Research on Green Management Innovation and Environmental Regulation Efficiency

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INTRODUCTION

In recent years, the conflict between economic development and ecological environment caused by extensive economic growth mode of high-input and low-output in China is getting more outstanding, and problems like air, water, and soil pollution as well as vegetation deterioration have become the bottleneck for sustainable development of China. With the rapid development of high-speed economic growth, wasting of resources, environmental pollution and extensive economic development mode, all of the above have become social public issues currently and cannot be ignored [1-2]. Since the first three decades of reform and opening up in China’s economic development, “China’s economic miracle” has been created, because the economy and GDP growth rates have grown and maintained rapidly; however, at the same time the distortion of environment has reached an important threshold, and “Environmental dividend” gradually disappear [3], reaching the lowest level of the contribution rate in marginal efficiency. To protect resources and environment, the way of economic growth should be changed through turning the resource environment into “hard rationing” of economic development.

In recent years, China has introduced a series of environmental protection policies and measures, while the effect of regulatory policy is not satisfactory, and traditional theory does not recognize the environmental regulation, regarding its existence as the result of excessive government involvement [4], so it will lead to market resources mismatch in market failure, and will bring additional pollution and control costs, and production difficulty for enterprises [5-6]. As a “conservation of interests” approach [7], environmental regulation is reasonable, because the environment destruction caused by the manufacturing enterprises, will inevitably bring about losses of public social welfare [8]. Relying on some measures like mandatory restrictions and economic punishment can make constraints on the behaviors of polluters at the same time compensate social welfare losses [9-10].

ABSTRACT: Environmental regulation is the main tool for the government to deal with the market failure and externalities of pollution, aiming to promote the reform of green management and change the current relationship of factors and mode of production through formulating environmental regulation measures. The research on the green management innovation of enterprises under the environmental regulation needs to clarify its formation, implementation and practical impacts on the enterprise management. On the basis of reviewing the input-output efficiency of environmental regulation in China, the regulation of economy, industry, and environment efficiency in recent years, this paper attempts to study the relative efficiency of input-output multiple decision-making units by DEA, and has discovered that four major existing problems including over-investment, positioning bias of regulation contents, regulation of low response, and inefficiency regulation of input for scientific research. In addition, through the dissimilarity analysis of comprehensive technical efficiency of environmental regulation and the related index, it has also found that changes in industrial structure, scientific research and infrastructure construction input can really promote the comprehensive technical efficiency of environmental regulation. In view of the above problems, green management innovation of enterprises needs to actively cooperate with the green transformation of the government, participate in the government pollution control, and implement the green management innovation consciousness, to build a new system and strategic alliance of green management innovation.
“Study on environmental regulation efficiency” in essence is the analysis and evaluation of policy efficiency. There is a view that policy efficiency depends on the realization of policy objectives, the government’s regulator measures can actively regulate production organizations under the control of the government and serve for economic practice without costs, so the regulatory policy has obvious political effects in this view. At present, other people think that there are regulatory costs of environmental regulation, and obvious contradictions exist between the “ensuring growth” and “emission reduction” [11]. Some studies show that environmental regulation has instant effects on cleaner production industries, but has a hysteresis effect on pollution-intensive industries and the intensity of environmental regulation and efficiency are in line with inverted U-type relationships [12].

The efficiency evaluation of environmental regulation from the perspective of the government and society as a whole is mainly based on whether the environmental regulation achieves the government’s expected goals and the promotion of social welfare. The concern is the government’s environmental regulation policy is effective or not, regardless of the function of environmental regulation on corporate pollution control and green management practice. Evaluations from micro perspective mainly include the related factors of industries and enterprises as independent variables into the model, environmental regulation as the dependent variable, and the impacts on enterprise green management are not involved, and effects on environmental protection in enterprise of environmental regulation are not able to show. This study attempts to do research in input-output through using environmental regulation as input variable, green management innovation of enterprise as output variable, changing the enterprise green management innovation and enterprise response to the state of environmental regulation from constant to variable, thus confirming the function of environmental regulation to enterprise management events, and then put forward to some recommendations accordingly.

2. Research methods and models

In this study, DEA analysis will be used to analyze the green management innovation of enterprises under environmental regulation through studying the relative efficiency of the input-output multiple decision-making units, in order to get the effectiveness of “environmental regulation” on enterprise green management. The efficiency calculation can reflect the adaptive behavior of enterprises in the process of green management innovation.

2.1 Screening the index system of input and output

There are three main processes in the environmental regulation system, mainly including the regulation of input, implementation and the final output. Regulatory input mainly refers that the government govern production and sewage behavior through formulating laws and regulations, environmental protection ban, and strengthening environmental protection supervision. Regulation implementation refers to carry out environmental regulation, involving technical efficiency and allocation efficiency. The final output of enterprises means the pollution caused by the final production behavior after regulation implementation. This study will build the DMU input-output index system from these three perspectives. The index system and conceptual framework of environmental regulation efficiency evaluation are established, as shown in Table 1 and Figure 1 on this basis. According to the final data, it has found that many data are missing in index design, so that adjusting the index system by using interpolation method is needed.

<table>
<thead>
<tr>
<th>The First Grade Index</th>
<th>The Second Grade Index</th>
<th>The Third Grade Index</th>
<th>The Fourth Grade Index</th>
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</thead>
<tbody>
<tr>
<td>Efficiency Evaluation of Environmental Regulation on Green Management Innovation of Enterprises</td>
<td>Input on Environmental Regulation</td>
<td>Policy Input</td>
<td>Numbers of Environmental Protection Rules Promulgated by Departments in Those Years (X_{11}) (million)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Numbers of environmental monitoring instruments (X_{12}) (million per set)</td>
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<td></td>
<td></td>
<td></td>
<td>Numbers of Local Environmental Standards (X_{13}) (item)</td>
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<tr>
<td></td>
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<td>Environmental Investment On Items For</td>
</tr>
</tbody>
</table>
2.2 Preprocessing of input-output index

The data is from the EPS global statistical data/analysis platform of the Chinese Environment Database, Tata Data Search Platform, Founder
China Foreign Economic and Trade Database. As the number of index in the evaluation index system exceeds the number of the DMU, the data in the design index system are summarized and analyzed by principal component analysis. Some data are as follows: policy input (KMO=0.683, Bartlett Test=25.82), labor input (KMO=0.618, Bartlett Test=50.98), capital input (KMO = 0.55, Bartlett Test = 31.31), economic output (KMO = 0.68, Bartlett Test = 70.30).

Better results can be received by principal component analysis to extract the common factors (the total square deviation is 70.6%, 96.2%, 88.8%, and 76.28%, respectively), the expression is as follows, and the environmental regulation input and output data are summarized in Table 2.

A. Policy Input: \[ F_1 = 0.973 \times \text{numbers of local environmental standards} + 0.961 \times \text{numbers of environmental monitoring instruments} + 0.899 \times \text{environmental investment on items for acceptance protection project completed in those years} + 0.381 \times \text{numbers of environmental protection rules promulgated by departments in those years} \]

B. Labor Input: \[ F_2 = 0.994 \times \text{numbers of environmental inspectors} + 0.987 \times \text{numbers of environmental protection administrative staffs} + 0.962 \times \text{numbers of environmental supervisors} \]

C. Capital Input: \[ F_3 = 0.986 \times \text{environmental pollution control investment} + 0.954 \times \text{infrastructure construction investment} + 0.883 \times \text{scientific research project fund} \]

D. Economic output: \[ F_4 = 0.994 \times \text{urban sewage treatment rate} + 0.979 \times \text{urban garbage harmless treatment rate} + 0.951 \times \text{production value of “the three wastes” comprehensive utilization} + 0.86 \times \text{comprehensive utilization of hazardous waste} + 0.470 \times \text{comprehensive utilization rate of industrial solid waste} \]

### Table 2 Preprocessing Results for Policy Input Data from 2005 To 2014

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</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>1.35</td>
<td>1.74</td>
<td>1.24</td>
<td>1.37</td>
<td>1.30</td>
<td>3.36</td>
<td>4.29</td>
<td>4.72</td>
<td>5.76</td>
<td>7.02</td>
</tr>
<tr>
<td>F2</td>
<td>2.56</td>
<td>2.64</td>
<td>2.78</td>
<td>2.89</td>
<td>2.97</td>
<td>3.05</td>
<td>3.15</td>
<td>3.12</td>
<td>3.14</td>
<td>3.13</td>
</tr>
<tr>
<td>F3</td>
<td>1.09</td>
<td>1.15</td>
<td>1.34</td>
<td>1.65</td>
<td>2.26</td>
<td>2.98</td>
<td>3.22</td>
<td>3.87</td>
<td>4.94</td>
<td>5.65</td>
</tr>
<tr>
<td>F4</td>
<td>2.72</td>
<td>3.06</td>
<td>3.52</td>
<td>3.98</td>
<td>4.11</td>
<td>4.46</td>
<td>4.99</td>
<td>5.31</td>
<td>5.11</td>
<td>5.45</td>
</tr>
</tbody>
</table>

### Table 3 Efficiency Evaluation Results of Environmental Regulation Implementation Process from 2005 to 2014

<table>
<thead>
<tr>
<th>DMU</th>
<th>Efficiency of Regulation Economy</th>
<th>Efficiency Of Regulation Industry</th>
<th>Efficiency of Regulation Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.953</td>
<td>increasing</td>
<td>1.000</td>
</tr>
<tr>
<td>2006</td>
<td>1.000</td>
<td>unchanged</td>
<td>0.980</td>
</tr>
<tr>
<td>2007</td>
<td>1.000</td>
<td>unchanged</td>
<td>1.000</td>
</tr>
<tr>
<td>2008</td>
<td>0.996</td>
<td>decreasing</td>
<td>0.945</td>
</tr>
<tr>
<td>2009</td>
<td>1.000</td>
<td>unchanged</td>
<td>0.983</td>
</tr>
<tr>
<td>2010</td>
<td>1.000</td>
<td>unchanged</td>
<td>0.893</td>
</tr>
<tr>
<td>2011</td>
<td>1.000</td>
<td>unchanged</td>
<td>0.865</td>
</tr>
<tr>
<td>2012</td>
<td>0.983</td>
<td>increasing</td>
<td>0.899</td>
</tr>
<tr>
<td>2013</td>
<td>0.922</td>
<td>increasing</td>
<td>0.919</td>
</tr>
<tr>
<td>2014</td>
<td>1.000</td>
<td>unchanged</td>
<td>80.948</td>
</tr>
</tbody>
</table>

average 0.9854 - 0.9812 - 0.9812 -
The empirical results show:

(1) The Overall Efficiency Increases Steadily
On the whole, environmental regulation has shown an upward trend in the “comprehensive technical efficiency” for green management output of enterprises. From 2005 to 2010, environmental regulation input data in China shows “scale decreasing” on the enterprise green management output of the comprehensive technical efficiency, and the scale efficiency is often lower than the pure technical efficiency. From 2011, it turns to “scale increasing”, and maintains unchangeably in 2014. However, in the three efficiency evaluation of the implementation process, economic efficiency of regulation economy basically maintains a steady increase, while efficiency of environment economy shows an unstable trend, and efficiency of industry regulation indicates downswing.

(2) The Source of Comprehensive Technical Efficiency
From the specific point of view, the rising of “comprehensive technical efficiency” due to the promotion of “scale efficiency”, indicate that the gap between actual scale and optimal scale of production in the green management of China’s enterprises is narrow, the enterprise production efficiency has generally promoted. However, only the efficiency of regulation economy among the three types maintains an upward trend, which reflects that environment regulation has been gradually emerging from the contradictions with economic development since 2009, and the relationship between production and environmental governance has been gradually harmonized. Enterprises do not limit their production in the case of increasing inputs on environment regulation while have gained compensation of “scale efficiency” during this period. In other words, the source of comprehensive technical efficiency is still the final product of enterprises through making up for the cost of environment regulation with the economic output.

(3) Efficiency Adjustment Process
From the particular term point of view, China’s “purely technical efficiency” is effective (=1) in 2007, 2009 and 2010 respectively, but “scale efficiency” is invalid (<1), which leads to ineffectiveness of “comprehensive technical efficiency”, and the slack variable is all zero. Therefore, DMU itself does not need to “reduce the input and increase the input” the need, so the main reason is that the scale does not match input and output, resulting in ineffectiveness of “comprehensive technical efficiency”. The three years can be seen as enterprises make relevant adjustments in the green management process to environment regulation, thus producing stable increasing and unchangeable results. However, the regulation does not realize energy conservation and emission reduction, the industrial structure changes are not obvious, and not achieve very good results in the production mode, pollution output and industrial restructuring.

3.2 Evaluation on efficiency factors
This study will analyze the comprehensive technical efficiency of the environmental regulation and the relevant indexes by using the Euclidean distance measure between the variables. The indexes include infrastructure input, the proportion of gross domestic product (GDP) in tertiary industry, constant price of GDP, the proportion of foreign investment, the total amount of imports and exports, funds of scientific research, population density. The results of their combined Proximity distance technical efficiency are 0.185, 1.328, 2.696, 1.147, 0.581, 0.721, and 0.191, respectively. It is found that the comprehensive technical efficiency of environmental regulation is strongly correlated with all the indexes, and the correlation coefficient and
significance are high. The most similarity one of comprehensive technical efficiency is the proportion of the tertiary industry, followed by the population, the use of foreign capital, rather than funds of scientific research which has the largest similarity, followed by infrastructure investment, constant price of GDP. It also reflects the following problems that changes in the industrial structure can really promote the comprehensive technical efficiency of environmental regulation. However, analysis of the previous two sections has found that the efficiency of industrial regulation in recent years has been decreasing year by year. The development of technical efficiency has little potential, and inputs on scientific research and infrastructure construction have played an indirect role with unapparent effects. Economic output efficiency of environmental regulation has small influences on environmental regulation, because it is only through the final product to make up for regulatory costs.

4. Results discussion

Four kinds of DEA models, similarity analysis and dissimilarity analysis results all reflect several problems in the process of environmental regulation including excessive input in regulation, positioning bias of regulation contents, low response of regulation, and low efficiencies of input in regulation scientific research.

(1) Excessive Input in Regulation

Environmental regulation as a government tool, mainly aims to standardize the production of enterprises to solve the problem of polluted market failure and externalities. Similarly, environmental regulation also boosts externalities, excessive regulatory input will increase the cost of regulatory implementation, be responsible for weakening the autonomy of the market players and the total social capital out of the crowding-out effect, thus interfering with the operation of the market and normal production of enterprises. Therefore, in the progress of environmental regulation, the following questions should be understood: whether some actions should be made to regulate, how to pursue regulatory strength and mode of choice, whether the regulation needs to be readjusted and the regulator itself needs to be regulated.

(2) Positioning Bias of Regulation Contents

This phenomenon can explain the ineffectiveness or inefficiency in terms of environmental regulation. The reasons include: first, environmental regulation blurs the boundaries between itself and the law of the market, which limits the normal production behavior instead of providing energy-saving emission reduction solutions and corresponding policies for enterprises, infrastructure support system in the case. Many enterprises, in order to balance the increases in the cost of environmental protection caused by the problem, exploit the underground pipe and infiltration pit for illegal sewage and fail to get access to the sewage permission while conducting private sewage, excessive sewage. Besides, they exercise unauthorized disposal of hazardous waste and other acts to carry out sewage and increase production to remedy the cost of environmental penalties. Second, environmental regulation is the embodiment of government self-expansion. In the absence of control or changing the law of the market circumstances, the government will tend to expand its own functions to control and manage enterprises’ behaviors. The limitations of regulation itself, which needs to set up its own “self-regulation” system, emphasize the organization, procedures, information, negotiation, authorization of various forms of legal policy to prevent the positioning of regulatory content bias. To improve the problem, the government should take first actions to expand the cognition of the main parts of the market and the scope of the regulation; they should clearly keep in mind the regulation theme, namely, not only including the government itself, as well as enterprises, social organizations and civil intermediary institutions, etc. These measures should reduce the excessive intervention, and make full use of market rules and the main supervision of each other to maintain the normal operation of market. Furthermore, the government needs to judge and define the public scope of environmental pollution problems, rationally define the areas where environmental regulation plays a role, rather than just correcting market failures in line with targeted goals. Otherwise, it will be difficult to find a balance between the market and the government.

(3) Low Response in Regulation Content

The term mainly refers that in the case of reasonable content and sound implementation of the environmental regulation, the results of the regulation operation does not conform to the value judgment of the market main body and are driven to adapt to the content of the regulation, as well as cannot really change the production behavior of the enterprises. The low response in regulation content push the environmental regulation has less positive effects on industrial structure improvement and energy saving and emission reduction, resulting in the fact that above-mentioned environmental regulation industry output and environmental output comprehensive technical efficiency is invalid.

To improve the low responses of regulatory content, first of all, in the formulation and
implementation of environmental regulation, the government needs to establish communication - feedback channels to ensure that the channels are smooth and timely be communicated with regulatory object, thus ensuring that the regulatory objects have complete recognition to the policy itself. Moreover, the enactment of environmental regulation should avoid changeable policies or excessive investment, otherwise the supporting steps and balances will be difficult to maintain between old and new regulation on the one hand, and various kinds of regulations on the other hand, thus worsening the conflicts and contradictions between regulations. Third, some efforts should be made to encourage enterprises, industry organizations, civil society organizations and professional policy advisory structure to participate in the development of environmental regulation process, to ensure the participation of all citizens and the objectivity of regulation. China has established policy laboratories from the central to the county, but these groups receive less recognition and less popularity. Besides, their publicity and consultation are weakening. In the formulation process of environmental regulation, it is necessary to attract civil policy research organizations (like universities, research institutions, private think tanks, etc.) to cooperate closely with official policy research institutions to avoid policy bias and improve the recognition of environmental regulation caused by regulatory objects.

(4) Low Efficiencies of Input in Regulation Scientific Research

In this study, the energy-saving technology research funds supported by government will be acted as a cost of scientific research. At present, many scholars have found the U-type relationship of Kuznets curve between environmental regulation and independent innovation. Tu Hongxing found that economic development has a threshold effect in the role of environmental regulation and independent innovation in the process. In the case of low economic development, input on scientific research and development innovation cannot produce a promoting role [13]. In the implement process of environmental regulation, the government employs strict control in pollutant discharge quantity and discharge standard. While being restricted by environmental regulation, enterprises usually draw on two ways including attaining sewage standards by increasing the funds of pollution management as well as improving production technology to raise the pollution control capacity. However, these two ways will have a crowding-out effect to the enterprise innovation funds. Enterprises will face a situation, in the case of limited funds, where the pollution controlling and energy-saving emission reduction are hard to choose. Faced with the uncontrollability and uncertainty in research and development processing and their results, more companies will reduce the investment funds to select the immediate pollution control. This is to say, the funds for energy-saving emission reduction research supported by government, will be difficult to make differences, and even become a gray channel for enterprises to obtain pollution compensation.

5. Conclusion and enlightenment

In view of the current “environmental regulation efficiency” which is lack of uniform standards, it is found that four major problems exist on the implementation process of environmental regulation through the DEA method to study the comprehensive technical efficiency and the implementation process efficiency, including excessive input in regulation, positioning bias of regulation contents, low response of regulation, and low efficiencies of input in regulation scientific research. Analysis of DEA models, similarity and dissimilarity all have made explained the above issues, so the author proposes several recommendations on green management innovation of enterprises based on the results.

On the whole, environmental regulation has shown an upward trend in the “comprehensive technical efficiency” of enterprises green management output. However, in the three efficiency evaluation of the implementation process, the environmental regulation of the regulatory economic efficiency basically maintained a steady rise, while the regulation environment efficiency shows an unstable trend and efficiency of industry regulation shows a downward trend. First, it reflects enterprises do not limit their production in the case of increasing inputs on environment regulation while have gained compensation of “scale efficiency” during this period, and the source of comprehensive technical efficiency is still the final product of enterprises through making up for the cost of environment regulation with the economic output. Second, the regulation content does not achieve good energy conservation and emission reduction results, and the industrial structure changes are not obvious. Enterprise adaptability, mainly reflected on the coordinate of production, also does not attain good achievements on production mode, pollution output and industrial restructuring. From the similarity and dissimilarity, the factor that can promote the comprehensive technical efficiency of environmental regulation is the change of industrial structure. However, results
of redundancy analysis reflect that environmental rules do not significantly change the industrial structure, so that enterprises are difficult to change their business direction on management, and have done little to industrial restructuring. This is one of the main reasons for the inefficiency of environmental regulation.

Therefore, it is necessary to encourage enterprises to carry out green management innovation to promote the enterprise to adapt to the adjustments. Management innovation is divided into two parts, the first one is to implement green management innovation coordinated with the government reform, and the second one is to improve and enhance their own green management innovation level. The specific practices are as follows: actively cooperate with the green transformation of the government through affording their own green management responsibility; participate in government pollution control and the construction of environmental protection think tank to help the government and professionals understand the actual production process of energy-saving emission reduction technology and the actual production status; implement green management innovation awareness among enterprises through actively participating in environmental regulation of voluntary agreements and research and development organizations; build enterprise green management innovation system; establish strategic alliance of the green management innovation with the government and related enterprises.

6. Acknowledgement

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7. REFERENCES