Measurement of Contribution Rate of Energy Saving and Emission Reduction in China's Scientific and Technological Innovation

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Summary
This article reviews the progress of research on economic growth, energy efficiency and pollution reduction at home and abroad, established an energy conservation and emission reduction index system, analyzed the impact of technological innovation on energy saving and emission reduction. Establishing a method for measuring the contribution rate of scientific and technological innovation to energy conservation and emission reduction based on the residual value method, Quantitatively calculated the average contribution rate of energy saving and emission reduction for science and technology innovation in 2006-2016 was 51.37%.[1]

Key words:
Technological innovation, Energy conservation, Contribution rate

1. Introduction

Science and technology are productive forces and the primary productive forces. The rapid development of science and technology and the rapid transformation of their productive forces have become the most active factor and the most important driving force in the economic and social development. The problems of the global resource shortage, environmental pollution, ecological destruction, lack of funds, and the sudden increase of population have greatly influenced the human survival and development, which make people further realize the potential impact and practical role of science and technology in environmental protection work.

Since the reform and opening up, China's economy has been growing at a high speed, the scale of the economy is expanding, environmental pollution is increasingly serious, and the contradiction between economic growth and environmental protection is becoming increasingly prominent. [2]It is imminent to control and reduce the emission of pollutants. To this end, during the "11th Five-Year" period, the state put forward two major pollutants emission reduction binding targets.(COD and SO2 emissions are reduced by 10%). In the process of implementing the pollution reduction strategy, technological innovation is undoubtedly an important support for the whole emission reduction work.

Pollution reduction is not only the end treatment, but also the whole process pollution control, including 4 aspects: structure adjustment, production process control, and consumption process control and end treatment. Whether structural adjustment or process control and terminal governance are inseparable from technological innovation. Technological innovation directly determines the optimization and upgrading of industrial structure and the clean production process. (reduction of unit product / output value of pollutants); Therefore, technology emission reduction, as the basis of structural emission reduction, engineering emission reduction and management reduction,

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largely determines the effectiveness of the whole pollution reduction. [3]

During the period of 2006~2016, in the case of more than expected economic growth, pollution reduction and emission reduction in China completed all the tasks formulated in the plan, and the target of pollution reduction was realized ahead of time. However, the main pollution reduction is still based on the end treatment of pollution control projects, and the mode of environmental pollution control based on end treatment has not changed radically. Admittedly, terminal management is undoubtedly important and necessary, which can solve the most easily solved pollution problems quickly. However, it cannot solve the deep-seated contradiction of pollution reduction. At present, the implementation rate of China's engineering emission reduction is relatively high, and the implementation rate of engineering emission reduction in coastal cities and economically developed areas has reached 85%~90%. With the further development of our country's society and economy in the future, the total amount of the economy is increasing, and the output of pollution will be further increased. By that time only the emission reduction of the project will not be sufficient to support the completion of the economic development and the task of pollution control and emission reduction. [4]

2. Design of index system

According to the requirements of energy saving and emission reduction in China, the evaluation index system of energy saving and emission reduction is constructed by using the AHP analytic hierarchy process, which includes two major parts: resource saving and pollution control. From the two aspects of resource conservation and pollutant control, the control elements of energy conservation and emission reduction are constructed. In the intensive resource saving target plate, we choose 3 indexes of 10000 yuan GDP energy consumption, 10000 yuan GDP water consumption and comprehensive utilization rate of industrial solid waste; In the target plate of pollutant control, 3 indexes were selected, including the COD emission of 10000 yuan industrial output value, the SO2 emission of 10000 yuan industrial output value, and the pesticide application per unit cultivated land area. [5]

Table 1: Evaluation index system of energy saving and emission reduction

Target layer	Index layer
1. Resource conservation	1.1 Energy consumption of ten thousand yuan GDP
	1.2 Water consumption of ten thousand yuan GDP
	1.3 Comprehensive utilization of industrial solid waste
2. Pollutant control	1.1 COD quantity of industrial output value of ten thousand yuan
	1.2 SO2 quantity of industrial output value of ten thousand yuan
	1.3 Pesticide application per unit arable area

3. Residual value and its application practice

The remainder, using the production function, is usually a production function in the form of Cobb - Douglas function. Through analysis, the contribution rate of scientific and technological progress to growth is obtained.

Set the following Cobb-Douglas functions:

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

Among them, Y is output value, K is capital, L is labor force, A is technology factor, α, β is output elasticity of capital and labor force.

The logarithm of the production function can be obtained:

$$\log Y_t = \log A_t + \alpha \log K_t + \beta \log L_t \tag{2}$$

Derivative of time：

$$\frac{d \log Y_t}{dt} = \frac{\log A_t}{dt} + \alpha \frac{\log K_t}{dt} + \beta \frac{\log L_t}{dt} \tag{3}$$

Further obtain：

$$\frac{dY}{dt} \cdot \frac{1}{Y} = \frac{dA}{dt} \cdot \frac{1}{T} + \alpha \cdot \frac{dK}{dt} \cdot \frac{1}{K} + \beta \cdot \frac{dL}{dt} \cdot \frac{1}{L} \tag{4}$$

Thus, it can be written as:

$$r_Y = r_A + \alpha \cdot r_K + \beta \cdot r_L \tag{5}$$

That is, the growth rate of output value is equal to the sum of the growth rate of technological progress, the product of capital growth rate and capital elasticity, and the sum of the product of labor growth rate and labor elasticity. Based on this, you can get the contribution rate of technological progress.

The former State Development Planning Commission and the National Bureau of Statistics announced 《Notice on Measuring the Role of Scientific and Technological Progress in Economic Growth》（Science and Technology [1992] No.2525）， Determined method for quantitative analysis. The method is as follows. [6]

3.1 Calculating the speed of technological progress

The speed of scientific and technological progress is a comprehensive indicator that reflects the progress of science and technology in a given period of time. The formula is:

$$a = y - \alpha k - \beta l \tag{6}$$

Among them:

a ——the average annual growth rate for scientific and technological progress

y ——average annual growth rate for output

k ——the average annual growth rate of capital

l——the average annual growth rate for workers

α ——coefficient of output elasticity of capital （Refers to a α % increase in output when the capital increases by 1% under the same conditions）

β —— output elasticity coefficient for labor (Refers to a β % increase in output when labor is increased by 1% under the same conditions).

Among them, y is output value, k is capital, L is labor force, a is technology factor, α， β is output elasticity of capital and labor force.

3.2 Calculating the Contribution of Technological Progress to the Growth of Production Value

The contribution of scientific and technological progress to the growth rate of output value, that is, the proportion of scientific and technological progress in the growth rate of output value, is a comprehensive indicator reflecting the effect of scientific and technological progress on economic growth. The formula is:

$$EA = a/y \times 100\% \tag{7-1}$$

At the same time, the contribution of capital and labor input to the growth rate of output value can also be separately contributed.

The contribution of capital to the growth rate of output EK is:

$$EK = \alpha k/y \times 100\% \tag{7-2}$$

Contribution of labor to the growth rate of output value EL is

$$EL = \beta l/y \times 100\% \tag{7-3}$$

3.3 Coefficient of elasticity

Nationwide, when comparing different regions, the same elasticity values can be used in principle. α is the elasticity of capital output, and β is the output elasticity of labor.

The calibration method can be adopted, that is, without the method of regression estimation, according to the economic significance of the parameters, the corresponding parameter values can be directly solved through the corresponding economic statistics and economic balance of the parameters. Here, based on the relevant research and combined with the actuality of this study, we have improved the original parameter calibration method and calibrated it from the input-output table to get a value of α, β.

The input-output table is a balance sheet that reflects the relationship between input and output of various departments in a certain period of time.

In the general sense, "input" refers to the amount of various consumptions consumed in an economic activity (or production) during a certain period (usually one year), including raw materials, fuel, power, and fixed assets (depreciation) Consumption of material forms, consumption of non-material forms characterized by services (such as communications, technology, consulting, goodwill, etc.) and labor consumption.

In the general sense, "output" refers to the various results that are produced or formed within a certain period of time in certain economic activities (including various production and labor activities), including physical products and service products.

$$\alpha = \frac{m}{N}$$
$$\beta = \frac{V_l}{N}$$
$$P = \frac{t}{N} \qquad (8)$$

Among them, V_l is the added value of labor, that is, the labor remuneration in the input-output table, m is the added value of capital, that is, the operating surplus in the input-output table, N is the added value, and the ratio of the production tax to the added value is P, We treat it as a policy variable, that is, after calculating the contribution rate, after deducting the policy variable, we get the contribution rate of scientific and technological progress to energy conservation and emission reduction. After the initial P value is calculated, further corrections are made by expert scoring. [7]

3.4 Technique level

$$A_t = \frac{Y_t}{(K_t)^{\alpha}(L_t)^{\beta}} \qquad (9)$$

Among them:

A_t —Technical level for t years；

Y —output of t years；

K_t —Capital for t years；

L_t —Labor for t years。

3.5 Calculating Steps of Contribution Rate of Saving Energy and Reducing Emissions by Science and Technology Innovation Based on Residual Value Method

Firstly, calculate the coefficient of elasticity of capital and labor based on the input-output table and formula (11), as shown in Table 2.

Table 2: Calculated from the input-output table, α, β coefficient

	α	β
Year 2006	0.3015	0.4779
Year 2007	0.3015	0.4779
Year 2008	0.3015	0.4779
Year 2009	0.3015	0.4779
Year 2010	0.3015	0.4779
Year 2011	0.2373	0.4921
Year 2012	0.2373	0.4921
Year 2013	0.2373	0.4921
Year 2014	0.2373	0.4921
Year 2015	0.2373	0.4921
Year 2016	0.2373	0.4921

Secondly, calculate the time series values of various indicators for energy saving and emission reduction (2005-2016). We have adopted a method of standardizing and standardizing the growth rate of indicators. Let the data for the first year be 1, then the data for the i th year is the raw data for the second year divided by the raw data for the first year. [8]

Its formula is:

$$\overline{X_1} = 1 \tag{10-1}$$

$$\overline{X_i} = \frac{X_i}{X_1} \tag{10-2}$$

Thirdly, we synthesized the various energy-saving and emission reduction targets and obtained China's energy-saving and emission reduction index. Calculate the overall contribution to technological advancement based on equations (6) and (7-1).

Fourth, the calculation of the contribution rate, the use of policy variables to be corrected, the national science and technology innovation contribution to energy conservation. [9]

4. Calculation results and discussion

The calculation results show that during the period of 2006-2016, the average contribution rate of China's scientific and technological innovation to energy-saving and emission reduction was 51.37%, and it showed a trend of continuous growth. See Figure 1 and Table 3.

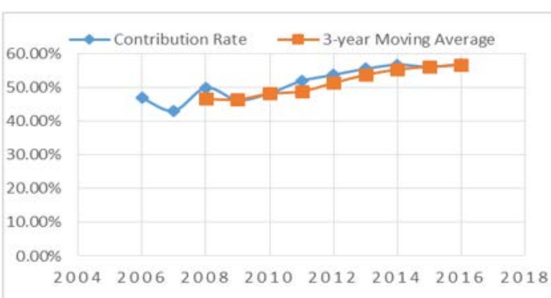

Fig. 1 Contribution of China's science and technology innovation to energy saving and emission reduction 2006-2016

Table 3: Contribution rate of China's scientific and technological innovation to energy conservation and emission reduction from 2006 to 2016

years	Technology contribution rate	Three-year moving average
2006	46.80%	
2007	43.10%	
2008	49.90%	46.60%
2009	46.20%	46.40%
2010	48.30%	48.13%
2011	51.90%	48.80%
2012	53.70%	51.30%
2013	55.50%	53.70%
2014	56.70%	55.30%
2015	56.10%	56.10%
2016	56.90%	56.57%

During the period of 2006-2016, the contribution rate of China's scientific and technological innovation to energy conservation and emission reduction continued to increase. This proves that the Chinese government's energy saving and emission reduction policies have played an active role. [10]These policies have objectively promoted the widespread application of energy saving and emission reduction technologies and energy conservation and emission reduction projects. Implementation. [11]

China's economic development model is still relatively extensive, and there is still room for improvement in energy-saving and emission reduction levels. In the future, technological innovation will continue to be the first factor in promoting China's energy conservation and emission reduction efforts.

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References

[1] Chen Ying-hsiu， Estimating the speeds of long-run technological catch-up and growth of total factor productivity for countries，2018 27(2): 220-234

[2] F.M.Xile (1999)，New Perspectives on economic growth and technological innovation， the brooking institution press.

[3] G. C. Chow.，Capital Formation and Economic Growth in China[J]， Quarterly Journal of Economic，1993(8): 809-842.

[4] Marsiglio S.， Toloti M.， Endogenous growth and technological progress with innovation driven by social interactions. Economy theory，2018 65(2): 293-328.

[5] Romer， Paul M.，Increase returns and long-run growth. Journal of political economy， 1990，(2)：241-256

[6] Sual C. Kumbhaka. Productivity and technical change: measurement and testing. Empirical economics， 2004:97-104

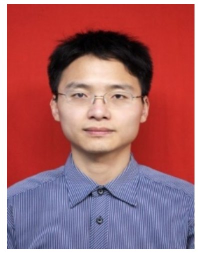
[7] Zhuang, J., , Estimating Distortions in the Chinese Economy: A General Equilibrium Approach. Economica, 1996 63(252): 543-568.

[8] Sheng Xueliang, Ren Bingxiang,Zhu Deming, Research on Measurement Method and Prediction of Contribution Rate of Environmental Protection Technology Progress[J]. Environmental pollution and prevention，2003，25(6):365-366

[9] Wang Yuandi, Pan Xiongfeng, Liu Fengchao, An Empirical Study on the Measurement and Forecast of the Contribution Rate of Scientific and Technological Progress [J]. Business research,2005(5):28-31

[10] Wang Tianying, Measurement and Analysis of the Contribution Rate of Science and Technology Progress in China's Economic Growth Productivity Research, [J]. Productivity Research,2003(5):49-52

[11] Jinwei. Research and Discussion on the Measurement of the Contribution Rate of Scientific and Technological Progress in Inner Mongolia [J] Inner Mongolia Statistics,1999(4)



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