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Computing of the contribution rate of scientific and technological progress to economic growth in Chinese regions

Haixiang Guo [a,b,c], Jinglu Hu [c], Shiwei Yu [a], Han Sun [a,*], Yuyan Chen [d]

[a] School of Economics and Management, China University of Geosciences, Wuhan 430074, PR China
[b] Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Wuhan 430074, PR China
[c] Graduate School of Information, Production and Systems, Waseda University, Hibikino 2-7, Wakamatsu-ku, Kitakyushu-shi, Fukuoka 808-0135, Japan
[d] Center for Environmental Sciences, Saint Louis University, St. Louis, MO 63103, USA

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ABSTRACT

According to the new economic growth theory, a new method of computing the contribution rate of scientific and technological (S&T) progress to economic growth based on the Cobb–Douglas production function and the Solow residual value method is proposed in this paper. This method includes three steps: Firstly, according to their levels of S&T progress, fuzzy soft clustering of thirty one Chinese regions is performed to obtain the membership degree of these places to the categories. Secondly, to calculate the contribution rates that different categories of levels of S&T progress contribute to economic growth. Thirdly, to multiply the obtained contribution rate of each category by the membership degree of the place belonging to this category, from which the contribution rate of S&T progress to economic growth in each place is obtained. Finally, this method is used to calculate the contribution rates of S&T progress to economic growth in thirty one Chinese regions during the period from 1998 to 2007. Last but not least, some reasonable suggestions and conclusions are proposed by analyzing the computing results.

1. Introduction

Economy is a product of the co-operation of science, techniques, labors and capital. Seeing from the strategic angle of the economic development, in order to realize the economic development in a continual, stable, and highly efficient way, we have to adjust the proportion of various input factors in the economy. It is important to obtain the contribution rate of each factor to economic growth, especially the contribution rate of S&T progress, which can help the leader make reasonable macro policies. The contribution rate of S&T progress to economic growth, in the broad sense, refers to the sum of contributions rate of other factors to output increase, excluding those of the increase in labor force and capital (Li, 1995; Robert, 1996; Sun, 1998). Mokhtarul Wadud (2004) and Lewis (1954) had proposed the total factor productivity (TFP). Since then, the idea that S&T progress has been an important factor in economic growth which attracted the attention of economists. In 1957, Solow (1957) adopted residual value method in computing the contribution rate of S&T progress, which created the measurement of S&T progress operational. After that economists have made continuous improvement in studying the contribution rate of S&T progress to economic growth (Hilbrink, 1989; Jorgenson, 2001; Sengupta, 2004; Shipley, De Korvin, & Yoon, 2004; Tallon & Kraemer, 1999), among which Denison's research in the 1970s is relatively significant. Denison, when analyzing economic growth reasons from the year of 1929 to 1969 in the USA, divided the total input and total factors productivity into several small factors, and based on this classification he made a quantitative measurement of the effect of each individual factor on economic growth (Denison, 1962).

The study on S&T progress in China starts relatively late. In the 1980s, Jia (1997) initiated the potential analysis method with Chinese characteristics to estimate contribution rate of S&T progress to economic growth, which is based on the active decision theory. In 1983, the research group guided by Shi and Qin the first time completed the analysis of the effect of industrial technological progress in China (Shi & Qin, 1985). In 1998, the Department of Science and Technology of the former State Planning Committee in China launched research program on measuring the effect of S&T progress on economic growth (Jia, 1997). In 2000, Lu, Fan, Wei, and Xu (2000) had adopted such methods as the Solow function, the Denison's analysis on economic growth factors, the Jogenson's analysis of production efficiency and the production function to measure the effect of S&T progress on economic growth and had made empirical analysis. In 2002, Li (2003) had utilized the input and output method to measure the contribution rate of S&T progress to economic growth. Song (2003) had improved the

* Corresponding author.
E-mail addresses: faterdumk0732@sina.com (H.X. Guo), jinglu@waseda.jp (J.L. Hu), ysw81993@sina.com (S.W. Yu), sunhan2004@126.com (H. Sun), ychen27@slu.edu (Y.Y. Chen).

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measuring method of S&T progress by adopting the potential analysis theory. Zhou (2008) had applied the Cobb–Douglas production function in measuring the contribution rate of S&T progress to economic growth in 10 regions in Henan Province of China in the year of 2005. Liu (2006), by taking the Cobb–Douglas production function as the basic method, had measured the contribution rates of S&T progress, capital and labor force to economic growth respectively during the period of 1985–2002 and the period of 1995–2002 in Hebei province of China. Wu (2008) had measured the contribution rate of S&T progress in agriculture in Henan Province of China from the year of 1996 to 2005, and used the gray production function metabolizing model (Liu, 1997; Liu, Dang, & Fang, 2004; Liu, Dang, Li, & Li, 1999) in predicting the contribution rate of S&T progress in agriculture in Henan province of China from the year of 2006 to 2015.

It is obvious that Chinese and overseas scholars have made encouraging achievements in measuring the contribution of S&T progress to economic growth, but these researches are limited to use data in one specific country or region when at a given period of time. The limited data may have negative impact on the accuracy of parameter estimation in the production function. What's more, the contribution rate of the same S&T progress in different regions may be significantly different and incomparable. In addition, the social and economic system is complicated and nonlinear, and the same S&T progress may make different contributions in different regions. So the new method proposed in this paper aims at measuring the contribution rates of S&T progress to economic growth in thirty one regions of China from the year of 1998 to 2007, by adopting the soft computing approach, the Cobb–Douglas production and the Solow residual value method. In the new method, we first make soft clustering of S&T progress in thirty one regions of China, then compute the contribution rates of S&T progress at various classifications to economic growth. And then calculate the contribution rate in each region by summing up the products of the contribution rate of each classification and the membership degree of this region to each classification. Finally, comparison of the rates in different regions is provided and rational suggestions to the economic development in various regions are presented.

2. The calculation model, index and sample

2.1. The combined model of production function

The combined model of the extended Cobb–Douglas production function (C–D production function) and the Solow residual value method is employed in measuring the contribution rate of S&T progress to economic growth in various Chinese regions. The combined model is described as follows:

$$Y = AK^{\alpha}L^{\beta}H^{\gamma} \tag{1}$$

$$a = y - \alpha k - \beta l - \gamma h \tag{2}$$

Eq. (1) is the C–D production function, in which Y represents the output, K represents the capital input, L represents the labor input, H represents the actual human capital, A represents the technological level in a given situation, α represents the capital elastic coefficient, β is the labor elastic coefficient, γ is the actual human capital elastic coefficient. The value of α, β, γ can be computed based on this equation.

Eq. (2) is the Solow residual value method. In this equation y is the growth rate of output, a is the technological progress rate, k is the growth rate of capital input, l is the growth rate of labor input, h is the increase rate of human capital input. Eq. (2) means that the contribution of S&T progress to economic growth is equal to the sum effect of other factors excluding the increase of capital, labor and human capital.

In the combined model above, the S&T progress is assumed to be the neutral technological progress defined by Hicks, namely the output-growth-oriented technological progress, and it satisfies constant returns to scale, namely $\alpha + \beta + \gamma = 1$.

2.2. Production factor indexes and samples

In the extended C–D production function $Y = AK^{\alpha}L^{\beta}H^{\gamma}$, the gross domestic product (GDP) is used to measure the output Y, the fixed assets stock is used to measure the capital input K, the number of employers is used to measure the labor input L, the actual human capital H is measured in the relative number and the time spans is from the year of 1998 to 2007. Data of production factors in Beijing of China is shown in Table 1 and the data of other regions is omitted because of limited space of this paper.

2.2.1. The output Y

The data on gross domestic product (GDP) in thirty one Chinese regions are adjusted to standard data with the year of 1998 as the base period. The adjustment function is as follows: the adjusted GDP of the tth year = GDP of the base period $\times$ the GDP index at the tth year $\div$ the GDP index at the base period.

2.2.2. The fixed assets stock K

The fixed assets stock refers to the total scale of fixed assets capital at a given time. According to the requirements of the C–D production function, the perpetual inventory method (Huang, Ren, & Liu, 2002) is used to adjust the comparable prices of fixed assets stock of each year. The adjustment equation is as follows:

$$K_t = (1 - \delta)K_{t-1} + R_t \tag{3}$$

In Eq. (3), K_t is the net value of fixed assets stock of the tth year after adjustment; δ is the depreciation rate of the fixed assets (δ = 5% in this paper); R_t is the comparable price of the fixed assets investment in the tth year. R_t = the fixed assets investment at the tth year $\times$ the price index of fixed assets investment at the base period $\div$ the price index of fixed assets investment at the tth year. The net value of fixed assets stock of the base period (the year of 1998) is supposed to be equivalent to the fixed assets investment, namely $K_0 = R_0$.

Table 1
Data in Beijing of China from the year of 1998 to 2007.

Year	Index Beijing Data					
	GDP_i	GDP_a	K_i	K_a	L	H
1998	100.00	2011.31	100.00	1124.62	624.30	1.5985
1999	110.23	2217.06	99.90	2191.88	621.86	1.8377
2000	122.34	2460.60	100.90	3217.02	622.15	1.8694
2001	136.08	2736.99	101.50	4197.71	629.54	1.8150
2002	150.23	3021.64	101.91	5133.93	798.90	1.7872
2003	166.26	3344.08	104.15	6048.55	858.60	1.7597
2004	188.25	3786.34	108.62	6967.69	895.02	1.6813
2005	210.52	4234.29	109.39	7849.55	920.35	2.0029
2006	237.47	4776.28	109.83	8692.23	1011.38	1.7604
2007	269.05	5411.52	112.90	9527.37	1111.42	1.7207

Note: Data is from China statistical yearbook from the year of 1999 to 2008. GDP_i denotes GDP index and the base period is the 1998 year. GDP_a denotes GDP after adjustment and the unit is billion Yuan. K_i denotes the price index of fixed assets investment and the base period is the 1998 year. K_a is the fixed assets stock after adjustment and the unit is billion Yuan. L is the number of employers and the unit is ten thousands people. H is the actual human capital. Because of the limited space for the paper to be printed, the above table takes Beijing as an example, the data in other thirty regions of China are not listed.