

Empirical Research on the Industrial R & D Investment and “Two Oriented Society” Construction in China—On the Analysis of Anhui Industrial Sector

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Abstract

In this paper, we estimated the level of “Two Oriented Society” of Anhui province industrial sector by Principal Component Analysis based on the data of 2000-2008, then we constructed a grey correctional degree model to analyze the relationship between R & D investment and “Two Oriented Society”. The empirical results showed that R & D investment would promote “Two Oriented Society” construction, especially the high-quality scientists.

Keywords

Industrial Sector, R & D Investment, “Two Oriented Society” Construction

1. Introduction

Two-oriented society refers to a resource-conserving and environment-friendly society which is defined at the Fifth Plenary Session of the Sixteenth Central Committee of the Party passed the Suggestion of Central Committee of the Communist Party of China (CPC) on Making the Eleventh Five-year Plan for National Economy and Social Development (hereinafter referred to as Suggestion) in 2005. It is a kind of new development pattern which brings resources and environment into the economic development process. In order to realize sustainable development, two-oriented society focus on resource utilization efficiency and environmental friendliness while achieving economic growth.

Technological change plays an important role in the construction of two oriented society since it makes the whole society advanced, and then investment in science and technology will promote regional “Two Oriented

Society” levels rising. As a pillar industry in the national economy, the industry is the important sources of resource consumption and environmental pollution, and also is the priority of affecting “Two Oriented Society” construction. Therefore, this paper tends to take Anhui province industrial sector as the research object, analyzes the relationship between R & D investment and “Two Oriented Society”, and provides an objective basis for decision-making that establish the proper investment policy in science and technology input.

2. Overview

The construction of “Two Oriented Society” is a complex process with multiple levels and dimensionalities, based on the central elements; it mainly proceeds on the dimensionalities of the economic development and social ecology, the social development and cultural ecology, and the social development and institutional environment. Research on driver factors of “Two Oriented Society” construction has just started. Now, most of the researches are a bit theoretical. Liu [1] discussed the relationship between industrial cluster and “Two Oriented Society” construction of Wuhan Urban Circle. Chen [2] has studied the relations between FDI and “Two Oriented Society” construction of Wuhan industry.

While researches on the “Two Oriented Society” construction are scarce, resource and environmental economics have done quite a lot of empirical research on driving factors of resources and environment, and most studies have resources and environment separately for research. On one side, research about resources mainly focuses on its efficiency, and factors contributing to resources efficiency are classified scientifically into three major categories: Industrial structure, total factor productivity (TFP), and technology progress and innovation [3]. Where Li Lianshui [4] had found that technical efficiency is the key cause of the industrial sector to improve resource efficiency through empirical analysis of 35 industries in China, but the effects of technology progress strengthen gradually over time. On the other hand, research about driving factors of environment predominantly focuses on its regulations, and furthermore, some researchers began to study the influential factors of environmental pollution in China-Industries. Zhao Wei [5] demonstrated that the scale effect is a major factor of growth in environmental pollutants through factor decomposition analysis, and holds the opinion that the adjustment of industrial structure is good for preventing and controlling the pollutant emissions after 2000.

Building on recent research, technical progress is an effective way to promote the building of a society of resource-conserving and friendly style and realize the sustainable development [6]. But the near absence of empirical research on science and technology promoting the construction of “Two Oriented Society” construction makes it impossible to this research. This paper attempts to take Anhui province industrial sector as the research sample to test and verify the role of R & D inputs in promoting “Two Oriented Society” construction.

3. Evaluation on “Two Oriented Society” Construction Level of Industrial Sector

“Two Oriented Society” construction involves and contains wide and complicated contents. “Two Oriented Society” construction of industrial sector mainly includes economic development, resources reduction, environment pollution, science and technology development, etc. [7]. This paper makes a study on the relationship between R & D investment and “Two Oriented Society” with only considering the occurred facts. In other words, this paper has taken economy, resources and environment as the content of the evaluation with no thought to support forces such as technology.

3.1. Evaluation Index System

To construct our evaluation system, this paper selects seven indexes to reflect “Two Oriented Society” construction level of industrial sector with taking the principle of scientific, practicable, representative and operability on the base of previous study (see **Table 1**). Firstly, the evaluation index system contains three aspects including economy, resource efficiency and environmental-friendship degree, reflecting a comprehensive “Two Oriented Society” construction level. Secondly, the first level indexes, such as resource efficiency and environmental-friendship degree, involves three second level indexes which reflects the overall level of industrial sector. Finally, all the indicators will be measured by the unit of value-added industrial output on the considering of economic benefit.

3.2. Evaluation Model and Data Processing

The common evaluation method of “Two Oriented Society” includes DEA (data envelopment analysis [8]),

Table 1. Evaluation index system on “Two Oriented Society” construction level of industrial sector.

Level 1	Level 2	Variable	Index
Evaluation index system on “Two Oriented Society” construction level of industrial sector	Economic level	X_1	Industrial added value
		X_2	Industrial added value of energy consumption
	Resource efficiency	X_3	Industrial added value of electrical consumption
		X_4	Industrial added value of energy water consumption
		X_5	Wastewater per unit of value-added industrial output
	Environmental-friendship degree	X_6	Waste gas per unit of value-added industrial output
		X_7	Solid waste per unit of value-added industrial output

AHP (analytic hierarchy process [9]), and PCA (principal component analysis [10]), etc. This article chooses PCA (principal component analysis) as evaluation method to establish the evaluation model as follows:

$$R_i = \lambda_1 x_{1i} + \lambda_2 x_{2i} + \dots + \lambda_7 x_{7i}, \quad \text{where } i = 1, 2, 3, \dots, n$$

where x_{ji} is the level of indicator j in a given year i . R_i is the “Two Oriented Society” construction level of industrial sector in a given year i . $\lambda_1, \lambda_2, \dots, \lambda_7$ is the weighting of each indicator. The bigger R_i , the higher the “Two Oriented Society” construction level of industrial sector in a given year i .

This paper mainly applies the methods of principal components analysis to confirm the weight of each indicator, and selected data from the year 2000 to 2008 in Anhui industrial sector. Since different magnitude, various units, and negative indexes, we positive design first and then standardize the index data as follows:

Step1: Positive design $x'_{ji} = -x_{ji}$;

Step 2: Standardization method $x''_{ji} = \frac{x'_{ji} - \bar{x}_j}{\sigma_j}$.

3.3. Empirical Results

The data was analyzed by SPSS 11.5. The standardized data was performed by applying procedure called “factor analysis” in the module of SPSS Data Reduction, and get the table of variance decomposition principal component (see Table 2).

As seen in Table 2, the first principal component explained 95.829% of the total variance. Since the cumulative percent of principal component is 80% or greater, we extract the first principal component, get the factor loadings, and divide the data in the factor load matrix by the square roots of principal component’s corresponding eigenvalues. Then we get the coefficients of each index in each principal component and the following evaluation model,

$$R_i = 0.3571x_{1i} + 0.3848x_{2i} + 0.3842x_{3i} + 0.3831x_{4i} + 0.3831x_{5i} + 0.3685x_{6i} + 0.3842x_{7i}, \quad \text{where } i = 1, 2, 3, \dots, 9.$$

Take the processed data into the evaluation model, we get a display similar to Figure 1.

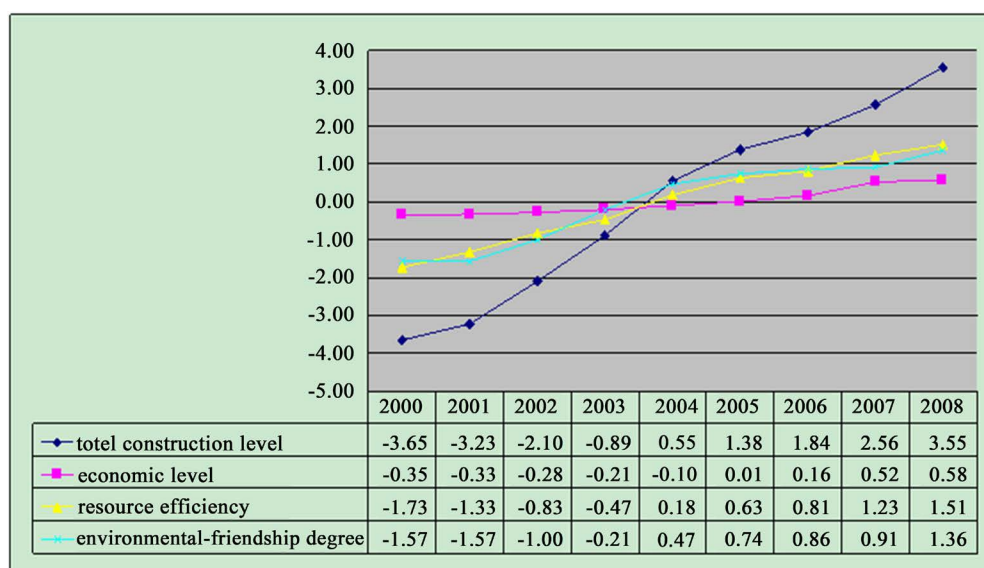
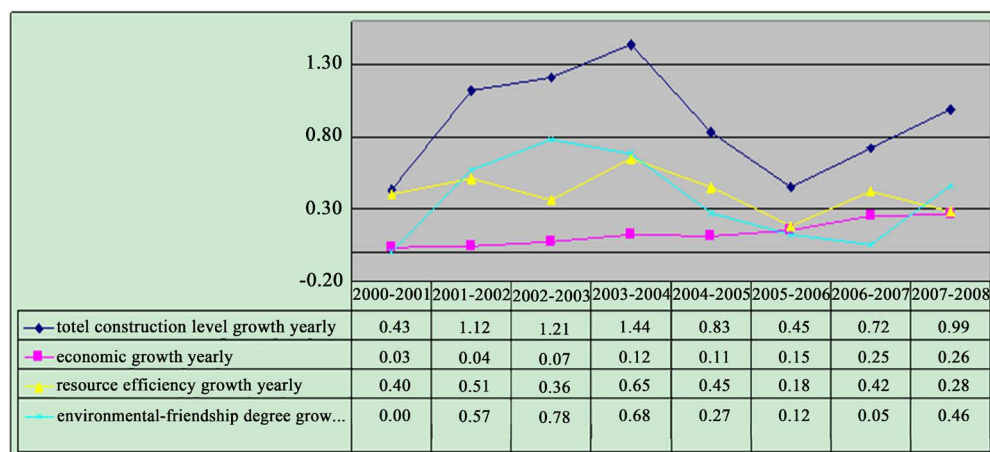
3.4. Results Analysis

1) As saw in Figure 1, “Two Oriented Society” construction level of Anhui industrial sector has improved year by year, which means that levels of economy, resource efficiency and environmental-friendship have been presented a well development tendency as a whole.

2) As saw annual growth (details can be seen in Figure 2): On the whole, “Two Oriented Society” construction level improvement is growing from 2000 to 2004, and the increase margin of 2003-2004 is the biggest. But then the growth is slowing until 2006; The annual growth on the economic level is increasing which signifies that economy of Anhui industrial sector is annually developing; the annual growth on resource efficiency is accompanied by irregular, or more specifically, has seen the largest increases in 2003-2004, but then appeared a slowdown in resource efficiency growth according to Figure 2. The environmental-friendship appears a similar increasing process with the whole case of “Two Oriented Society” construction, which the growth is growing from 2000 to 2003, and the increase margin of 2002-2003 is the biggest, but then the growth is slowing until 2007.

Table 2. Variance decomposition principal component extraction analysis.

Extraction sums of squared loadings		
Total	% of variance	Cumulative %
6.708	95.829	95.829
0.220	3.144	98.972
0.059	0.850	99.822
0.006	0.088	99.911
0.004	0.056	99.967
0.002	0.033	99.999

**Figure 1.** “Two Oriented Society” construction level of Anhui industrial sector.**Figure 2.** Annual growth of “Two Oriented Society” construction level of Anhui industrial sector.

From what we have mentioned above, we found that “Two Oriented Society” construction level of Anhui industrial sector is rising in 2000-2008 in general, but the increase states vulnerable. Among the reasons, of course, resources and environment did not have the same change tendency with the acceleration of economic growth.

The current development key to Anhui industrial sector is the economic progress has been proved immune to the intervention of fact. However, since resources and environment did not get the full attention, “Two Oriented Society” construction still needs to further strengthen.

As an important driving force, science and technology have significant influence on “Two Oriented Society” construction. The relationship between science and technology investment and “Two Oriented Society” construction of Anhui industrial sector will be discussed in the next section, and the positive role of science and technology in promoting economy, resource efficiency and environmental friendship will be studied separately, and tends to find out some of the reasons that resources and environment did not grow consistently with economic growth.

4. The Relationship between R & D Investment and “Two Oriented Society” Construction

4.1. Technological Resource Allocation of Anhui Industrial Sector

Since Anhui entered a high growth path, large and middle-sized companies play a leading role in Anhui industrial sector. In the meanwhile, they are the major undertakers for the R & D of Anhui industrial sector, and over the past five years the average costs make up more than 91% of scale industrial enterprises’ R & D cost. So the author chooses the R & D investment of large and medium-size enterprises in Anhui province as the object of study (the data are provided in **Table 3**).

1) R & D funds

It can be seen from **Table 3**, first, R & D funds are on the rise year by year, which R & D funds in 2008 have increased by nearly 6.7 times more than in 2000. Growth rate of R & D funds has been kept at a fairly high level except 2001, and average annual growth rate reached to 30%. Second, the proportion of R & D funds to sales revenue keeps around the rate around 2.3% since 2000 except 2003. Industrial sector should continue to strengthen R & D funding support since that the growth rate of the R & D expenditure should exceed economic growth the same period according to international practice and R & D investment in Anhui industrial sector is still insufficient.

2) S & T personnel

The number and growth rate of S & T personnel in Anhui industrial sector is gradually reduced from 2000 to 2004, and then have increased year by year, which show an inverted U shape. The number of S & T personnel in 2008 has increased by approximately 36% over the year 2000. At the same time, scientists & engineers are typical modern elite S & T personnel. The number of them has increased generally, and the proportion of scientists & engineers increased from 48% of S & T personnel in 2000 to 63% in 2008 which have been maintained in recent years. All of these mean that the quality of S & T personnel in Anhui province has improved.

Table 3. R & D investment of Anhui industrial sector.

Year	R & D funds (million)	Growth rate of R & D funds (%)	Proportion of R & D funds to sales revenue (%)	S & T personnel	Growth rate of S & T personnel (%)	Scientists & engineers	Growth rate of scientists & engineers (%)	Proportion of scientists & engineers to S & T personnel (%)
2000	79,882	—	1.79	54294	—	26123	—	48
2001	83,068	3.99	2.31	46964	-13.50	25631	-1.88	55
2002	107,457	29.36	2.62	43647	-7.06	26089	1.79	60
2003	127,298	18.46	5.58	40700	-6.75	23200	-11.07	57
2004	184,162	44.67	1.83	41543	2.07	22743	-1.97	55
2005	238,344	29.42	2.56	44067	6.08	27230	19.73	62
2006	329,545	38.26	2.38	50814	15.31	31762	16.64	63
2007	426,682	29.48	2.65	66486	30.84	41443	30.48	62
2008	612,300	43.50	2.3	84418	26.97	53457	28.99	63

4.2. Model and Data Processing of Anhui Industrial Sector

Methods based on mathematical model and mathematical statistical are the two major ways to analyze the complex interactions between variables. Subject to restrictive assumptions, the reality is far more difficult to measure by a mathematical model, but not in mathematical statistical, which, although its evaluation result is not accurate, can reflect the interrelationship between variables and do not depart from reality. Therefore, in this paper, Grey Relational Analysis (GRA) is applied to analyze the relationship between R & D investment and “Two Oriented Society” construction with mathematical statistics method.

Basic idea of GRA is that a similar level of curves’ geometrical shape proposed a way to determine whether the variables are closely related. The closer the curves are, the bigger the degree of relation between variables is, contrarily, become smaller [11]. We set $\{Y_i, Y_j, \dots\}$ to a grey system formed by Anhui R & D investment and “Two Oriented Society” construction of industrial sector, where Y_i is the data of variable i since 2000-2008, $Y_i = (y_i'(1), y_i'(2), \dots, y_i'(9))$, where 1 = the year 2000, 2 = the year 2001, ..., 9 = the year 2008. The steps required to get to either of these options include:

Step1: eliminates the effect of index dimension and quantity of data,

$$y_i'(k) = \frac{y_i(k) - \min y_i}{\max y_i - \min y_i}, \quad k = 1, 2, \dots, 9$$

Step2: solves the difference series between two variables,

$$\Delta_{i,j}(k) = |y_i'(k) - y_j'(k)|$$

Step3: solves the minimum difference and the maximum difference,

$$M = \Delta(\max) = \max_i \max_j \{ \max \Delta_{i,j}(k) \},$$

$$m = \Delta(\min) = \min_i \min_j \{ \min \Delta_{i,j}(k) \}.$$

Step4: gets the correlation coefficient and correlation degree,

$$\text{Correlation coefficient: } r_{i,j}(k) = \frac{m + \zeta M}{\Delta_i(k) + \zeta M}, \quad \zeta \in (0,1), \quad k = 1, 2, \dots, 9,$$

$$\text{Correlation degree: } R_{i,j} = \frac{1}{9} \sum_{k=1}^9 r_{i,j}(k).$$

4.3. Results Analysis

We suppose Y_1 as the “Two Oriented Society” construction level of Anhui industrial sector, Y_2, Y_3, Y_4 as the economic level, resource efficiency and environmental-friendship degree (the raw data are provided in **Table 1**), Y_5, Y_6, Y_7 as the number of R & D funds, S & T personnel and scientists & engineers (the raw data are provided in **Table 3**), respectively. And then we set array $\{Y_1, Y_5, Y_6, Y_7\}$, array $\{Y_2, Y_5, Y_6, Y_7\}$, array $\{Y_3, Y_5, Y_6, Y_7\}$, array $\{Y_4, Y_5, Y_6, Y_7\}$ as different grey system to analyze the grey correlation degree between the series $\{Y_1, Y_2, Y_3, Y_4\}$ and the series $\{Y_5, Y_6, Y_7\}$. A correlation degree can be obtained by calculating results in **Table 4**:

First, from **Table 4** we can see a strong correlation existed between R & D investment and “Two oriented society” construction (since the gray correlation is greater than 0.5, the variables have exhibited a remarkably high correlation), which means that a tremendous help developed to “Two Oriented Society” construction by R & D investment of Anhui industrial sector. In a word, the number of scientists & engineers is most closely linked with “Two oriented society” construction, followed by R & D funds, whereas the total number of S & T personnel experienced only a very low correlation. The S & T personnel is one of the major driving forces to push “Two oriented society” construction, while the effect of high-quality S & T personnel is more distinct. Meanwhile, growing R & D funds create a good environment for scientific research, and help the creativity of S & T personnel as another kind of power to push “Two oriented society” construction.

Second, on economic development R & D fund is the highest correlation variable, followed by the number of scientists & engineers and S & T personnel. In other words, the output efficiency of R & D funds to economic development is greatest in Anhui industrial sector, followed by S & T personnel and the number of scientists & engineers, whereas the scientific and technological quality is not an important factor in economic progress.

Table 4. The correlation degree between R & D investment and “Two Oriented Society” construction.

	Total	Economic level	Resource efficiency	Environmental-friendship degree
R & D funds	$R_{1.5}$ 0.59	$R_{2.5}$ 0.66	$R_{3.5}$ 0.57	$R_{4.5}$ 0.63
Technological personnel	$R_{1.6}$ 0.56	$R_{2.6}$ 0.56	$R_{3.6}$ 0.56	$R_{4.6}$ 0.56
Scientists & engineers	$R_{1.7}$ 0.60	$R_{2.7}$ 0.56	$R_{3.7}$ 0.59	$R_{4.7}$ 0.61

Third, in resource and environment part, the number of scientists & engineers is the highest correlation variable, followed by R & D funds, whereas the total number of S & T personnel experienced only a very low correlation. All of this underscores the point that the contribution of high-quality S & T personnel to resource efficiency and environmental-friendship degree is higher than ordinary S & T personnel. Meanwhile, as the material basis of S & T personnel, R & D funds have an essential effect on resource and environment.

Finally, the relation between variables that include R & D funds and S & T personnel, and economic progress is closer than in resource and environment part. All variables, whether they are R & D funds, S & T personnel or the number of scientists & engineers, have an even more tightly correlation with environment than with resource. And the results are coincided with the fact that whether government departments or ordinary businesses now pay closer attention to the environment than resource, especially the effect of environmental regulation policies.

Above all, three results are shown as follows: On the one hand, a definite positive correlation existed between R & D investment and “Two Oriented Society” construction. On the other hand, the aim and S & T output of R & D investment focus more on economic development which can verify the result that the resource and environment haven’t kept pace with the economy in section 3. S & T outputs of resource and environment are lower than fiscal, and the resource is not getting enough attention though environment gets some improvements due to power sharing and public anger. Besides, quality of S & T personnel plays an important role on “Two Oriented Society” construction notably in resource and environment part. High-quality S & T personnel can improve the resource and environment but not at the expense of economic progress.

5. Proposals to “Two Oriented Society” Construction of Anhui Industrial Sector

From the analysis of the results given above it is possible to establish several proposals to “Two Oriented Society” construction of Anhui industrial sector as follows:

First, increase the investment of R & D funds since R & D funds have a strong correlation with “Two Oriented Society” construction, especially in promoting economic development. R & D funds continue to increase with higher growth annually from the S & T resource allocation of Anhui industrial sector. A good phenomenon in the development process is the growth rate of the R & D funds should be higher than the rate of economic growth over the same period, whereas the proportion of R & D funds to sales revenue keeps around the rate around 2.3%, which means the S & T resource allocation is low efficiency, shortage of R & D funds.

Second, train the introduction of S & T personnel, especially high-quality S & T personnel. As the main part in the study, S & T personnel play the leading role on “Two Oriented Society” construction of Anhui industrial sector, especially the high-quality personnel. The government should create a safe research environment for researchers.

Third, lead the trend of science and technology to modest changes in science and technology center. Anhui province is in rapid development stage of industrializations which the pursuit of rapid economic growth is the focus at this stage, but we can’t put the resources and the environment aside, be should be careful to avoid the “pollution first, first damage control after” industrialized road. Judging from the empirical results, R & D funds and S & T personnel are associated with economic development more, description of input and output focus in Anhui industrial sector is dominated by the economy. The government could adopt appropriate fiscal policy, tax policy by directing resource of science and technology flows to balance between resource and environment development.

Finally, plan the resources allocation and improve the use efficiency of S & T resources. The contribution rate of R & D to “Two Oriented Society” construction is not high (about 0.6). The total is not the output of science and technology, the government should pay more attention to structure and resource allocation.

6. Conclusion and Limitation

This article uses the data from Anhui industrial sector to test and verify the role of R & D inputs in promoting “Two Oriented Society” construction. The empirical results not only provide objective a fact-based to decision-making departments, but also fill theory blank between R & D investment and “Two Oriented Society” construction. However, there are two drawbacks in current research.

First, we do not consider heterogeneous between industrial sectors in this paper. Second, affecting factors are not clearly being considered in this paper. People have not formed integral system about research on the theory of “Two Oriented Society”. Some variables, such as staff structure and management efficiency, can not be combined into the research framework owing to the reason like hard data.

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