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Input Factors Contribution Degree Analysis of Energy Service Industry based on Economic Growth Model

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Abstract – *With the sustainable development background and in order to meet the economic transformation, energy structure adjustment and environment demand, energy services industry has attracted more and more attention and got rapid development, but the current theoretical system of energy services industry is still not perfect now. The economic contribution degree analysis of each factor input in the energy service industry can help the industry to break growth bottleneck, promote development, and achieve more social and environmental benefits. By constructing the economic growth model for various elements in the industry, the paper analyzes the contribution rate of input factors and the influence of industrial economic growth on the society economy. The results showed that the factor of enterprise growth ability has the highest contribution rate to the energy service industry's economic growth, followed by the capital input and labor input, and the contribution rate of human capital, knowledge capital and policy factors is relatively small. The result has practical significance to China's energy service industry development at the present stage, at the same time, the research framework and method put in the paper can give certain reference for the study of other industrial*

Keywords – China, economic growth model, energy services industry, input factors, production function.

1. INTRODUCTION

Energy is the material basis for the existence and development of human society, with the problem of resource depletion, climate change and environmental pollution, countries around the world are committed to realize the transformation of energy production and consumption to more efficiency, clean and low carbon development style. With the government strong push, energy service industry developed rapidly in China. By the end of "12th Five-Year" period, the total number of enterprises engaged in energy related services industry in China reached 5426 and employing people were 607 thousand. During the period, the investment based on contract energy management totaled 59.038 billion USD, and annual energy-saving capacity reached 0.124 billion tons of standard coal with reducing carbon dioxide emissions 0.31 billion tons. The energy service industry has gradually become an important emerging industry in China national economy, which makes important contributions to stimulating economic growth, promote related industries development. In addition to creating direct economic benefits, it also has obvious environment and social benefits including reducing greenhouse gas emissions and environmental pollution, increasing employment opportunities, ensuring energy security and achieving resource conservation.

The existing researches on energy services industry are mostly focused on barrier factor analysis, market mechanism design, industrial planning and policy recommendations [1]-[3]. Energy prices, financing environment, government policies, human resources and business models are the main barriers to energy services industry development [4]-[8]. Sorrell [9], Mills [10], Bannai [11], Reddy [12], Pedra-sa [13] *et al.* conducted the researches on energy services industry business model, and operation, transaction cost, price mechanism of energy management contract in the energy services industry. In addition to the above research areas, using the economic growth theory to analyze the various elements inputs' contribution to the energy services industry economic growth and find the key driving factors is very important for stimulating economic growth and promoting the industry development.

Economic growth theory can not only analyze the main driving factors of economic growth, but also clarify the promoting cause and paths, which helps to exhibit the relationship between energy service industry factor input and economic growth. Scholars mainly usedthe economic growth theory and model to estimate the contribution to economic growth of each factor input, as well as the relevant empirical research, or to make a comparative analysis among countries. With the help of Solow economic growth model, Shi [14] made an empirical analysis on the relationship between factor input, TFP and China's economic growth. Li [15] found that due to the spillover effect of human capital, the economy overall showed increasing scale of returns, and for China, the effect of human capital spillover and output elasticity is higher than that of institutional change factor. Wang [16] also conducted related research about human capital and regional economic growth. With Cobb Douglas production expansion function, Wang and Liu [17] found that Chinese property rights system's contribution to the economic growth is smaller in the eastern region than in the

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middle and western during 1998-2006, but the contribution of government efficiency factors and opening-up degree factor was significantly higher in the eastern than the western. Hanushek [18] analyzed the human capital function in economic growth in the developing countries. The economic growth theory is widely used in macro and regional economic analysis, but its application in factor input contribution rate analysis of industry, especially energy service industry, is still in the blank. This paper uses the economic growth theory to establish an economic contribution degree analysis model of each factor input in the energy service industry, to find the most important factors, and finally put forward relevant suggestions to promote the whole industry development.

2. ECONOMIC GROWTH MODEL AND EXPANDING

The economic growth theory mainly based on the production function analysis studies the relationship between the elements inputs (*e.g.* national capital, labor force quantity) increase and GDP growth to obtain the driver factors of national economic growth.

Cobb-Douglas (C-D) production function is widely used which is an empirical hypothesis. The equation is:

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

Where, Y, A, K, L respectively represent total output, material capital input, labor input and technological progress. α , β respectively represent the elasticity coefficient of material capital and labor input to output.

Based on the Cobb-Douglas production function, many researchers extended the function by introducing other variables. Fu Xiaoxia introduced the system factor into the C-D production function, and constructed the extended function including the variables of labor, material capital, technology and institution. The expanding equation is as following:

$$Y = AK^{a}L^{b}I^{c}e^{\varepsilon} \tag{2}$$

Y, K, L, I respectively represent total output, material capital input, labor input and institution factor. A indicates other growth factors such as technological progress, human capital, etc. which have not been shown in the production function. a , b , c are the parameters, ε is the random perturbation term.

Wang and Liu introduced two variables including institution factor and government efficiency, constructing the extended C-D production function as follows:

$$Ln(\frac{Y_{it}}{L_{it}}) = Ln(A) + \alpha Ln(\frac{K_{it}}{L_{it}}) + \gamma B + \lambda ge_{it} + \mu_{it} \tag{3}$$

Where, Y_{it} , K_{it} , L_{it} , B , ge_{it} respectively indicate the output in year t of region i, material capital input, labor input, institutional factors and government efficiency. α , γ , λ are the parameters, μ_{it} is the random perturbation term.

Li [15] not only introduced the institutional factor into the model, but also introduced the human capital variable. He constructed the extended C-D production function model as follows:

$$Ln(\frac{Y_t}{L_t}) = Ln(A) + \alpha Ln(\frac{K_t}{L_t}) + \beta Ln(HR_t) + \gamma Ln(ICI_t) + \varepsilon_t \tag{4}$$

Where, Y_t , K_t , L_t , HR_t , ICI_t respectively indicate actual output, material capital stock, labor input, human capital stock and institutional factors. α , β , γ are the elasticity coefficient of each input factor to actual output, ε_t is the random perturbation term.

In addition, Wang [19] established the extended C-D production functions including institutional factors, per capita human capital, knowledge capital and industrial structure, based on which he studied China's economic growth further. The economic model is as follows:

$$LnY = a_0 + a_1 LnI + a_2 LnS + a_3 LnL + a_4 LnK + a_5 LnAH + a_6 LnR\&D + \varepsilon \tag{5}$$

Where, Y , I , S , L , K , AH , $R\&D$ respectively represent total output, institution factor , industrial structure , labor input, material capital, per capita human capital and knowledge capital labor input.

3. ANALYSIS OF THE MAIN FACTORS FOR ENERGY SERVICE INDUSTRY ECONOMIC GROWTH

In recent years, many scholars have studied the affecting factors and problems during the China's energy services industry development process. Combined the general impact factors of economic growth with the specific development circumstances of the industry, we conclude that the factors affecting China's energy services industry mainly include investment and financing level, technology and talent input level, policy system, industry environment and other factors, as shown in Figure 1.

The first factor is the level of investment and financing. Energy service industry, as an emerging strategic industry in China, needs continuous capital input to keep the industry rapid development. The energy service industry financing refers to the investment subject (government, enterprises, individuals or non-governmental organizations NGO) providing capital for management innovation, technology research and development, production and other activities of energy conservation and ecological environment improvement,. According to the data provided by China Environmental Science Society, the capital sources of energy service companies are still mainly from own funds (65.2%), followed by bank credit (28.1%). At present, the total investment in the industry is still insufficient compared to its potential capital needs, and there is no strong financial support for industrial development. The level of investment and financing becomes an important factor affecting energy service industry development.

The second is technology and talent input level of energy services industry. The level of technological innovation and talent input is considered to be one of the most important reasons for economy and society rapid development. The special technological innovation activities and talents input are also significant for energy service industry. Although the special technical level of energy saving in China shows a trend of rapid improvement, compared with the international advanced level, it is still necessary to vigorously promote the technology innovation and application ability of government and enterprises. About talent input, because energy services industry develops in a relatively short time, professional talent training in high education is still in the initial stage. Besides, the current domestic university talent cultivation often pays attention to the basic professional knowledge, rather than advanced technology development and application. The strength of talents is relatively weak, which usually cannot meet the technology research and development demand of emerging industry.

The third is the industrial policy factor. The governments' role is very important in the development of China's energy service industry. The main function of governments lies in: through the corresponding policies or measures to guide the element inputs such as capital, land, technology and human resource to flow into energy service industry. How to design and select energy saving policies effectively has important guiding and normative functions for promoting energy saving, environmental improvement and energy service industry development in China. At present, China's energy service industry policy types and design content are relatively diversity and complete, but the policy distribution is obvious imbalance, and there is lack of coordination between the various policies, which causes conflicts or counteract effects in energy saving and emission reduction during the policies reality application.

The fourth is the industrial environmental factor. Industrial environment refers to the external conditions faced by enterprises in the industrial development process which as exogenous factors of industrial development can be divided into three aspects of economic level and structure, market structure and external environment. Different economic levels and structures can be used as the different basis for promoting the industry development. Market structure refers to the degree of marketization, which is one of the important reasons influencing the efficiency of resource allocation in the economic system. The external technological environment refers to the overall level of technology R&D and application in the whole society, not only the specific technical level of the energy-saving industry. The external technological environment factors can be measured by the society overall R&D investment.

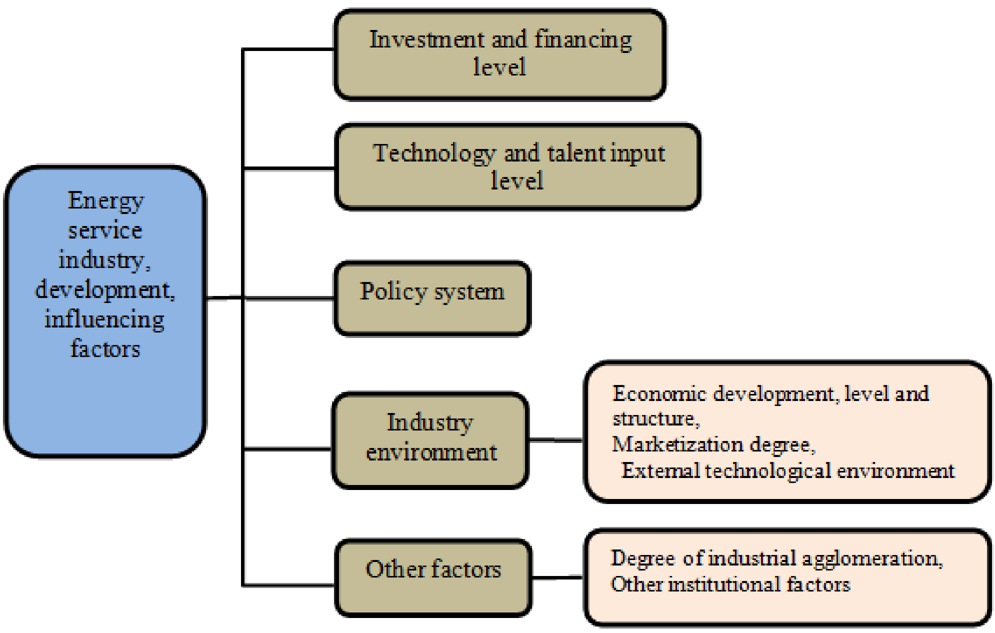

Fig. 1. Factor analysis frame of energy service industry economic growth.

The fifth are other institutional factors. Other institutional factors refer to the meso and micro systems including industrial organization system and enterprise management system that exclude policy factors. For example, industry management modes and enterprise accounting systems will affect the development of energy service industry; industrial agglomeration can promote the specialization of labor organization, and save transaction cost by avoiding middlemen at the same time. Enterprises gathered in a region, through patent technology transfer, personnel flow or informal exchanges, etc., to promote technology R&D and application level.

In fact, all above factors are not independent of each other, and there is a complex and close relationship between them. The financing factors, technology development, talent input and industrial environmental factors can directly determine the energy service industry economic growth through market mechanism. The policy factor by affecting financing factor, technology development, talent investment and industry environmental factor, can indirectly affect the industry economic growth. The specific performance of policy factor's influence on financing factor is introducing related financial subsidies, funds, bonds, insurances to increase the investment and financing opportunities of energy services industry. Many energy-saving planning policies are also seen as the economic barometer, further affecting people's expectations and investment decision. The policy factor impact on technology development and talent input can act as kinds of energy-saving emission reduction standards, technical standards, environmental monitoring and assessment policies, which all encourage enterprises to improve producing process with cleaner production technology. The specific performance of policy factor's influence on industrial environmental factor is energy saving and environmental protection relevant laws, regulations, planning, environmental information disclosures and public participation, which can improve market mechanism and then further promoting the positive effect on the industry development though the industrial environmental factor. The influence of policy factors on industrial agglomeration factors shows as the government fostering leading enterprises or merging related enterprises to improve the industrial agglomeration and market concentration.

4. ECONOMIC GROWTH MODEL OF ENERGY SERVICE INDUSTRY

4.1 Model Assumption

The third section summarizes that in the development process of energy services industry, the levels of investment and financing, technology and personnel input, policy system, industry environment and other factors all will affect the output value of the industry to a certain extent. So in order to obtain industrial economic benefits and social benefits, it is necessary to input considerable elements including capital, advanced technology, labor, talent resource, policy system (investment subsidy policy, tax preferential policy etc.) and more opened market environment and so on. Given the existing researches of extended C-D production function, the paper combines with the factors affecting energy service industry to extend the Cobb Douglas production function, which introduces the policy factors, human capital, enterprise growth ability, knowledge capital and financial capital. The basic form of the extended C-D function is as follows:

$$Y_t = A_t L_t^{\alpha} KC_t^{\beta} I_t^{\gamma} H_t^{\theta} M_t^{\delta} E_t^{\lambda} e^{\varepsilon_t} \quad (6)$$

Where, Y_t, L_t, KC_t, I_t, H_t, M_t, E_t respectively indicate: actual output of year t, labor input, knowledge capital, institutional factors, human capital, enterprise growth ability and financial capital. α, β, γ, θ, δ, λ respectively represent the elasticity coefficient of L_t, KC_t, I_t, H_t, M_t, E_t to actual output. A_t indicates technical progress, ε_t is the random perturbation term.

Take logarithms at both ends of the equation (6), and obtain the following equation (7), which is the regression equation to be studied in this model.

$$LnY_t = LnA_t + \alpha LnL_t + \beta LnKC_t + \gamma LnI_t + \theta LnH_t + \delta LnM_t + \lambda LnE_t + \varepsilon_t \quad (7)$$

Take the derivative of both ends of equation (8) with respect to time t:

$$\frac{Y_t'}{Y_t} = \frac{A_t'}{A_t} + \alpha\frac{L_t'}{L_t} + \beta\frac{KC_t'}{KC_t} + \gamma\frac{I_t'}{I_t} + \theta\frac{H_t'}{H_t} + \delta\frac{M_t'}{M_t} + \lambda\frac{E_t'}{E_t} + \frac{\xi_t'}{\xi_t} \quad (8)$$

Where, $\varepsilon_t = Ln\xi_t$, and $y_t' = \frac{Y_t'}{Y_t}$, $l_t' = \frac{L_t'}{L_t}$, $kc_t' = \frac{KC_t'}{KC_t}$, $i_t' = \frac{I_t'}{I_t}$, $h_t' = \frac{H_t'}{H_t}$, $m_t' = \frac{M_t'}{M_t}$, $e_t' = \frac{E_t'}{E_t}$, they represent annual output of year t, and growth rates of labor, knowledge capital, policy factors, human capital, enterprise growth ability and financial capital, in year t. And set $\mu = \frac{A_t'}{A_t} + \frac{\xi_t'}{\xi_t}$, the equation (8) can be expressed as:

$$y_t' = \alpha l_t' + \beta kc_t' + \gamma i_t' + \theta h_t' + \delta m_t' + \lambda e_t' + \mu \quad (9)$$

Make the equation (9) divided by y_t' on the both sides, and then obtain the each factor inputs' contribution rate equation for the energy service industry economic growth:

$$1 = \alpha\frac{l_t'}{y_t'} + \beta\frac{kc_t'}{y_t'} + \gamma\frac{i_t'}{y_t'} + \theta\frac{h_t'}{y_t'} + \delta\frac{m_t'}{y_t'} + \lambda\frac{e_t'}{y_t'} + \frac{\mu}{y_t'} \quad (10)$$

We assume that $L_c = \alpha\frac{l_t'}{y_t'}$, $KC_c = \beta\frac{kc_t'}{y_t'}$, $I_c = \gamma\frac{i_t'}{y_t'}$, $H_c = \theta\frac{h_t'}{y_t'}$, $M_c = \delta\frac{m_t'}{y_t'}$, $E_c = \lambda\frac{e_t'}{y_t'}$, which represent the contribution rates to the industry economic growth respectively of labor, knowledge capital, policy factors, human capital, enterprise growth ability and financial capital, in year t. Make $\mu_c = \frac{\mu}{y_t'}$ as the residual value, indicating the contribution rate of other factors excluding the above factors.

The contribution of the energy services industry to GDP can be calculated using the following methods. We assume that the increased value of GDP is the sum of all industries' added output value. Then each industry's influence degree of GDP is in the direct ratio of the industry GDP accounted for the whole region GDP.

Thus, the contribution rate to GDP of the energy service industry can be expressed as:

K_t = (Output growth rate of energy services industry in the year t / GDP growth rate)×energy services industry output share of GDP in the year t and the get L_cK_t, KC_cK_t, I_cK_t, H_cK_t, M_cK_t, E_cK_t, μ_cK_t respectively indicate the contribution rates to GDP added value of labor, knowledge capital, policy factors, human capital, enterprise growth ability and financial capital, in year t.

4.2 Estimation of Parameters

Because there is severe multicollinearity when using the least-square method to estimate the model parameters, the established regression model is of poor stability. Principal component estimation has good properties, such as minimum information loss, uncorrelated between principal components, minimum mean square error, and so on. In this paper, we use PASW Statistics 18 Software to estimate the parameters such as α, β, γ, θ, δ and λ, by using the biased estimation method. The main steps are as follows: calculate the eigenvalues and eigenvectors of the principal components in PASW analysis module; multiply the obtained eigenvectors respectively with the corresponding standard data; at last, get the principal component expression which general form is:

$$F_i = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + \ldots + a_iX_i \tag{11}$$

Where F is the main components, $(a_1, a_2, a_3, a_4, a_5, \ldots, a_i)$ is the eigenvector, X represents the standardized values of $(LnL_t, LnKC_t, LnI_t, LnH_t, LnM_t, LnE_t)$ respectively. Using the regression analysis module in PASW, obtain the regression equation of LnY_t and main components F, that is the standard regression coefficient of LnY_t and variable X. And then transform the standard regression coefficient to the original regression coefficient, namely getting the corresponding parameters α, β, γ, θ, δ, λ in equation (2).

4.3 Indicators and Data

4.3.1 Industrial output

The research focus in this part is the elements input contribution rate of energy services industry's economic growth, so the actual industrial output can be expressed by the total output value of China's energy services industry (Table1), and the output growth rate can be calculated accordingly (Table 2). It can be seen from the data that the 2010-2015 industry output growth rates are at a downward trend overall. Because at the beginning of "12th Five-Year" period, the energy services industry is at the initial rapid development stage, the output grows swift, but to the end of "12th Five-Year" period, the energy service industry has begun to take shape, so the development becomes relatively stable and steady.

Table 1. The output of energy service industry from 2010-2015 (One hundred million USD).

Year	2010	2011	2012	2013	2014	2015
Output	133.05	198.92	263.05	342.96	421.67	497.56

Data source: Annual report of China Energy Service Industry.

Table 2. The output growth rate of energy service industry from 2010-2015.

Year	2010	2011	2012	2013	2014	2015	Mean value
Rate	40.38	49.5	32.24	30.38	22.95	18	32.24

Table 3. The employment of energy service industry from 2010-2015 (Ten thousand people).

Year	2010	2011	2012	2013	2014	2015
	17.5	37.8	43.5	50.8	56.2	60.7

Table 4. The employment growth rate of energy service industry from 2010-2015 (%).

Year	2010	2011	2012	2013	2014	2015	Mean value
	54.87	116	15.1	16.78	10.63	8.01	36.9

4.3.2 Labor Output

The labor input can be measured by the employment data of energy services industry (Table 3), and calculate the average growth rate of employment during 2010-2015 years (Table 4). From the data in the tables, we can see that the growth rate of 2010 and 2011 years are much higher, especially in 2011, the rate more than 100%. In 2011, energy service industry is at the rapidly expanding development stage, so there need more labor force to participate in the industry development. Accordingly, in 2011, the labor input influence on the industry development should be larger than other years.

4.3.3 Enterprise Growth Ability

Like other industries, the energy service industry needs a number of different types and distinctive leading enterprises to lead its rapid development in the initial period. In the field of energy services, there has formed a group of companies with strong competitiveness. As a result, the enterprise growth ability can be represented by the annual number of energy service companies

(Table 5), and the annual average growth rate of the companies can be obtained (Table 6). As can be seen from the data, the 2011 year's number growth rate of enterprises is still significantly higher than other years'. We can obtain the conclusion that 2011 is an important sign of the energy services industry development.

4.3.4 Human Capital

In this paper, the human capital is measured by the average education period of the labor force in the energy service industry. Getting different academic levels needs corresponding schooling years which are 6 years of primary school, 9 years of junior high school, 12 years of senior high school, and 16 years of junior college or higher. The level of human capital can be expressed as a weighted average value of education years, that is:

Average education period ΔS=（6×S6+9×S9+12×S12+16×S16）/S. S stands for the total population over the age of 6; S6 stands for primary school population over 6 years old; S9 stands for junior high school population over 6 years; S12 stands for high school population over 6 years old; S16 stands for the college population over 6 years old. The data (in Table 7) shows that the education level of practitioners in the industry relatively maintains stable.

Table 5. Number of energy companies in energy services industry.

Year	2010	2011	2012	2013	2014	2015
	782	3900	4175	4852	5125	5426

Table 6. Number growth rate of energy companies in energy services industry (%).

Year	2010	2011	2012	2013	2014	2015	Mean value
	55.78	399	7.05	16.22	5.63	5.87	81.59

Table 7. Human capital of energy services industry from 2010-2015 (Years).

Year	2010	2011	2012	2013	2014	2015
S	1091868	1067267	1047865	1041825	1047090	19833469
S6	328934	294232	281681	274658	274858	5199574
S9	455002	441905	430799	425144	420432	7600489
S12	150648	165049	168941	172088	174847	2434365
S16	79567	107348	110990	117925	120698	2280850
ΔS	8.38	8.846	8.942	9.048	9.037	8.335
H	1466438	3343664	3889936	4596222	5078695	5059128

Data source: China population statistics yearbook.

4.3.5 Knowledge Capital

The increase of knowledge capital comes from the continuous improvement and creation of knowledge. From the point of view of investment, research and development activities (R&D) are the source of knowledge capital. From the aspect of output, knowledge capital is represented as technical invention patents and so on. Due to the input-output efficiency of technology R&D investment, this paper uses scientific and technological output indicators to reflect the knowledge capital of energy services industry. To a certain extent, the number of patents can reflect invention activities and corresponding outputs and ownership in a region, technological innovation and technology development level, as well as the competition position in the technical and economic development. This paper adopts the patent license number of energy service companies, technical equipment companies or research institutions, as the substitute measure indicator of knowledge capital (Table 8). According to the data, apart from the negative growth in 2013, the growth rate of other years remained at a relatively stable level (Table 9).

4.3.6 Policy System Factor

The policy environment covers some policies and regulations introduced by the state or regions to promote the energy services industry development, including investment subsidies, tax incentives, and so on. This paper uses marketable income indicators of each province and city to represent the policy system factors, which can be represented by the proportion of non fiscal revenue income to the total output value of the energy services industry. Thus, the growth rate of policy system variable I_{it} (Table 10) and system variable (Table 11) are obtained.

Table 8 .The knowledge capital in energy services industry from 2010-2015.

Year	2010	2011	2012	2013	2014	2015
	2555	2821	3789	3689	4936	6059

Source: National Bureau of statistics

Table 9. The knowledge capital growth rate in energy services industry from 2010-2015 (%).

Year	2010	2011	2012	2013	2014	2015	Mean value
	31.77	10.41	34.31	-0.03	33.8	22.75	22.17

Table 10. System variable of energy services industry from 2010-2015 (One hundred million USD).

Year	2010	2011	2012	2013	2014	2015
	377.46	408.38	461.36	530.58	552.22	700.43

Table 11. System variable growth rate of energy services industry from 2010-2015 (%).

Year	2010	2011	2012	2013	2014	2015	Mean value
	25.12	8.19	13	15	4.08	26.84	15.37

Table 12. Investment in energy services industry from 2010-2015 (One hundred million USD).

Year	2010	2011	2012	2013	2014	2015
	45.74	65.62	88.72	118.10	152.54	165.39

Table 13. Investment growth rate in energy services industry from 2010-2015 (%).

Year	2010	2011	2012	2013	2014	2015	Mean value
	2.68	43.45	35.21	33.12	29.16	8.43	25.34

4.3.7 Financial Capital

Financial capital refers to the directly involved funds in the implementation of energy services projects, including energy consumption enterprise's own funds, the funds of the energy service companies and the funds provided by the financing institutions. In this paper, the annual investment in the energy services industry is used as an indicator of financial capital capability (Tables 12 and 13). Seen from the data, 2011 is an important year for the energy services industry development when the industry's annual investment growth rate is particularly large, and generally speaking, in the "12th Five-Year" period, the energy services industry investment growth trend is relatively stable,

5. EMPIRICAL ANALYSIS

5.1 Parameters Estimation Results

The original data of each factor is shown in Table 14: As shown in Table 15, there is a very significant relationship between energy services industry output and labor input, knowledge capital, policy factors, financial capital, and a relative significant relationship with the enterprises growth. Obviously, the direct correlation between the variables is strong, which proves that they contain overlap information.

Based on ANOVA, the resulting principal component extraction analysis table is shown in Table 16. The extraction regulation of principal components m is the components' corresponding eigenvalues greater than 1. The eigenvalues to a certain extent can be seen as the impact degree index of principal component represents. If the eigenvalues is less than 1, the explain intensity of the principal component is less than directly introducing a variable, so a principal component inclusion criteria is that its corresponding eigenvalue must greater than 1. Through the variance decomposition analysis (Table 17) to extract the principal component, there are 2 principal components extracted. In addition, according to the result, the cumulative contribution rates of the first two eigenvalues have reached 97.881%, exceeding 85%, so it is appropriate to select the two principal components to estimate the value of parameters.

Table 14. The original data of inputs.

Year	Output	Labor input	Enterprise growth	Human capital	Knowledge capital	Policy system	Financial capital
2010	836.29	17.5	782	8.38	2555	2372.5	287.51
2011	1250.26	37.8	3900	8.846	2821	2566.79	412.43
2012	1653.37	43.5	4175	8.942	3789	2899.81	557.65
2013	2155.62	50.8	4852	9.048	3689	3334.89	742.32
2014	2650.37	56.2	5125	9.037	4936	3470.9	958.76
2015	3127.34	60.7	5426	8.335	6059	4402.48	1039.56

Through principal component analysis, the corresponding correlation matrix (Table 15) is obtained.

Table 15. The correlation matrix of inputs.

		Output	Labor input	Enterprise growth	Human capital	Knowledge capital	Policy system	Financial capital
Correlation	Output	1.000	0.945	0.851	0.044	0.965	0.970	0.996
	Labor input	0.945	1.000	0.976	0.304	0.869	0.878	0.940
	Enterprise growth	0.851	0.976	1.000	0.435	0.754	0.771	0.844
	Human capital	0.044	0.304	0.435	1.000	-0.138	-0.160	0.096
	Knowledge capital	0.965	0.869	0.754	-0.138	1.000	0.964	0.952
	Policy system	0.970	0.878	0.771	-0.160	0.0964	1.000	0.946
	Financial capital	0.996	0.940	0.844	0.096	0.952	0.946	1.000

Table 16. Principal component extraction of variance analysis.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.558	79.394	79.394	5.558	79.394	79.394
2	1.294	18.487	97.881	1.294	18.487	97.881
3	0.107	1.532	99.413			
4	0.034	0.486	99.899			
5	0.007	0.101	100.000			
6	8.815E-16	1.259E-14	100.000			
7	7.610E-17	1.087E-15	100.000			

Table 17. Load matrix of the principal components.

	Component	
	1	2
Output	0.992	-0.085
Labor input	0.976	0.200
Enterprise growth	0.907	0.358
Human capital	0.120	0.985
Knowledge capital	0.950	-0.264
Policy system	0.954	-0.276
Financial capital	0.985	-0.40

Table 18. The estimation results of parameters.

Parameter	α	β	γ	θ	δ	λ
	0.369	0.371	0.206	0.282	0.282	0.332

The selected principal component load matrix is shown in Table15.

Each load represents the correlation coefficient between the principal component and the corresponding variable. From the Table 17, we can see that the energy services industry output, labor input, enterprise growth, knowledge capital, policy factors and financial capital have a higher load in the first principal component, which means that the first principal component reflects the basic information of these indicators; index of human capital has a higher load in the second principal component, which means the second principal component mainly reflects the human capital information, so the extraction of two principal components can basically reflect the information of all the indicators (Table 17). The data in the principal component load matrix divided by the corresponding eigenvalues, then taking the square root of the results, we can obtain the coefficients corresponding to each indexes in the two principal components, *i.e.*, the eigenvectors.

$$a_1 = (0.414, 0.385, 0.051, 0.403, 0.405, 0.418)$$

$$a_2 = (-0.075, 0.176, 0.315, 0.866, -0.232, -0.243, -0.035)$$

Thus, the expression of principal component is obtained:

$$F_1 = a_1 \times X$$

$$F_2 = a_2 \times X$$

Where, $X = (\ln L_t、\ln KC_t、\ln I_t、\ln H_t、\ln M_t、\ln E_t)$

Take the proportion of each principal component's eigenvalue to the total eigenvalues of all extraction principal components as the weight to calculate the comprehensive analysis results. The coefficients of each index in the first principal component F_1 multiply the corresponding contribution rate of F_1, then divided by the two principal components' total contribution rates; similarly, perform the calculation process for F_2 and add together as shown below. The estimated parameters are shown in Table 18.

$$\begin{aligned} F &= 0.81 * F_1 + 0.19 F_2 \\ &= 0.369 \ln L_t + 0.37 \ln KC_t + 0.206 \ln I_t + 0.282 \ln H_t + 0.282 \ln M_t + 0.332 \ln E_t \end{aligned}$$

5.2 Analysis of the Results

After the parameters estimation, we can use the equation (5) in the third section to calculate the contribution rate of each factor input to the industry economic growth.

$$1 = \alpha \frac{l_t^{'}}{y_t^{'}} + \beta \frac{kc_t^{'}}{y_t^{'}} + \gamma \frac{i_t^{'}}{y_t^{'}} + \theta \frac{h_t^{'}}{y_t^{'}} + \delta \frac{m_t^{'}}{y_t^{'}} + \lambda \frac{e_t^{'}}{y_t^{'}} + \frac{\mu}{y_t^{'}} \qquad (12)$$

When calculating the energy service industry contribution of GDP, firstly, we assume that the GDP increase of a region is the sum of all industry output value increase; then each industry's influence degree of GDP is in the direct ratio of the industry GDP accounted for the whole region GDP. Thus, the contribution rate to GDP of the energy service industry can be expressed as:

K = (Output growth rate of energy services industry / region GDP growth rate)×energy services industry output share of GDP

The energy service industry contribution rate in 2010-2015 years to GDP development is calculated by using the equation above, seen in the Table 19. As a result, the contribution rate of each input factor to economic growth in energy service industry can be further calculated. The results are shown in Table20 below.

The results show that in 2010-2015, the contribution of enterprise growth ability to energy service industry's economic growth is the highest as 46.8%, followed by the labor input and financial capital, respectively 21% and 13%. While the contribution of human capital, knowledge capital and policy system factor to energy service industry output value is relative limited.

6. CONCLUSION

Firstly, this paper identifies the main factors affecting the economic growth of the energy service industry, including the level of investment and financing, technology and human capital input, policy system, industry environment and other factors, and analyzes factors influence on the industry development. Secondly, based on the Cobb-Douglas production function, introduce the policy system factor, human capital, enterprise growth ability, knowledge capital, financial capital and other parameters, establishing the economic growth model of elements input into the energy services industry. Finally, use the relevant industry development data during "12th Five-Year" period to make an empirical analysis. The results clarify the factor input's contribution degree to industrial economic growth and industrial economy growth contribution to GDP.

Based on the results of economic growth model of energy services industry, in the industry development process, we should pay special attention to the growth of energy service companies, including the quantity growth and service level improvement. The government should establish perfect management system to further strengthen the supervision of energy service enterprises. Secondly, attach importance to the talent and capital investment. On the one hand, intensify the cultivation of talents; on the other hand, implement corresponding fiscal incentive policies to encourage social capital to enter the energy services industry. Human capital factor is mainly determined by the education years; knowledge capital refers to the ability of technical innovation, and policy system factor represents the financial support of the state for energy services industry. Therefore, in the industry development process, it is essential to intensify the professional training of employees, increase energy-saving technology innovation, and at the same time, further increase energy services industry support from governments.

Table 19. The statistics of the GDP and energy service industry outputs.

	2010	2011	2012	2013	2014	2015
Whole society GDP (Billion USD)	6331.9	7502.6	8262.4	9050.3	10117.3	10766.4
Growth rate (%)	10.3	9.2	7.8	7.7	7.4	6.9
Output of the energy service industry (Billion USD)	13.3	19.9	26.3	34.3	42.2	49.8
Growth rate (%)	40.83	49.5	32.24	30.38	22.95	18
Proportion of the whole society GDP (%)	0.21	0.27	0.32	0.38	0.42	0.46
GDP contribution rate of energy service industry (%)	0.83	1.45	1.32	1.5	1.3	1.2

Table 20. The contribution rate of the inputs to economic growth in energy service industry.

	Average annual growth rate	Elasticity coefficient	Contribution rate to the industrial output increase value	Contribution rate of GDP growth
Output	32.24			
Labor input	36.9	0.369	0.210483244	0.002667
Enterprise growth	81.59	0.371	0.467924342	0.005969
Human capital	8.76	0.206	0.027895627	0.000356
Knowledge capital	22.17	0.282	0.096645046	0.001232
Policy system	15.37	0.282	0.067002001	0.000851
Financial capital	25.34	0.332	0.130049741	0.001651

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