refers to the output quantity of a unit of equipment in a given time. According to the quantity of production factors, productivity is divided into single factor productivity, multi factor productivity and total factor productivity. Total factor productivity, or TFP for short, mainly refers to the comprehensive efficiency of converting all kinds of resources, including human, material and financial resources, input into output in the production process. The sources of TFP are generally analyzed from three aspects: technical progress, technical efficiency and scale effect. Tinbergen (1942) put forward the concept of total factor productivity for the first time when analyzing the change trend of factor input and factor output rate [5]. Solow (1957) found that 80% of the U.S. economic growth from 1909 to 1949 could not be explained by factor input, which Solow attributed to the contribution of technological progress, that is, total factor productivity [8]. After that, scholars have conducted in-depth research on the source and estimation method of TFP, and achieved fruitful results, C. Duguleana (2019) [2] analysed the contributions of economic growth factors in Romania. There are also many scholars in China who focus on the measurement of China's total factor productivity and its contribution to economic growth. However, different scholars have different definitions, measurement methods and data processing of TFP, so the results are quite different.

Scholars have reached a consensus that TFP is the main source of improving the quality of economic growth [1, 3, 9, 12]. China's vast territory makes great differences in resources and economic development among different regions, so it is necessary to analyze specific regions in order to put forward targeted measures to improve TFP. This paper estimates the contribution of factor input and total factor productivity to the economic growth of Zhejiang Province based on the data from 2003 to 2019.

3 Model Construction and Index Selection

3.1 Model Construction

When calculating TFP, most scholars use C-D production function model and Solow residual theory. Solow residual method is a measurement method based on Cobb Douglas production function proposed by American economist Robert Solow in 1957 when he studied the American economy. This method studies the contribution of output growth rate to economic growth brought by the growth of capital production factors, labor production factors, and other production factors (such as education and technological innovation) excluding capital and labor. The Solow residual is the portion of an economy's output growth that cannot be attributed to the accumulation of capital and labor, the factors of production. The Solow residual represents output growth that happens beyond the

simple growth of inputs. As such, the Solow residual is often described as a measure of productivity growth due to technological innovation. The Solow residual is also referred to as total factor productivity (TFP).

In this paper, the C-D production function model is used:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \tag{1}$$

Among them, Yt represents the total output of T period, at represents the level of technological progress of T period, Kt represents the capital input of T period, Lt represents the labor input, t (t = 0,1, n) are time variables, and α and β are the marginal output elasticity coefficients of capital and labor.

According to the hypothesis of Solow's residual method, the Cobb Douglas function here satisfies that the return to scale of production is constant, that is, $\alpha + \beta = 1$. Therefore, we can take logarithm on both sides of formula (1) and make identical deformation to get formula (2).

$$\mathrm{n}\frac{Y}{K} = LnA_{\mathrm{t}} + \beta Ln\frac{L}{K} \tag{2}$$

Solow growth rate equation is derived from Cobb Douglas function, the following is the Solow growth rate equation:

$$\mathrm{y} = \mathrm{a} + \alpha k + \beta l \tag{3}$$

Solow residual value can be calculated by formula (3).

$$\mathrm{a} = \mathrm{y} - \alpha k - \beta l \tag{4}$$

Y is the growth rate of total output, K is the growth rate of capital input, L is the growth rate of labor force, and a is the Solow residual value. As for the calculation of the average growth rate of the three, some choose algebraic average method, some choose geometric average method, this paper chooses geometric average method to calculate. The specific calculation formula is shown in Formula (5).

$$\begin{aligned} \mathrm{y} &= \left(\sqrt[t]{\frac{Y_t}{Y_0}} - 1\right) \times 100\% \\ \mathrm{k} &= \left(\sqrt[t]{\frac{K_t}{K_0}} - 1\right) \times 100\% \\ l &= \left(\sqrt[t]{\frac{l_t}{l_0}} - 1\right) \times 100\% \end{aligned} \tag{5}$$

The contribution of each factor to output is calculated by formula (6). E_A is the contribution percentage of total factor productivity to output, E_K is the contribution percentage of capital to output, and E_L is the contribution percentage of labor to output.

$$E_A = \frac{a}{y} \times 100\%$$

$$E_K = \frac{\alpha k}{y} \times 100\%$$
$$E_L = \frac{\beta l}{y} \times 100\% \quad (6)$$

3.2 Selection of Indicators

3.2.1 Output Indicators

There are many indicators to measure output. In order to ensure the collectability and consistency of sample data, this paper selects GDP as the indicator to measure output based on China's current statistical system. GDP is the total monetary value of the final goods and services produced by a country (region) in a year. It is the core index of China's national accounting system. It reflects the economic development and changes of a country (region) and describes the economic scale of a country (region). GDP index is relatively complete and standard in statistics, and its data is easy to obtain, so it is often used in related research [4, 6]. The total output Y in this paper is the GDP value of Zhejiang Province from 2003 to 2019. In order to eliminate the impact of price changes, we use GDP index to adjust it.

3.2.2 Capital Input Index

Here, capital input K refers to the estimation of capital stock of an economy in a certain period. Theoretically, the perpetual inventory method proposed by Goldsmith can be used to measure the capital stock. However, the depreciation system of fixed assets in China is not so perfect and the renewal cycle of fixed assets is relatively long, there is no available data for the application of perpetual inventory method [7, 10, 11]. Therefore, this paper uses fixed asset investment after the adjustment of the fixed asset investment price index to measure the amount of capital investment.

3.3 Labor Input Index

In this paper, the number of employees in the whole society is selected to measure the labor input L. The original data collected are shown in Table 1.

4 Empirical Analysis

Based on the production function model, the parameters of the production function are estimated. SPSS 25.0 was used to perform regression analysis on formula (2), and the results were shown in Table 2, Table 3 and Table 4.

The statistical results show that the regression effect is good, and the explained variable ln (Y/k) can be mostly explained by the model: the adjusted R square value is 0.998, close to 1; the F statistical value is 6603.422, the corresponding probability is close to 0. The DW value is 1.312, which is close to 2, indicating that there is no

Table 1. Original data of total output, capital input and labor input of Zhejiang Province (2003–2019).

	GDP (100 million)	Adjusted GDP (100 million)	Total Fixed Assets investment (100 million)	Adjusted fixed assets investment (100 million)	Social Workers (L) (10000 people)
2003	9753	8503	4180	4039	2919
2004	11482	8851	5384	4912	2992
2005	13028	8895	6138	5584	3101
2006	15303	9165	6964	6241	3172
2007	18640	9750	7705	6620	3405
2008	21285	10112	8551	6722	3487
2009	22834	9953	9906	8053	3592
2010	27400	10673	11452	8892	3636
2011	31855	11383	14077	10168	3674
2012	34382	11366	17096	12448	3691
2013	37335	11396	20194	14704	3709
2014	40023	11343	23555	17048	3714
2015	43508	11418	26665	19814	3734
2016	47254	11535	29571	22084	3760
2017	52403	11867	31126	21971	3796
2018	58003	12264	33336	22262	3836
2019	62352	12344	36703	24007	3875

Sources: Zhejiang Statistical Yearbook (2004-2020), China Science and Technology Statistical Yearbook (2004-2020), the table is compiled by the authors.

Table 2. Summary of regression analysis results.

R	R square	adjusted R square	Errors in standard estimates	Durbin - Waston
.999[a]	.998	.998	.02399	1.312

a. Predictors: (Constant), Ln(L/K)

autocorrelation problem in the residual sequence. The regression results show that both the constant term and the explanatory variable ln (L/K) pass the t test, and both of them can be used as explanatory variables in the regression equation.

According to the (formula 7) is obtained:

$$\mathrm{Ln}\left(\frac{Y}{K}\right) = 1.025 + 0.934Ln\left(\frac{L}{K}\right) \tag{7}$$

Table 3. Regression analysis results ANOVAa.

	Sum of Squares	**df**	Mean Square	F	Sig.
Regression	3.799	1	3.799	6603.422	.000[b]
Residual	.009	15	.001		
Total	3.808	16			
a. Dependent Variable: Ln(Y/K)					
b. Predictors: (Constant), Ln(L/K)					

Table 4. Coefficientsa.

	Unstandardized Coefficients		standardized Coefficients	t	Sig.
	B	*Std. Error*	*Beta*		
(Constant)	1.025	.014		72.604	.000
Ln(L/K)	.934	.011	.999	81.261	.000

a. Dependent Variable: Ln(Y/K)

Thus, the α value is 0.066, the β value is 0.934, and the Cobb-Douglas production function is shown in Formula 8.

$$Y = e^{1.025} K^{0.066} L^{0.934} \tag{8}$$

According to formula 8, the following Solow growth rate equation (formula 9) is obtained:

$$y = a + \alpha k + \beta l = a + 0.066k + 0.934l \tag{9}$$

According to the data in Table 1 and Eq. (5), the growth rate of output, capital and labor input can be obtained, and the contribution rates of capital, labor and technological progress can be calculated respectively by using Eq. (6), as shown in Table 5.

From 2003 to 2019, the labor force plays a leading role in the economic growth of Zhejiang Province, especially the scientific and technological talents. From the analysis of Table 5 and Fig. 1, we can see that the average contribution rate of labor input to economic growth is 71%. From the perspective of labor input, the number of employees in Zhejiang Province in 2009 is 29.19 million, and by 2019, the number of employees is 38.75 million, with an average increase of 1.8%. This shows that although the absolute number of employees in Zhejiang province does not increase much, the quality of employees is constantly improving. This is illustrated by the trend chart of employees and R&D personnel in Zhejiang Province in Fig. 2. R&D personnel refer to those engaged in scientific research and experimental development activities, including those directly engaged in scientific research and experimental development activities, as well as those engaged in scientific and technological services and administrative work in research

Table 5. Growth rate of output, capital and labor and contribution rate of capital, labor and tfp to economic growth in Zhejiang Province from 2003 to 2019.

	Growth rate			Solow residual value (a)	Factor Contribution rate		
	Output	K	L		K	L	TFP
2003	5.8%	12.3%	2.1%	0.03	0.14	0.34	0.52
2004	4.1%	21.6%	2.5%	0.00	0.35	0.57	0.08
2005	0.5%	13.7%	3.6%	−0.04	1.80	6.77	−7.57
2006	3.0%	11.8%	2.3%	0.00	0.26	0.71	0.03
2007	6.4%	6.1%	7.3%	−0.01	0.06	1.07	−0.14
2008	3.7%	1.5%	2.4%	0.01	0.03	0.60	0.37
2009	−1.6%	19.8%	3.0%	−0.06	−0.83	−1.79	3.62
2010	7.2%	10.4%	1.2%	0.05	0.10	0.16	0.75
2011	6.7%	14.4%	1.1%	0.05	0.14	0.15	0.71
2012	−0.2%	22.4%	0.5%	−0.02	−9.68	−2.85	13.53
2013	0.3%	18.1%	0.5%	−0.01	4.52	1.67	−5.19
2014	−0.5%	16.0%	0.2%	−0.02	−2.28	−0.30	3.57
2015	0.7%	16.2%	0.5%	−0.01	1.64	0.75	−1.39
2016	1.0%	11.5%	0.7%	0.00	0.73	0.64	−0.37
2017	2.9%	−0.5%	1.0%	0.02	−0.01	0.31	0.70
2018	3.4%	1.3%	1.1%	0.02	0.03	0.29	0.68
2019	0.7%	7.8%	1.0%	−0.01	0.79	1.46	−1.25
average	2.4%	11.8%	1.8%	0.00	0.33	0.71	−0.04

institutes and research institutes. This index is a commonly used index to measure the input of scientific and technological talents. From 2003 to 2019, the average growth rate of R&D personnel is 16.5%, which is much higher than the growth rate of employees.

From the above calculation results, the contribution rate of technological progress in Zhejiang's economic growth is small. From 2003 to 2019, the contribution of total factor productivity to economic growth is −4%, indicating that Zhejiang's economic growth is still a typical factor input driven economic growth mode.

5 Conclusion

The growth achieved by increasing labor, capital and natural resources input is called "extensive growth", and the growth achieved by improving total factor productivity is called "intensive growth". China's economy has shifted from the stage of high-speed growth to the stage of high-quality development. The focus is to promote high-quality development and change the mode of economic growth. Change from factor driven and investment scale driven development to innovation driven development, and promote

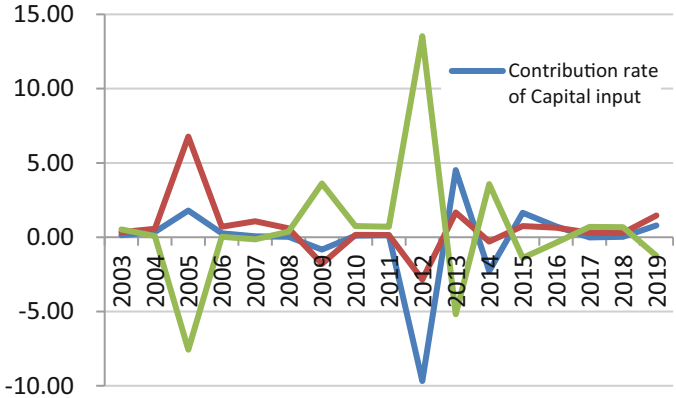

Fig 1. Contribution rate of capital input, labor input and total factor productivity to economic growth.

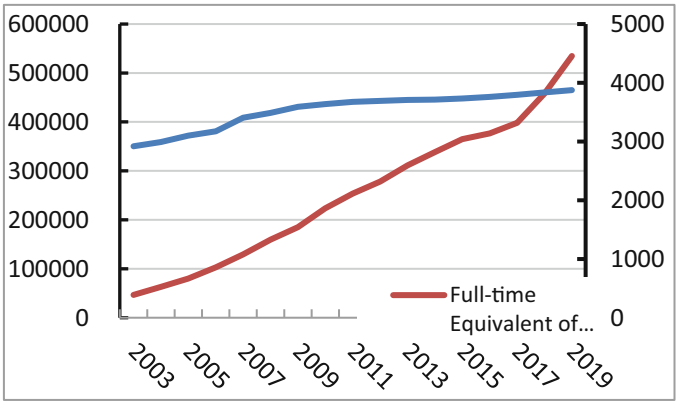

Fig 2. Trend of practitioners and R & D personnel in Zhejiang Province.

high-quality economic development through efficiency reform. This paper uses Solow residual method to estimate the growth rate of TFP from 2003 to 201. From the empirical analysis, we can see that labor input plays a leading role in the economic growth of Zhejiang Province, the average contribution rate of labor input to the economic growth of Zhejiang Province is 71%; followed by capital input, the contribution rate of capital input to economic growth is 33%; the contribution rate of total factor productivity to the economic growth of Zhejiang province fluctuates greatly, but the average value of the overall contribution rate is −4%, which shows that the economic development of Zhejiang Province is still factor input growth.

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