Carbon emissions and optimal scale of China's manufacturing agglomeration under heterogeneous environmental regulation

Yongpei Wang [a, *], Weilong Yan [a], Ding Ma [b], Chenglong Zhang [b]

[a] *School of Government Audit, Nanjing Audit University, Nanjing 211815, China*
[b] *State Grid Energy Research Institute, Beijing 102209, China*

ARTICLE INFO

ABSTRACT

This article has studied the optimal scale of manufacturing agglomeration aiming at controlling industrial CO_2 emissions and the role of environmental regulation in China using the main function of panel cointegration and Full Modified Ordinary Least Square(FMOLS) based on the Dynamic Comprehensive Measure (DCM) of intensities of environmental regulation for 28 China's manufacturing subsectors and classification of the manufacturing subsectors according to their intensities of environmental regulations. The empirical results show that: (i) Higher intensity of environmental regulation can spur manufacturing subsectors get more agglomerative economies with less CO_2 emissions. (ii) The relationship between the agglomerative manufacturing subsectors with high and medium intensity of environmental regulation and CO_2 emissions shows inverted U-shaped changing trend. (iii) By contrast, the relationship between the agglomerative manufacturing subsectors with low intensity of environmental regulation and CO_2 emissions more likely presents U-shaped changing trend. (iv) High intensity of environmental regulation aiming at high polluting manufacturing subsectors can make them reach the inflection of CO_2 emissions under high scale of industrial agglomeration. Consequently, the government should take the policy with a general increase in the intensity of environment regulation, and use heterogeneous regulatory instruments according to different manufacturing subsectors so as to increase the emission reduction effect of manufacturing agglomeration.

1. Introduction

A frustrating by-product of China's status of the world factory is that China's total energy-related carbon emissions have experienced dramatic growth. According to Global Carbon Atlas statistics, China had already surpassed the United States as early as 2005, becoming the world biggest emitter of carbon dioxide (Global Carbon Atlas, 2017). Due to the rapid industrialization led by manufacturing industry, the industrial sector has cumulatively consumed 67.9% of China's energy and emitted 83.1% of carbon dioxide in the country (Chen, 2009). For this reason Chinese regulators have announced efforts to regulate industrial CO_2 emissions, especially the carbon emissions of high polluting manufacturing subsectors. Many regulatory instruments such as environmental and industrial regulations are waiting to be taken out of the toolbox, even if it is still an unsolved mystery that how

intensities of environmental regulations should be adopted for different manufacturing subsectors so as to keep the balance between carbon emission reduction and agglomeration economy.

In the light of industrial relocation hypothesis and pollution haven hypothesis, manufacturers tend to transfer to the regions with lower environmental standards, causing the evolution of industrial agglomeration, and thereby affecting the concrete form of the agglomerative economy(He, 2006; Zhu and Ruth, 2015; Kearsley and Riddel, 2010; D'Agostino, 2015). It is generally accepted that the scale of industrial agglomeration is neither conducive to the reduction of the total carbon emissions, nor conducive to lower carbon intensity, nothing but bring reallocation of pollutants between regions, and even the total carbon emissions just increase and never decrease. However, environmental policymakers still spare no effort to put forward suitable policies of environmental regulations with the aim of avoiding and reducing the increasing total carbon emissions caused by the agglomeration of manufacturing subsectors. From the view of empirical research, despite the effect of environmental regulation on industrial location has more or less been proven empirically in

---

many literature (Levinson, 1996; Jeppesen et al., 2002; Gray, 1997; Kheder and Zugravu, 2012), the empirical evidences of these literature are not exactly identical, even contradictory for some time, which indicates that the impact of environmental regulation on producers' location choices is obviously heterogeneous, a further research is needed on each manufacturing subsector.

Therefore, this article attempts to analysis the heterogeneous relationship between industrial agglomeration of main manufacturing subsectors and their carbon emissions under different intensities of environmental regulation. First of all, we measured the scale of industrial agglomeration, environmental regulation intensity and total CO_2 emissions of each manufacturing subsector. Then, we used the empirical method of FMOLS premised on the basis of panel unit root and panel cointegration with the aim of testing the mechanism of carbon emission effect of environmental regulation on manufacturing agglomeration, which would provide practical reference for policymakers of environmental regulation.

The novelty of this paper is to take into account the heterogeneity of environmental regulation across manufacturing subsectors instead of only focusing on several pollution-intensive manufacturing subsectors. The key initiatives are as follows: First, considering the different classification of environmental regulation intensity, we tried to divide the manufacturing subsectors into three categories, i.e., high intensity, moderate intensity and low intensity according to the method of Dynamic Comprehensive Measure (DCM) of environmental regulation. Second, in order to solve the shortage of microcosmic data of China's manufacturing enterprise and improve the measurement accuracy, a modified EG index was introduced to measure manufacturing agglomeration for the 28 manufacturing subsectors. Finally, the changing shape of relationship between manufacturing agglomeration and carbon emissions of each manufacturing subsector was analyzed through the panel FMOLS estimator of cointegration parameters, which seldom appeared in the previous studies in this field.

2. Related literature review

Making a comprehensive survey of the existing literature, there are mainly three aspects of researches on the relationship between environmental regulation and manufacturing agglomeration based on the industrial relocation and pollution haven hypothesis. First, many empirical researches focused on the impact of national and regional environmental regulation and heterogeneity of pollution abatement cost on the flows of Foreign Direct Investment (FDI), location selection and spatial distribution of FDI in accordance with the different intensities of environmental regulation of the host countries and regions, and then verified the existence of industrial relocation and pollution haven hypothesis (Cole and Elliott, 2003; List and Co, 2000; Keller and Levinson, 1999; Soest et al., 2006; Henderson and Millimet, 2005; Zhu et al., 2011; Lin and Sun, 2016). Although most of these studies have validated the pollution haven hypothesis, especially for relatively backward countries and regions, abatement costs of pollution have had moderate deterrent effects on FDI, even if the lack of the perspective of different manufacturing subsectors.

Second, some researchers have analyzed the impact of environmental regulation on the endogenous location choice of manufacturing through many empirical tests to verify the mechanism of agglomeration and decentralization of manufacturing activities (Mcconnell and Schwab, 1990; Levinson, 1996; Jeppesen et al., 2002; Brunnermeier and Levinson, 2004; Raspiller and Riedinger, 2008; Broner et al., 2012; Cheng, 2016; Shen et al., 2017). As we know, air pollution policy has moved steadily toward strict uniformity of regulations across regions of major emitters in the world which impels firms place a heavy weight on the intensity of regional environmental regulation when choosing a location. Hence, the main findings usually indicated that the intensity of environmental regulation had negative impact on manufacturing agglomeration. For instance, Shen et al. (2017) found that environmental regulations could inhibit the formation of new pollution havens through the analysis of location and relocation patterns of pollution-intensive industries in Guangdong province. In addition, the relationship between manufacturing agglomeration and environmental pollution studied by Cheng (2016) whose results showed that manufacturing agglomeration aggravated environmental pollution, while environmental pollution restrained manufacturing agglomeration, which implies that there are negative effects of environmental regulations on manufacturing agglomeration.

Third, same other scholars theoretically studied the effect of environmental policies on industrial agglomeration through the theories of New Economic Geography (NEG). The main work in this field was to explore the interaction mechanism between environmental regulation and agglomerative economy under the framework of NEG, thus theoretically proved that the income reduction effect of environmental regulation spurred manufacturers tended to select the countries and regions with low intensity of environmental regulation which led to morphological changes of enterprise location transfer effect of environmental pollution and spatial re-allocation of regional agglomerative resources(Zeng and Zhao, 2009; Ben Kheder and Zugravusoilita, 2008; Jürges and Ludwig, 2007; Kheder and Zugravu, 2012). In essence, the factor of environmental regulation was endogenously embedded in the new economic geography which could reveal the motive force of industrial re-location, and provide a theoretical basis for empirical researches.

However, despite the theoretical explanations provided by the new economic geography are quite convincing, strictly speaking, the conclusions of the empirical studies above are not complete and usually have no universal significance because of those researches are often limited to specific regions or industries. Furthermore, it is a pity that how to coordinate various kinds of environmental policies to maintain appropriate manufacturing agglomeration under the rigid constraints of energy consumption and pollutant emissions, meanwhile realize the win-win goal of manufacturing agglomerative economy and successful completion of emission reduction task, is still seldom concerned field. Hence it is very instructive to research the relationship between manufacturing agglomeration and pollution emissions under increasingly stringent environmental policies, because it is not only conducive to solving the problem of what regulation should be selected for different manufacturing subsectors, but also conducive to solving the problem of how to regulate according to differential effects of different intensities of environmental regulations.

3. Methodology, variables and data

3.1. Methodology

3.1.1. Measurement of environmental regulation intensity

Environmental regulation is an important effect factor of manufacturing location selection, so we should have a comprehensive understanding of different intensities of environmental regulation across manufacturing subsectors before studying those heterogeneous effects. For this reason, we first used a method called Dynamic Comprehensive Measure (DCM) to measure environmental regulation intensities of 28 manufacturing subsectors from 2001 to 2012 through the corresponding panel data of waste gas, waste water and solid waste from each manufacturing subsector.