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The effects of three types of environmental regulation on eco-efficiency: A cross-region analysis in China

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ABSTRACT

The improvement of regional eco-efficiency is a significant approach to achieve coordinated development of China's economic development and environmental protection, and an effective environmental regulation system is a crucial driver to the improvement of regional eco-efficiency. Based on the panel data of China's 30 provinces during 2000–2013, this paper divides environmental regulation into three types: command-and-control regulation, market-based regulation and voluntary regulation. STIRPAT model is employed to test the effects of these three environmental regulations on eco-efficiency in the eastern, central and western regions of China. Research results turn out that: (1) in the eastern region, market-based and voluntary environmental regulation have a positive impact on eco-efficiency improvement while command-and-control environmental regulation has no significant impact, and (2) in the central region, command-and-control and market-based environmental regulation can promote eco-efficiency more significantly compared with voluntary environmental regulation, and (3) in the western region, command-and-control environmental regulation plays a positive role in eco-efficiency improvement whilst market-based and voluntary environmental regulation have no significant impacts. These findings indicate that the effects of different types of environmental regulation on eco-efficiency apparently differ in regions. Finally, to optimize and adjust the environmental regulation tools, policy recommendations targeting different regions are concluded.

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1. Introduction

Since the reform and opening up, China has achieved rapid economic development. However, China's economic growth is at the expense of excessive consumption of resources and environmental pollution. In 2014, China's gross domestic product (GDP) has reached 63.4 trillion Yuan and accounted for 13.4% of the whole world while 21.5% energy sources and 44.4% steel of the whole world were consumed in China. In 2013, the total amount of waste water discharge was 69.54 billion tons, and the amount of industrial SO₂ emission was 20.439 million tons. In 2014, there were only 16 cities whose urban air was qualified according to the Ambient Air Quality Standards of China (GB3095-2012), accounting for 9.9%

in the 161 monitoring cities. These circumstances evidence that China is undergoing the objective historical process where the consumption of resources and energy and the emissions of pollutant are intensifying. And in order to transform the pattern of economic development and thus to promote the sustainable development of economy and society, China has to resort to resources conservation and environmental protection. Eco-efficiency expresses the efficiency with which ecological resources are used to meet human needs (OECD, 1998). Eco-efficiency is improved by reducing the environmental impact added or resources consumption while maintaining or increasing the value of the output produced (Mickwitz et al., 2006). As a result, improving regional eco-efficiency is important for realizing sustainable development. Nevertheless, prior studies are mainly concerned about how to evaluate regional eco-efficiency (Zhang et al., 2008; Li and Hu, 2012) while a paucity of literature investigates the institutional factors influencing regional eco-efficiency.

Confronted with the problems of excessive consumption of resources and environmental damages incurred by economic

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development, Chinese government has enacted a series of environmental protection laws such as *Law on the Prevention and Control of Environmental Pollution by Solid Waste (2004)*, *Law on Energy Conservation (2007)*, *Circular Economy Promotion Law (2008)*, *Atmospheric Pollution Prevention and Control Law (2015 Revision)* etc. since 2000. Additionally, Ministry of Industry and Information Technology released entry conditions for industries like cement, printing and dyeing, casting, etc. Above environmental protection policies specify the technology standards of production and discharge standards of pollutant. To overcome environmental externalities by taking advantage of such instruments as fines, taxes, subsidies, emissions trading, etc., Chinese Ministry of Environmental Protection issued market-based policies like *Administrative Regulations on Levy and Use of Pollutant Discharge Fee (2003)*, *Measures for Environmental Administrative Punishment (2010)*, *Notice on the adjustment of the subsidies for energy-efficient vehicles (2011)*, *Guiding opinions on further promoting compensable use and pilot tests of emissions trading (2014)*, etc. Besides, this ministry has also released voluntary policies to encourage the enterprises and public to participate in environmental protection, such as *Measures on Open Environmental Information (Trial) (2007)*, *Administrative Measures for the use of China Environmental Labeling (2008)*, *Measures for the Public Participation in Environmental Protection (2015)*, etc. Overall, China environmental protection system integrating command-and-control, market-based and voluntary environmental regulation has basically formed. Nevertheless, have a substantial number of environmental regulation tools accelerated the coordinated development of both regional economy and regional environment? Do the differences in the effects of diverse regulation tools on eco-efficiency across region exist? Until now, few scholars have conducted in-depth studies on above questions, whereas such studies are of great and practical significance not only to scientifically evaluating the effects of current environmental regulation policies but to guiding different regions to adjust and optimize environmental regulation tools.

This paper has made following contributions to knowledge. Firstly, the effect mechanisms of diversified environmental regulation tools are different. Under this circumstance, environmental regulation is classified into three types: command-and-control regulation, market-based regulation and voluntary regulation. Moreover, this paper has made elaborate analysis on the effects of these three types of environmental regulation on eco-efficiency. And it is beneficial to precisely assess which kind of environmental regulation can jack up regional eco-efficiency in China more effectively. Secondly, environmental problems are characterized as regional and cross-regional due to the imbalance of China regional economic development. And with respect to the level of constructed environmental regulation, disparities between different regions distinctly exist. As a result, this paper divides China into three regions: the eastern, central and western regions and thereby discusses the regional difference of the influence of environmental regulation on eco-efficiency. It is favorable for putting forward the optimal combination of environmental regulation tools targeting different regional eco-efficiency. Thirdly, the lagged one-phase of environmental regulation is introduced to examine the dynamic effect of environmental regulation on regional eco-efficiency since it is time-lagged for environmental regulation policies to take effect, which is conducive for China regional government to revise environmental regulation policies according to the regulation period of different environmental regulation tools.

This paper is organized as follows. Section 2 presents literature review. Section 3 includes empirical models and calculation methods of major variables. Section 4 displays data sources and descriptive statistical analysis. Section 5 is composed of empirical results and discussions. Section 6 consists of research conclusions

and policy recommendations.

2. Literature review

2.1. Eco-efficiency

Eco-efficiency can be considered as a ratio of an output divided by an input: the “output” being the value of products and services produced by a firm, a sector, or the economy as a whole, and the “input” being the sum of environmental pressures generated by the firm, sector, or economy (OECD, 1998). To date, studies mainly focus on the evaluation of eco-efficiency of enterprises, industries and regions (Fernández-Viñe et al., 2013; Vogtlander et al., 2002; Song et al., 2012; Seppää et al., 2005; Chen and Jia, 2016; Passetti and Tenucci, 2016; Pekka and Mikulas, 2004; Morioka et al., 2005) and especially, Song et al. (2016) suggested that environmental performance might be evaluated via big data. The research on the factors influencing eco-efficiency, at present, mainly focuses on the industrial structure, science and technology investment, urbanization and FDI and so on (Zhang et al., 2013). Environmental regulation is an important instrument for the government to promote technical innovation, as well as improve both the economic performance and environmental performance of enterprises (Porter, 1991; Frondel et al., 2007; Wang et al., 2015). The studies on the impact of environmental regulation on eco-efficiency are scanty. Moreover, the effect mechanisms of different environmental regulation tools are not identical (Stavins, 1996), and distinct deviations exist when only a single indicator is used to measure environmental regulation. Furthermore, the sound degree of environmental regulation and the level of eco-efficiency vary in the eastern, central, and western regions of China. Hence, it is necessary to investigate the effect mechanisms of various environmental regulation tools on eco-efficiency in the different regions of China so that the effect of Chinese environmental regulation policies could be assessed more precisely. As a result, this study has significant implications for the future development of China's environmental protection system.

2.2. Environmental regulation tools

Cleff and Rennings (1999) defined environmental regulation as the pull-push effect of government policies. Jaffe et al. (2005) considered that environmental regulation is a kind of necessary response to environmental influence. Frondel et al. (2007) pointed out that environmental regulation is a tool of government environmental policies and also is an important driving force for ecological innovation. Wang et al. (2015) regarded environmental regulation as a sort of traditional tool for solving environmental problems. On the one hand, environmental regulation ought to be effective to improve environmental quality. On the other hand, it have to be efficient, minimizing the enforcing cost of the regulator (Ribeiro and Kruglianskas, 2015). When the regulated can perceive that the increment in production cost of environmental protection can be overcompensated by net income, the environmental regulation tool is effective and efficient (Korhonen et al., 2015). By contrast, if the goals of different types of environmental regulation are conflicting, environmental regulation may play a negative role in both the competitiveness of the regulated and the environment (Peuckert, 2014).

Based on a considerable literature and the development of Chinese environment regulation (Gunningham et al., 1998; Huang et al., 2014), we conceive that environmental regulation can be classified into three types: command-and-control regulation, voluntary regulation, and market-based regulation. The conventional command-and-control approach to environmental

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