Journal of Cleaner Production xxx (2016) 1–12

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Effects of local and civil environmental regulation on green total factor productivity in China: A spatial Durbin econometric analysis

Bin Li[*], Shusheng Wu

School of Economics and Trade, Hunan University, Fenglin Road, 410079, Changsha, Hunan Province, China

A R T I C L E I N F O

Article history:
Received 19 April 2016
Received in revised form
10 October 2016
Accepted 10 October 2016
Available online xxx

Keywords:
Environmental regulation
Green productivity
Spatial spillover effect
Spatial Durbin model

A B S T R A C T

This paper employs metafrontier malmquist luenberger index and a spatial Durbin model to investigate the influence of both local and civil environmental regulation and its spatial spillover effect on green total factor productivity in 273 cities of China in 2003–2013. According to city political attribute and regional differences, this article divides the sample city into six categories. The results show that effect of local environmental regulation on green total factor productivity is significantly positive in high political attribute cities (A1 and A2 zone), but negative effects in lower political attribute cities (B2 and B3 zone). Moreover, the 'race to the top' results in significantly positive spatial spillover effects from local environmental regulation on green total factor productivity in high political attribute cities (A1 and A2 zone), while the 'race to the bottom' causes significantly negative spatial spillover effects in lower political attribute cities (B2 and B3 zone). As for civil environmental regulation, it has positive direct and indirect effects in promoting green total factor productivity. We further find that environmental regulation inhibits the original technological innovation of enterprises, which suggests that government should reduce market intervention, improve enterprise flexibility of market change, and promote enterprises to carry out the original technological innovation. Thus, the government and citizen should make targeted pollution-reduction policies for the green total factor productivity increase.

1. Introduction

Since the 1960s, along with the advancement of industrialization and the growing use of fossil fuel, environment problems have emerged as major social problems in developed and developing countries. Taking China as an example, since the economic reform and opening-up, tremendous achievements have been made in China's economy. China developed to be the world's second-largest economy in 2010, and has remained in the position since. However, it is at the cost of huge energy consumption and environment pollution. Based on statistical results of China's National Bureau of Statistical, China's total energy consumption reached to 4.26 billion tons of standard coal in 2014, which accounted for 21.5% of the world total energy consumption. However, China's economy just accounted for 13.4% of the world economy in 2014. At the same time, China also generated 19.74 million tons of SO_2 and 20.78 million tons of NO_X.

In order to move forward with sustainable development, the government has placed environmental regulations on enterprise to reduce pollutant emissions, both in the form of command-control policy and market-related policy (Zhao et al., 2015; Dong et al., 2015). However, the Chinese government faces a dilemma in environmental regulation. As a kind of public resource, a good environment is very important to people's health and survival, though it will inevitably slow economic growth and increase unemployment rates by displacing 'productive investment'. Therefore, the core question of environmental regulation is whether or not it can improve the total factor productivity of enterprise. Some scholars have thought the displacement would be compensated, because ascension of the total factor productivity by technical progress in the long term would increase the profitability of enterprise, which can offset the enterprise loss (Porter and van der Linde, 1995; Ambec et al., 2013; Zhao et al., 2015). The above conclusion is based on a closed economy, in which there is no competition effect or demonstration effect between economies. This theory is, however, flawed in the real economy, especially in China. On one hand, local government officials' political promotion mainly depends on economic performance, which will induce local government to boost or reduce standards or enforcement of

* Corresponding author.
E-mail addresses: libin43@sohu.com (B. Li), wushushengjy@163.com (S. Wu).

http://dx.doi.org/10.1016/j.jclepro.2016.10.042

environmental regulation (Shen, 2012; Li et al., 2013). It creates significant demonstration effect and competition effect to induce adjacent local government change strategy in protecting the environment (Zhao and Sun, 2016). On the other hand, different political statuses and political treatments exist between cities. The high-political-status city possesses more rights of resource allocation, which leads to significant political heterogeneity. This poses a question for scholars: how does one resolve the dilemma of environmental regulation, given this political heterogeneity between cities?

In this paper we endeavor to provide a greater understanding of linkages between environmental regulation and green total factor productivity by studying the following several issues. Considering the political heterogeneity of city and production technology by differentiating cities in accordance with the political status, will there be a difference in the result of regional green total factor productivity? Will local and civil environmental regulations have spatial spillover effect on green total factor productivity in other city? If the spatial spillover effect exists, we will explore reasons for this effect change: efficiency change, best-practice gap change, or technology gap change? The remainder of this paper is organized as follows: Section 2 presents a literature review. Section 3 presents methodology, Section 4 presents the data and Section 5 presents the empirical analysis. Section 6 concludes this study and presents policy recommendation.

2. Literature review

As environmental pollution intensifies, a number of studies have been conducted using different methods regarding the influence of environmental regulation on total factor productivity (Christainsen and Haveman, 1981; Alpay et al., 2002; Chintrakarn, 2008; Shen, 2012; Simões and Marques, 2012a; Ambec et al., 2013; Li et al., 2013; Zhao et al., 2015; Zhang et al., 2015; Dong et al., 2015). Four distinct research statements have been identified. (1) Becker (2011) examined effects on plants in all manufacturing industries, not just those in 'dirty' industries, and found that no statistically significant effect on productivity in a county with higher environmental compliance costs. (2) Yang et al. (2012) used industry-level panel dataset for the 1997–2003 periods in Taiwan to explore the relationship between stringent environmental regulations and productivity, which supported the Porter hypothesis. Zhang et al. (2011) explored the strictness in enforcing environmental regulation and its impact on improvement in ML productivity and found that more stringent enforcement of environmental regulation would help to improve ML productivity growth in China. (3) Lanoie (2011) concluded that the contemporaneous direct effect of environmental policy stringency on business performance is negative and that innovation does not offset the costs of complying with regulation. (4) Sanchez-Vargas et al. (2013) proposed exponential *Gumbel* distributions to study a potential non-linear relationship between environmental regulation and manufacturing productivity in Mexico and found that the link is in fact non-linear. Moreover, they found a decreasing trade-off between those variables in the manufacturing industry, such trade-off is high for small firms but almost negligible for large companies. Wang and Shen (2016) adopted the GML index to calculate China's industrial productivity and examined the non-linear relationship between China's environmental regulation and environmental productivity, found that the relationship shows an 'inverted U-shaped' and displays three thresholds.

Though these studies provided many opportunities to understand the relationship between environmental regulation and productivity, they rarely took civil environmental protection, the political heterogeneity of cities and spatial interaction into consideration. In addition, these methods of measuring productivity ignored heterogeneity of production technology based on a data envelopment analysis (DEA) method. To fill these gaps, we make the following improvements.

Considering from aspects of civil environmental regulation, few scholars studied the impact due to restricted availability of statistical data and measure methods. Supply and demand of civil environmental regulation derive from survival essentially. Ebenstein (2012) found that damaging environmental conditions caused by pollution may affect people's health and lead to serious diseases. In order to survive and improve the quality of the environment, environmental protection of private organizations or civil pressure on the government and polluting enterprises are needed to cancel or postpone polluting industrial projects. Scholars must take the civil environmental protect into account and re-examine the influence between environmental regulation and total factor productivity.

As for spatial spillover effect, Quah (1996) found that interaction between adjacent regions by the spatial heterogeneity and correlation can be decomposed into a space demonstration effect and spatial competition effect. Because economic variables differ between regions, these two effects are asymmetric (Anselin, 1990), and the total effect is called the spatial spillover effect. Montero (2002) comparatively analyzed the enterprise technology innovation incentive effect of four kinds of environmental regulation (emission standard, management standard, tradable permit and license auction) and found that emission standards are the most effective tool. Thus, local economic development, regulation of different tools and enterprise innovation awareness all determine certain spatial heterogeneity of environmental regulation. However, the spatial Durbin model can identify the spatial correlation and spatial heterogeneity to analyze spatial spillover effects between different regions (Anselin, 2013).

In terms of calculating total factor productivity, methods are continuously improved and optimized. Since Charnes et al. (1978)'s seminal work, the DEA model has been widely applied as a non-parametric environmental efficiency measurement (Simões and Marques, 2012b). In order to avoid measure error caused by unexpected output, scholars (Chambers et al., 1996; Chung et al., 1997; Färe et al., 2001) established a new directional distance function, respectively. Tone and Tsutsui (2010) further put forward epsilon based measure (EBM) model, which contains the features of both radial model and non-radial model. In addition, we find that scholars mostly assumed that different areas have similar production technology, indicating that all parts will follow the same production technology frontier. This is clearly contrary to economic reality. De Witte and Marques (2009) extended the metafrontier framework to assess the overall efficiency of a utility while allowing for environmental differences. Oh and Lee (2010) raised metafrontier malmquist luenberger (MML) productivity index to calculate the green total factor productivity. It shows that EBM model and MML productivity index can effectively measure green total factor productivity.

As a consequence, this paper will first use EBM model and MML productivity index to calculate the green total factor productivity, and then use the spatial Durbin model to analyze the space spillover effect of 273 urban panel data from 2003 to 2013 in China.

3. Methodology

3.1. Econometric model

Considering the economic development has certain volatility, we first establish a non-spatial panel data model which is as follows: