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The emissions reduction effect and technical progress effect of environmental regulation policy tools

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ABSTRACT

How to set out the provisions that ensure emissions reduction and technical progress in environmental regulation is very important for both China's future emissions reduction and sustainable development. The paper uses statistical data from 30 Chinese provinces from 1997 to 2014 and empirically tests the effects of different types of environmental policies and regulations on emissions reduction and technical progress by using dynamic spatial panel models. The results of spatial autocorrelation tests show that there are both significant positive global autocorrelation and local spatial agglomeration effects relating to pollutant emissions and technical progress. Dynamic spatial panel models indicate that command and control regulations (CCR) are conducive to emissions reduction, but their effects on technical progress are not significant. Market based regulations (MBR) are conducive to technical progress, but their effects on the reduction of emissions are relatively weak. There is a significant inverted-U relationship between economic development level and carbon emissions, validating the EKC hypothesis in China, but the effects of foreign direct investment on carbon reduction and technical progress are not significant. The paper recommends that China should optimize a combination of environmental regulations so as to achieve the win-win outcome of both emissions reduction and technical progress.

1. Introduction

As China continues along its path of industrialization and urbanization, industrial pollution in China is becoming more and more serious and, as a result, damage to the environment is becoming very significant. In order to control the use of fossil energy and the ensuing greenhouse gas emissions that accompany economic growth, China has strengthened the penalties provided for in its environmental regulations since the "11th five-year plan" and has gradually been working out a 2030 long-term energy conservation and emissions reduction policy. And yet, China's industrial and urbanization goal has still not yet been achieved. A large number of rural poor remain and social welfare is still at a low level. This means that China must also consider social problems during this period of economic growth, and, at the same time, strengthen environmental regulations. China urgently needs to work out a win-win roadmap leading to economic growth, energy conservation and emissions reduction. Environmental regulation theories mandate that an essential part of environmental regulation must concern energy conservation and emissions reduction, with both resource reallocation and innovation compensation further promoting technical progress in the future (Harrison et al., 2015). It therefore follows that how to set out energy conservation, emissions reduction and technical progress provisions in environmental regulations is very important for both China's future energy conservation and emissions reduction and its future sustainable development.

In the evolution of China's environmental regulations, China has gradually combined the use of traditional command and control regulations with market based ones. Because there are significant differences between different types of environmental regulation tools, so these different types of tools have different effects on emissions reduction and technical progress (Ribeiro and Kruglianskas, 2015). In order to identify the environmental regulation policy tools, the existing literature has almost analyzed environmental regulation effects from the perspective of technical progress, but their conclusions are significantly different. Some studies have found that, compared to command and control policy tools, market based policy tools have stronger technical progress effects (Harrison et al., 2015), but some studies have obtained the

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opposite conclusion (Zhao et al., 2015b). However, these studies have only considered the technical progress effect, but have ignored the essential part of environmental regulation, that is, emissions reduction effect (Zhang and Wang, 2014). This may not, however, scientifically and rationally identify different types of environmental regulation policy tools. With this in mind, in this paper, we analyze the environmental regulation effects not only from the perspective of technical progress, but also from the perspective of emissions reduction, so as to provide recommendations for the effective implementation of China's environmental regulations. As China is currently faced with two serious and concomitant problems, a worsening economy and a serious pollution crisis, this study is significant from both a theoretical and practical point of view. The paper is organized as follows: the second part is the literature review, the third part is the model and indicator description, the fourth part reports the results and discussion, and the last part is the conclusion with implications for China.

2. Literature review

The effects of environmental regulation on technological innovation and economic performance have been widely studied in recent years. The traditional view has argued that environmental regulation increases the cost burden of enterprises, imposes new constraints on production performance, and makes the production, management and sale of enterprises more difficult, none of which is conducive to industrial development and improvement of economic performance. Porter (1991) questioned the traditional view and argued that, in order to decrease the compliance costs, the regulated enterprises must transform, upgrade and update their equipment and technologies, so as to increase their energy efficiency, labor productivity and added value. On the other hand though, environmental regulations can help stimulate enterprises to further optimize their allocation of resources under constraint conditions, improve management efficiency and reduce inefficient behavior in the production process. It follows that environmental regulations can not only improve environmental quality, but can also promote industrial development and economic growth. This view is called the Porter hypothesis.

Many scholars have carried out in-depth studies on the Porter hypothesis, mainly analyzing and discussing two aspects of the hypothesis: the weak Porter hypothesis and the strong Porter hypothesis. The weak Porter hypothesis looks at the effects of environmental regulation on technological innovation, and the strong Porter hypothesis discusses the effects of environmental regulation on productivity and technical progress (Rubashkina et al., 2015). With respect to the weak Porter hypothesis tests, many scholars have reached similar conclusions: environmental regulation can stimulate enterprises to pursue technological innovation including U.S. (Lee et al., 2011), UK (Kneller and Manderson, 2012), Australian (Ford et al., 2014) and China (Zhao and Sun, 2016). These conclusions have been criticized, however, as, by using only technological innovation, they were thought too narrow to measure the technical effects of environmental regulations; technological innovation does not fully reflect either the technical progress effects or the efficiency improvement effects brought by environmental regulation (Agostino, 2015).

In view of this, many scholars have tested the strong Porter hypothesis, although, their conclusions differ. They can be summed up by the following four points of view. The first view argues that environmental regulations impose many constraints on the production behavior of enterprises and these regulations inevitably increase the cost burden of enterprises, making production, management and sale more difficult. This is not conducive to productivity growth and technical progress (Lanoie et al., 2011). The second view argues that environmental regulation forces enterprises to further optimize their resource allocation, and improve energy efficiency and productivity through the transformation, update and upgrade of equipment and technology, thereby promoting productivity growth and technical progress including EU (Jaraite and Maria, 2012), U.S. (Rassier and Earnhart, 2015) and China (Wang et al., 2016). The third view argues that the effects of environmental regulation on productivity and technical progress are restricted by many factors, such as, *inter alia*, institutional basis, market efficiency, economic development levels, human capital accumulation, and research and development (R&D) investment. Moreover, the effects are closely related to the quality and form of environmental regulations, industrial technological levels and degrees of pollution. Consequently, the effects of environmental regulation on productivity growth and technical progress are not significant including U.S. (Becker, 2011), Romania (Arouri et al., 2012), Germany (Rexhauser and Rammer, 2014), EU (Rubashkina et al., 2015) and China (Zhao and Sun, 2016). The fourth view argues that when the environmental regulation intensity is weak, enterprises often pay pollution costs to deal with environmental regulation. With the constant hardening of environmental regulations, however, enterprises must transform, upgrade and update their equipment and technology. This then increases both energy efficiency and labor productivity in order to compensate for environmental compliance costs. There is, therefore, a threshold in the effect of environmental regulation on productivity growth and technical progress including Mexico (Sanchez-Vargas et al., 2013) and China (Wang and Shen, 2016).

The above literature depicts environmental regulation as a single policy, not a combination of various regulations and laws. Actually, because there are significant differences between different types of environmental regulation tools as to regulation efficiency, regulation cost, enterprise preference, regulator preference, supervision and punishment, application scope, etc., the effects of environmental regulation on emissions reduction and technical progress exhibit significant policy heterogeneity (Ribeiro and Kruglianskas, 2015). Many scholars have thus tested the Porter hypothesis from the perspective of policy heterogeneity. Theoretically, compared to traditional command and control policy tools, market based policy tools have obvious advantages in both cost effectiveness and invention and dissemination of energy saving technologies (Alesina and Passarelli, 2014). However, because the effective implementation of market based policy tools is not only based on good institutional quality, but also, to some extent, on restraints such as market effectiveness, pollutant characteristics, spatial factors, and monitoring ability, so command and control policy tools are usually irreplaceable (Montero, 2002). Some studies have compared and analyzed the two types of policy tools from an empirical perspective, but there are big differences in the research conclusions. Some studies have found that, compared to command and control policy tools, market based policy tools have stronger technical progress effects including China (Zhao et al., 2015a) and India (Harrison et al., 2015). Other studies have found that, compared to market based policy tools, command and control policy tools have had stronger technical progress effects including EU (Testa et al., 2011) and China (Zhao et al., 2015b).

After perusing the above literature, we have found that the existing literature has made great advances on the effects that environmental regulations have on technological innovation and economic performance. There are, however, two areas needing further study. On the one hand, the existing literature has always analyzed the environmental regulation effects from the perspective of technical progress, but has ignored the essential part of environmental regulation, that is, energy conservation and emissions