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Efficiency Research on Ecological Technology Innovation of Enterprises in View of Low Carbon Strategy based on Two-stage Chain DEA Model and Tobit Regression

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Abstract

Based on two-stage DEA model, this paper studies the efficiency of input and output of enterprises in ecological technology innovation in view of low carbon strategy, which embeds the efficiency of input and output of low carbon strategy in the first stage and the efficiency of eco-technological innovation in the second. Through empirical analysis on 96 high-tech enterprises, results got based on system theory. Analysis on the factors affecting efficiency by Tobit regression model contributes to the improvement of system efficiency. Results show that there are indexes positively influencing the efficiency of input and output significantly no matter on the level of consciousness, strength or implementation.

Keywords

low carbon strategy; ecological technology innovation; two-stage chain DEA; Tobit regression model, efficiency

0 Introduction

It was reported by Chinese government that "scientific and technological innovation is the strategic support to the improvement of social productivity and comprehensive national strength, so it should be put in the core position of national development, and strategy of innovation driven development must be implemented". Also, the concept of "Beautiful China" was first proposed with the emphasis on "green, cycle and low carbon development". We should reverse the trend of the deterioration of environment from the source to make sure a favorable environment. Scientific and technological innovation is a driving force to the development of economy, and it is a significant guarantee for the construction of beautiful China. As for Guangdong Province, who is one of the largest and most prosperous provinces in east coastal region of China, should take a greater responsibility on energy saving and emission reduction. With the purpose of advancing the efficiency of technology innovation, this paper takes high tech enterprises in Guangdong as samples to make a research on the efficiency of enterprises' ecological technology innovation based on low carbon strategy through the methods of theoretical and empirical, and the internal connection between ecological technology innovation and low carbon strategy is discussed.

A series of data about the input and output of 96 enterprises in Guangdong related with low carbon strategy and ecological technology innovation are acquired through questionnaire survey, with which an empirical analysis is made. This research on the one hand aims at better combining the strategy of development and low carbon of enterprises, and with the ideology of low carbon strategy, changing the technology innovation from traditional to ecological. On the other hand, help the government make a more forward-looking, targeted and effective policy.

1 Evaluation of Two-stage Chain DEA Model

(1) introduction of the method

Data Envelopment Analysis (DEA) is a new field in the development of operations research, it is a method and model to evaluate the efficiency proposed by American strategists A.Charnesh and W.W.cooper et al. based on the concept of efficiency, and it is relatively effective to the similar departments that with multiple input and output. [1-5]

Regard a system as a "black box", the traditional DEA model taking only the relative effectiveness between the initial input and the final output into consideration, while ignoring the production process, thus neither the information about the efficiency during the process nor the deep reasons for the non availability of the system be acquired. However, the chain DEA Model can evaluate the efficiency of both the whole process and each stage of a department with chain structure, so the overall efficiency can be appraised and the stage where non availability appear can be hunted out clearly.

In the past, scholars focused on low carbon strategy and ecological technology innovation respectively [6-10] and disregarded the inner relation between them. In this paper, the two concepts integrated by means of the system model of two- stage chain DEA.

The DEA system of two-stage chain is shown as Figure 1. In the first stage, X is the input vector of a decision-making unit of low carbon strategy, of whom Z^1 is the output vector. In the second stage, Z^1 and Z^2 are the input vectors of ecological technology innovation, and Y is the output vectors.

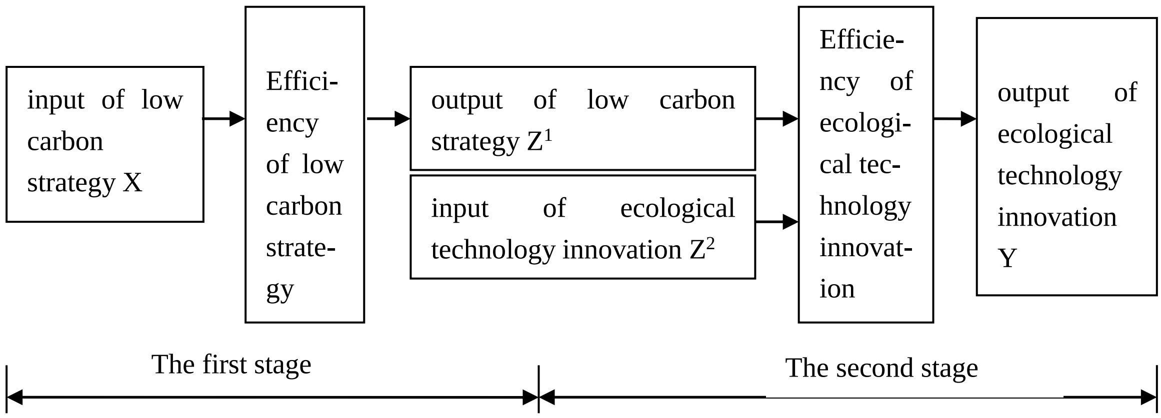

Fig.1 Two-stage chain of input and output of the evaluation for ecological technology innovation based on low carbon strategy

Considering the lag in the process from input to output of low carbon strategy and ecological technology innovation, we collected the data of the year t for the input of low carbon strategy, and the year of t+1 for the output of low carbon strategy and the input of ecological technology innovation, and the year of t+2 for the output of ecological technology innovation. Specifically, we used the data of 2010 for the indexes of low carbon strategy input, the data of 2011 for the indexes of low carbon strategy output and ecological technology innovation input, and the data of 2012 for the indexes of ecological technology innovation output.

(2) the index selection of input and output for two-stage chain DEA

In this paper, through literature research and investigation, combined with the current trend of development of social economy and technology, we constructed indexes systems (see in the appendix) for enterprise low carbon strategy and enterprise ecological technology innovation according to the principles of science, rationality, comparability and availability. The main factors that influence the two systems are extracted respectively by the method of factor analysis. Based on the results of factor analysis, take the factors which have important effect on enterprise low carbon strategy and enterprise ecological technology innovation as the factors of input and output.

There are five indexes including Annual fund input in energy saving and emission, Proportion of annual fund input in energy saving and emission in the total investment, Proportion of annual fund input of new energy technology R&D in the total investment, Number of staffs engaged in low carbon environmental protection, Gross value of equipment in low carbon environmental protection in the vector X.

In the vector Z^1, there are six indexes including Monitoring and measurement system of carbon emission throughout the supply chain, Water consumption per unit, Comprehensive utilization rate of industrial waste gas, Comprehensive utilization rate of industrial waste water, Comprehensive utilization rate of industrial solid waste and Rate of product recovery.

In the vector Z^2, there are also six indexes including Proportion of low carbon and green products output in the enterprise's GDP, Enterprise's annual profit rate, Rate of solid waste treatment, Rate of exhaust gas treatment, Rate of wastewater treatment and Advanced degree of ecological management of enterprises.

In the vector Y there are three indexes. Benefits of innovation output, Proportion of sales revenue of ecological products in the total sales revenue and Visibility of enterprise's green product included.

According to the indexes above, in the first stage, the number of decision making unit is 96, namely n=96, the number of input index is 5, namely m=5, the number of output index is 6, namely s=6.In the second stage, corresponding to the indexes in the first stage, the number are respectively n=96, m=12 and s=3. In the model of two-stage chain, the number of decision making unit is 96, namely n=96, there are 11 input indexes and 3 output indexes externally, and inside which the indexes in the first stage nested, so the total number of input indexes is m=23 while the output s=6, which meet the condition of $n \geq 3(m+s)$.

(3) construction of the two-stage DEA chain model

Suppose that there are J decision making units, for a decision making unit j, there is the same number M of input and N of output in the first stage, and X_{mj}（m=1,2,…,M; j=1,2,…,J）represents the input of the m^{th} item, Z^1_{nj}（n=1,2,…,N; j=1,2,…,J）represents the output of the n^{th} item. In the second stage, vector $Z = (Z^1, Z^2)$ means input, in which Z^1 indicates not only the output in the first stage, but also the input in the second. Corresponding to Z^2, there are the same P items of input and Q items of output in each decision making unit, Z^2_{pj}（p=1,2,…,P; j=1,2,…,J）is for the p^{th} input corresponding to Z^2, and Y_{qj}（q=1,2,…, Q ; j=1,2,…,J） is for the q^{th} output. In the model, λ represents the multiplier of input and output, θ represents the efficiency of the model of C^2R, θ_1 and θ_2 means the efficiency value of C^2R in the first and second stages respectively.

To measure the effectiveness of DEA of a certain decision making unit j_0, models are constructed as follows.

Taking the first stage into consideration only, the model is shown as Model 1.

$$\min \theta_1$$

$$s.t.\begin{cases} \sum_{j=1}^{J} X_{mj}\lambda_j \le \theta_1 X_{mj0} (\mathrm{m}=1,2,\ldots,\mathrm{M}) \\ \sum_{j=1}^{J} Z^1{}_{nj}\lambda_j \ge Z^1{}_{nj0} (\mathrm{n}=1,2,\ldots,\mathrm{N}) \\ \lambda_j \ge 0(\mathrm{j}=1,2,\ldots,\mathrm{J}) \end{cases}$$

Considering only the second stage, the model is as Model 2.

$$\min \theta_2$$

$$s.t.\begin{cases} \sum_{j=1}^{J} Z^1{}_{nj}\lambda_j \le \theta_2 Z^1{}_{nj0} (\mathrm{n}=1,2,\ldots,\mathrm{N}) \\ \sum_{j=1}^{J} Z^2{}_{pj}\lambda_j \le \theta_2 Z^2{}_{pj0} (\mathrm{p}=1,2,\ldots,\mathrm{P}) \\ \sum_{j=1}^{J} Y_{qj}\lambda_j \ge Y_{qj0} (\mathrm{q}=1,2,\ldots,\mathrm{Q}) \\ \lambda_j \ge 0(\mathrm{j}=1,2,\ldots,\mathrm{J}) \end{cases}$$

While the model of two-stage chain is as Model 3.

$$\min\theta$$

$$s.t.\begin{cases}\sum_{j=1}^{J} X_{mj}\lambda_j \le \theta_1 X_{mj0}(\mathrm{m}=1,2,\dots,\mathrm{M}) \\ \sum_{j=1}^{J} Z^1{}_{nj}\lambda_j \ge Z^1{}_{nj0}(\mathrm{n}=1,2,\dots,\mathrm{N}) \\ \sum_{j=1}^{J} Z^1{}_{nj}\lambda_j \le \theta_2 Z^1{}_{nj0}(\mathrm{n}=1,2,\dots,\mathrm{N}) \\ \sum_{j=1}^{J} Z^2{}_{pj}\lambda_j \le \theta_2 Z^2{}_{pj0}(\mathrm{p}=1,2,\dots,\mathrm{P}) \\ \sum_{j=1}^{J} Y_{qj}\lambda_j \ge Y_{qj0}(\mathrm{q}=1,2,\dots,\mathrm{Q}) \\ \sum_{j=1}^{J} X_{mj}\lambda_j \le \theta\, X_{mj0}(\mathrm{m}=1,2,\dots,\mathrm{M}) \\ \sum_{j=1}^{J} Z^2{}_{pj}\lambda_j \le \theta\, Z^2{}_{pj0}(\mathrm{p}=1,2,\dots,\mathrm{P}) \\ \lambda_j \ge 0(\mathrm{j}=1,2,\dots,\mathrm{J}) \end{cases}$$

(4) the empirical results and analysis

According to the model of two-stage chain DEA, the efficiency of input and output of the three models constructed above is calculated by using the data of 96 companies through the software of Matlab, the result is shown in Fig.2, where the horizontal axis represents the 96 enterprises and the vertical axis represents the input-output efficiency of each enterprise.

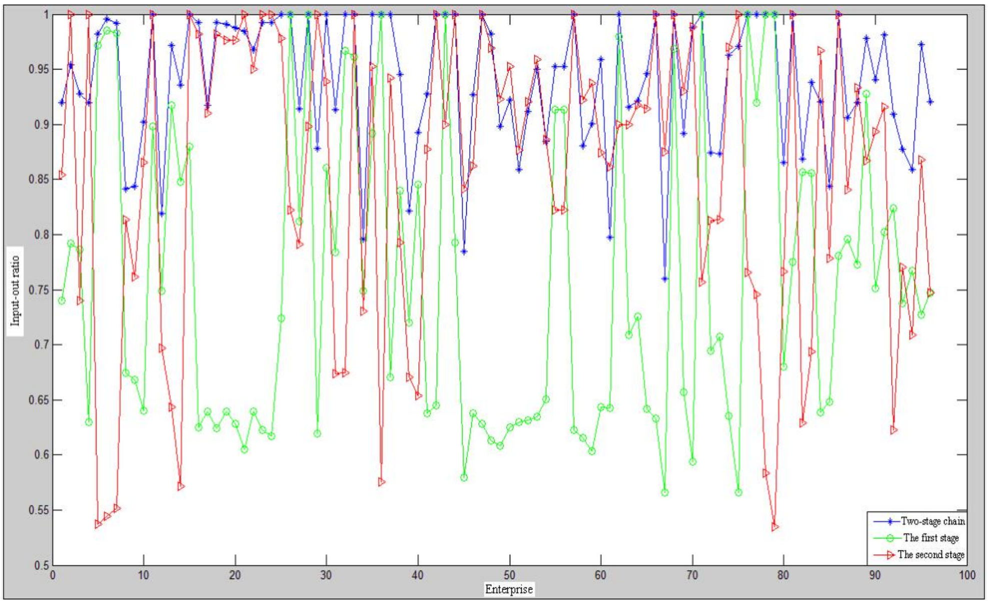

Fig.2 Results of the three models

The analysis of effectiveness: the numbers of DEA effective units in the two-stage chain, the first stage and the second stage are 26, 8 and 18, which meets the requirement that the number of effective units is less than the 1/3 of the total number of decision making units, which indicates that the three models are effective.

As Fig.2 shows, there are differences in different enterprises in the two-stage chain, the first and the second stage, from where the enterprise can see the gap with others. According to the three models, we can find out the stage with lower efficiency, and thus search the measures to improve the efficiency pertinently.

Since the value of efficiency got from DEA analysis is a relative value, which can be compared among the decision making units in a model, but is incomparable among different models, so we can compare the three models through the sort of efficiency value of different enterprises, and the result is shown in Fig.3, where the horizontal axis represents 96 enterprises, and the vertical axis represents the descending order value of various enterprises' input-output efficiency. The smaller the ordering value, the higher the efficiency.

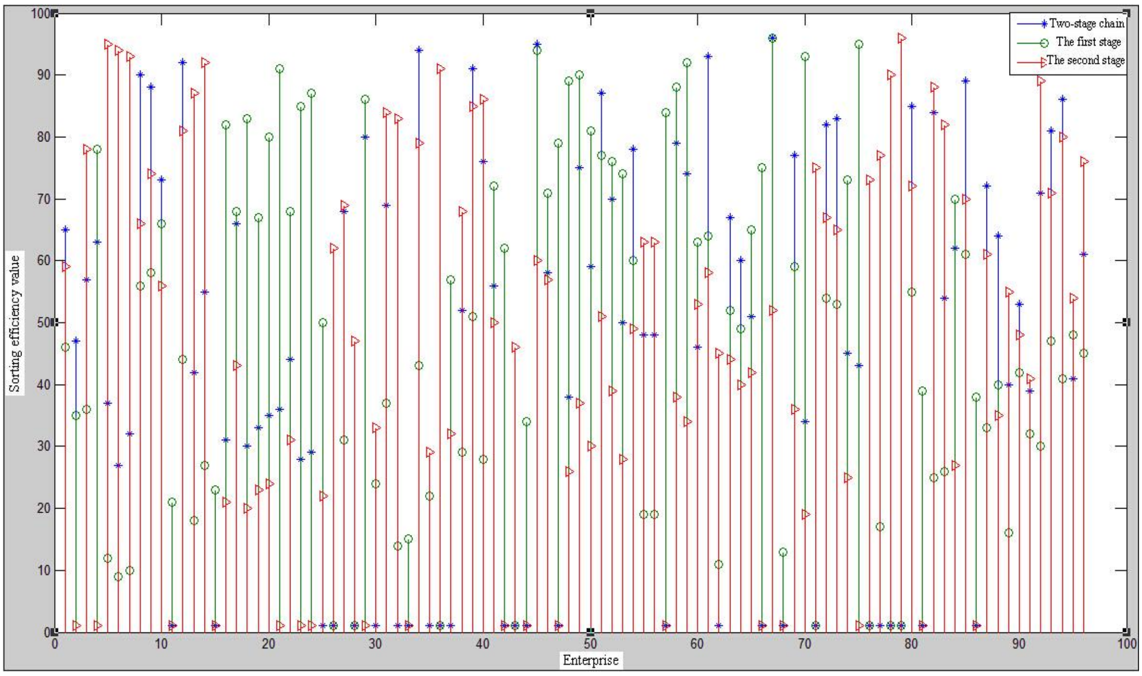

Fig.3 results sorting of the three models

According to the relation between the ranking values of the input-output efficiency in two-stage chain and the ranking values of the first and second stage, the results can be divided into the following three categories.

The first category: the ranking values of two-stage chain are higher than that of the first and second stage, which illustrates the poor resource allocation mechanism of ecological technology innovation based on low carbon strategy. Table 1 lists the enterprises belongs to this category and their corresponding ranking values. From the view of system theory [19], these systems are the kind of 1+1<2. The two-stage chain model, which is an integrated operation process formed by two sub operation processes in the two stages, focus not only on the input-output efficiency of low carbon strategy and ecological technology innovation, but also on how to obtain the maximun overall efficiency through unifying the intermediate variables in the two stages during the process. Though it may be well in the two separate stages, the overall input-output efficiency is poor when joining the two stages together.

Table 1 Enterprises whose ordering value of the two-stage chain are higher than both the first and second stage's

Enterprises	Efficiency ranking in the first stage	Efficiency ranking of two-stage chain	Efficiency ranking in the second stage
1	46	65	59
2	35	47	1
8	56	90	66
9	58	88	74
10	66	73	56
12	44	92	81
34	43	94	79
39	51	91	85
45	94	95	60
51	77	87	51
54	60	78	49
61	64	93	58
63	52	67	44
64	49	60	40
69	59	77	36
72	54	82	67
73	53	83	65
80	55	85	72
85	61	89	70
87	33	72	61
88	40	64	35
90	42	53	48
93	47	81	71
94	41	86	80

The second category: the ranking values of two-stage chain locates between that of the first and second stage, which shows that these enterprises are with the medium working effect of resource allocation mechanism in ecological technology innovation based on low carbon strategy. From the system theory, this system belongs to the kind of 1+1=2. Through the comparison of the sequencing values between the first and second stage and chase down the stage that languish at the lower end of the table, thus targeting to improve the efficiency of it in order to improve the overall efficiency.

The third category: the ranking values of two-stage chain are lower than that in the first and second stage, which explains the well operation of resource allocation mechanism in ecological technology innovation on the foundation of low carbon strategy. The category of enterprises are listed in Table 2 with their ranking values correspondingly, which will be divided into the system of 1+1>2 from the view of system theory. Bertalanffy emphasized that any system is an organic ensemble but the mechanical combination or simple addition of each part, the entirety function of a system is a new matter that do not appear when the elements are isolated [18]. So the enterprises in this category implementing ecological technology innovation in the concept of low carbon strategy effectively, reaching the effect of "the whole being greater than the sum of its parts".

Table 2 Enterprises whose ordering value of the two-stage chain are lower than both the first and second stage's

Enterprises	Efficiency ranking in the first stage	Efficiency ranking of two-stage chain	Efficiency ranking in the second stage
25	50	1	22
30	24	1	33
32	14	1	83
35	22	1	29
36	7	1	91
37	57	1	32
60	63	46	53
62	11	1	45
71	8	1	75
76	6	1	73
77	17	1	77
95	48	41	54

2 Tobit regression analysis

According to the input-output efficiency calculated by the two-stage chain model, we explore the factors that influence system efficiency through theoretical hypotheses and empirical analysis by means of Tobit regression model.

(1) Tobit regression model

The concept of Tobit regression model was first proposed by Tobit (1958), which is a model whose dependent variables are limited, and also known as Truncated Regression Model [20]. If the dependent variable values of the data are truncated or fragment, then the notion of ordinary least squares (OLS) is no longer applicable to estimate the regression coefficients, here the Tobit model which follows the maximum likelihood method becomes a better choice to estimate them. Since the values estimated by DEA method are truncated data between 0 and 1, it will be a lack of some data if estimated by OLS and thus leads to an error. Hence Tobit regression analysis is used in this paper, and the model set as follow:

$$y_i = x_i \times \beta + \varepsilon_i, 0 \le x_i \times \beta + \varepsilon_i \le 1$$

In the model, y_i represent the dependent variables, which are the efficiency values calculated according to the three models. x_i are the independent variables corresponding to each factor. β represents the coefficient proportion of each factor. ε_i are the residuals with the condition of $\varepsilon_i \sim (0, \sigma^2)$.

(2) theoretical hypothesis

We will build the Tobit model to analyze the influencing factors of input-output efficiency. The selection of the influencing factors follows two principles: one is that the variables adopted are commonly used in literature, the other is that the variables adopted should not contain the input-output variables of DEA model. In the subjects investigated——enterprise ecological technology innovation based on low carbon strategy, low carbon strategy belongs to strategic level and ecological technology innovation belongs to the level of implementation. According to the three kinds of efficiency in the three models, which including efficiency of low carbon strategy, efficiency of ecological technology innovation and enterprise ecological technology innovation based on low carbon strategy, and with the previous research results, we use three levels of factors of consciousness, strength and the implementation to verify their effect on three kinds of efficiency. There are three indexes on the level of consciousness, environmental conscientious of staff, the public's preference for low carbon and green products and customers acceptance of low carbon and green products are included. On the strength level, there are enterprise annual GDP, transformation ability of ecological technology and construction level of environmental protection infrastructure. Last, on the level of implementation, indexes of proportion that the annual procurement of biodegradable materials in the total volume of purchases, compliance rate of pollutant emissions and recycling rate of industrial waste are included. We assume that the three models of these nine indicators are positively related to the input-output efficiency.

(3) The empirical results and analysis

Validate the hypotheses above by using the software Eviews, and make a regression analysis on the significance of input-output efficiency of enterprise ecological technology innovation based on low carbon strategy, input-output efficiency of low carbon strategy and input-output efficiency of ecological technology innovation according to the nine indexes, results are in Table 3, Table 4 and Table 5, the significant factors are listed on the 5% level significance.

Table 3 Tobit regression analysis on influencing factors of input-output efficiency of enterprise ecological technology innovation based on low carbon strategy

		Coefficient	Std. Error	z-Statistic	Prob.
constant		0.873320	0.047473	18.39608	0.0000
consciousness	environmental conscientious of staff	0.008312	0.011804	1.704159	0.0481
	customers acceptance of low carbon and green products	0.006067	0.008677	1.699220	0.0484
strength	transformation ability of ecological technology	0.015285	0.011197	1.365090	0.0172
	construction level of environmental protection infrastructure	0.010599	0.011311	1.937028	0.0348
implementation	compliance rate of pollutant emissions	0.000143	0.000174	1.818987	0.0412
	recycling rate of industrial waste	0.000291	0.000257	1.129859	0.0258
Log likelihood		102.8407			

Results in Table 3 show that there are factors effecting the input-output ratio of enterprise ecological technology innovation based on low carbon strategy, among them environmental conscientious of staff and customers acceptance of low carbon and green products on the level of consciousness, transformation ability of ecological technology and construction level of environmental protection infrastructure on the level of strength and compliance rate of pollutant emissions and recycling rate of industrial waste on the level of implementation included, and the correlation is positive.

Table 4 Tobit regression analysis on influencing factors of input-output efficiency of low carbon strategy

		Coefficient	Std. Error	z-Statistic	Prob.
constant		0.634656	0.078200	8.115822	0.0000
consciousness	environmental conscientious of staff	0.005246	0.019443	1.269831	0.0078
	customers acceptance of low carbon and green products	0.013696	0.014293	1.958229	0.0337
strength	transformation ability of ecological technology	0.025627	0.018444	1.389443	0.0164
	construction level of environmental protection infrastructure	0.021107	0.018632	1.132847	0.0257
implementation	proportion that the annual procurement of biodegradable materials in the total volume of purchases	0.001393	0.000476	2.925110	0.0034
	compliance rate of pollutant emissions	0.000437	0.000287	1.522931	0.0127
	recycling rate of industrial waste	0.002483	0.000424	5.859188	0.0000
Log likelihood		65.90705			

Results in Table 4 show that on all the three levels, there are factors significantly influence the input-output ratio of low carbon strategy with the correlation of positive. On the level of consciousness, the factor include environmental conscientious of staff and customers acceptance of low carbon and green products; on the level of strength, transformation ability of ecological technology and construction level of environmental protection infrastructure included; and on the level of implementation, proportion that the annual procurement of biodegradable materials in the total volume of purchases, compliance rate of pollutant emissions and recycling rate of industrial waste do.

Table 5 Tobit regression analysis on influencing factors of input-output efficiency of enterprise ecological technology innovation

		Coefficient	Std. Error	z-Statistic	Prob.
constant		0.817799	0.093993	8.700654	0.0000
consciousness	customers acceptance of low carbon and green products	0.014232	0.017180	1.828426	0.0407
strength	transformation ability of ecological technology	0.039548	0.022169	1.783895	0.0074
	construction level of environmental protection infrastructure	0.023427	0.022395	1.046100	0.0295
implementation	proportion that the annual procurement of biodegradable materials in the total volume of purchases	0.000739	0.000572	1.292319	0.0196
	compliance rate of pollutant emissions	0.000422	0.000345	1.222817	0.0221
	recycling rate of industrial waste	0.001469	0.000509	2.884558	0.0004
Log likelihood		52.29469			

Table 5 reveals the factors on all the level of consciousness, strength and implementation that have significant effect on the input-output ratio of enterprise ecological technology innovation, and they are related positively. Factors including customers acceptance of low carbon and green products on the level of consciousness, transformation ability of ecological technology and construction level of environmental protection infrastructure on the level of strength, and proportion that the annual procurement of biodegradable materials in the total volume of purchases, compliance rate of pollutant emissions, recycling rate of industrial waste on the level of implementation.

3 Discussion

So far, there is lots of research on low carbon strategy and ecological technology innovation, while they are just studied separately. As for the research method Two-stage Chain DEA Model and Tobit Regression, they are used in quite a lot fields from social sciences to management science, from engineering course to liberal arts. However, when all of the factors of low carbon strategy, ecological technology innovation and DEA Model studied together, it's unprecedented.

In such databases as Elsevier, EBSCO, Google Scholar, China Journal Net, Wanfang Data Resource System and Veipu Chinese Periodical Database, with the keywords "low carbon", "ecological technology innovation," "efficiency", just a few papers relevant can be searched. However, the articles are either theoretical evaluation or literature review without empirical study, so this paper is not comparable with the previous since its innovation in both the object of study and results.

4 Conclusion

In this paper, two-stage chain model which is embedded in the first stage of low carbon strategy input-output efficiency and the second stage of enterprise ecological technology innovation input-output efficiency is used to the research on the input-output efficiency of enterprises ecological technology innovation on the basic of low carbon strategy. We get data from 96 high-tech enterprises and make an empirical analysis, and analyze the results from the perspective of system theory.

Analysis on the factors influencing each efficiency by Tobit regression model contributes to the direction of improving enterprise system efficiency. Results reveal that no matter on the level of consciousness, strength or implementation, there are factors affect all the three kinds of input-output efficiency which including enterprise ecological technology innovation based on low carbon strategy, low carbon strategy and enterprise ecological technology innovation, and their correlation are positive. Hence, to lead the transformation to ecological technology innovation under the guidance of low carbon strategy, an enterprise should need not only a certain strength, but also realized the importance of it, besides, the implementation is an effective guarantee for the transformation.

To carry out ecological technology innovation, the following suggestions are maybe efficacious. Firstly, increase the propaganda of the notion of low carbon and ecological technology innovation. Public service film of environmental protection is an advantageous try. Secondly, establish the legal mechanism of low carbon strategy. For one thing, make policy for low carbon energy and their utilization, encourage enterprises to the path of lower carbon; for another, establish carbon funds to support and encourage the development of low carbon technology. Lastly, build an industrial system of resource conserving and low carbonization.

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Appendix

Scale system of enterprise ecological technology innovation

factor	scale
Ecological environment	Proportion of low carbon and green products output in the enterprise’s GDP（A1）
	Enterprise’s annual profit rate（A2）
	recycling rate of industrial solid waste（A3）
	construction level of environmental protection infrastructure（A4）
	Green coverage rate（A5）
	Water environmental indicators（A6）
	Rate of solid waste treatment（A7）
	Rate of exhaust gas treatment（A8）
	Rate of wastewater treatment（A9）
	Proportion of environment friendly technology in high and new technology（A10）
	Green production input ratio（A11）
	Proportion of sales revenue of ecological products in the total sales revenue（A12）
Condition of ecological technology innovation	Enterprise annual GDP（A13）
	Innovation resources annual input（A14）
	Number of R & D personnel（A15）
	Ecological technology investment（A16）
	Benefits of innovation output（A17）
Level of ecological and social recognition of ecological products	transformation ability of ecological technology（A18）
	Stability of ecological industrial chain（A19）
	Advanced degree of ecological management of enterprises（A20）
	Incentive intensity of enterprise ecological technology innovation（A21）
	Degree of government's preferential tax（A22）
	Level of industry-university-research cooperation(A23）
	Public's preference for low carbon products and green products（A24）
	Customers acceptance of low carbon and green products（A25）
	Public satisfaction for enterprise ecological environment（A26）
Social benefits.	Enterprise social image

	（A27）
	Annual expansion rate of employment（A28）
	Visibility of enterprise's green product（A29）

Scale system of enterprise low carbon strategy

factor	scale
Resources input	Annual fund input in energy saving and emission（a1）
	Proportion of annual fund input in energy saving and emission in the total investment（a2）
	Proportion of annual fund input of new energy technology R&D in the total investment（a3）
	Number of staffs engaged in low carbon environmental protection（a4）
	Proportion of staffs engaged in low carbon environmental protection in the whole staffs（a5）
	environmental conscientious of staff（a6）
	Gross value of equipments in low carbon environmental protection（a7）
	Proportion of value of equipments in low carbon environmental protection in the gross value of equipments（a8）
Logistics	Monitoring and measurement system of carbon emission throughout the supply chain（a9）
	Low carbon environmental protection degree of transportation（a10）
	Low carbon environmental protection degree of storage（a11）
	Low carbon environmental protection degree of loading and unloading（a12）
	Low carbon environmental protection degree of packing（a13）
Production	Water consumption per unit（a14）
	Energy consumption per unit output value（a15）
	Raw material consumption per unit output value（a16）
	Waste water produced per unit of output（a17）
	Solid wastes produced per unit of output（a18）
Raw material and treatment after using	Proportion of annual procurement of renewable materials in the total volume of procurement（a19）
	Proportion that the annual procurement of biodegradable materials in the total volume of purchases（a20）
	Compliance rate of pollutant emissions（a21）
	Comprehensive utilization rate of industrial waste gas（a22）
	Comprehensive utilization rate of industrial waste water（a23）
	Comprehensive utilization rate of industrial solid waste（a24）
	Proportion of fund invested in environmental pollution control in the total fund needed（a25）
	Rate of packaging recycling（a26）
	Rate of product recovery（a27）