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Impact of Manufacturing Industry Agglomeration on Carbon Emissions based on New Evidence from China

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Abstract. With propose of green economy, carbon emissions in most of industries have been curtailed more or less. It is imperative to reduce carbon emissions in Manufacturing as it caused much more carbon emissions. Space Gini Coefficients and carbon emissions intensity have been calculated to interpret the industries agglomeration and carbon emissions exchange respectively. Biased on this, a Douglas production function model is adopted to make further study on its relationship. The results show that the industries agglomeration in Chinese Manufacturing industries dose have impacts on its carbon emissions. And corresponding suggestions have been put forward to the development of low-carbon and green economy.

Keywords: Manufacturing Industries, Space Gini Coefficients, Carbon Emissions Intensity, C-D Production Function.

1. Introduction

As the biggest developing countries in the world, China has become the world's second largest economy since 2010 after a rapid development for past four decades. However, a mass of carbon emissions has been produced along with the excellent development, and China has been the largest carbon emitter since 2006. So how to efficiently manage the relationship between economic development and low-carbon development in China is an essential issue to be solved. There are some evident features of manufacturing industry cluster formed in the course of manufacturing development. While, it is the crucial question to be explored that what impact the manufacturing industries agglomeration have on carbon emissions.

2. Literature Review

2.1 Positive Effect of Industries Agglomeration.

Existed studies on manufacturing industry agglomeration and carbon emissions are mainly divided into two kinds in terms of research conclusion. One is that industry cluster could reduce carbon emission and alleviates pollution. Such as proposed by Poter (1998) that industry cluster promote the development on environment-friendly products which make less pollution [1]. Hosoe etc (2006) believed that there is a good platform to apply the environmentally sound technology in agglomeration zone which contributes to pollution reduction [2]. There are some other externalities caused by industry cluster except in environment, such as financial, knowledge and technology [3]. Duranton and Puga (2001) considered that the advanced green technology can be spread to lower cluster zone because of knowledge spillover and technology spillover by which companies can reduce their costs of emission reduction by upgrading production technology [4]. Niemin and Zhang Hongmei(2013) has proved by construct econometric model with industry cluster and carbon emission intensity that industry cluster is beneficial to low carbon development of manufacturing[5]. Similarly, Niemin(2013)took spatial Gini coefficient as well as industry structure and technological advance as the variables in the Cobb-Douglas production function, and end up with the same conclusions [6].Besides, Jiang Jinhua(2015) calculated the spatial Gini coefficient and connected with industry cluster, industry structure, energy consumption structure and industry development level as its variables, to investigate whether those variables could affect carbon emission[7].

2.2 Negative Effect of Industries Agglomeration.

The other conclusion is that industry cluster aggravates pollution rather than alleviate it. Virkanen(1998)analyzed the environmental pollution and industrial agglomeration in southern Finland and found that it was the large-scale agglomeration of industrial enterprises that aggravated the environmental pollution [8].Previously, Coyle(1997)found that the major causes of serious environmental pollution in former Soviet Union and Central, Eastern Europe was its large-scale industrial development special zone [9]. Furthermore, the negative environmental impact may involve with other factors like industrial agglomeration scale. Verhoef (2008)'s study showed that added foreign investment could boost economic development as well as industry agglomeration scale which degrades environment [10].

3. Data and Variables

Related Statistic data came from China Industry Yearbook and China Energy Statistical Yearbook (2012-2017) and industry classification (C_i, (i=13,14,15……)represents manufacturing industry,eg.C13 represents Farm and Sideline Products Processing which is one of sub-divided industries in manufacturing industry.) is based on National Economic Industry Classification (GB/T4754-2017) in China.

3.1 Spatial Gini Coefficient

The paper measures industrial agglomeration of China's manufacturing sub-industries by the most widely used indicator -spatial Gini coefficient. Formula of spatial Gini coefficient is:

$$Gi=\sum_{j=1}^{n}\left(X_{ij}-X_{j}\right)^{2}\quad,\qquad\left(X_{ij}=\frac{Y_{ij}}{\sum_{j=1}^{n}Y_{ij}}\quad,\quad X_{j}=\frac{\sum_{i=1}^{m}X_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n}X_{ij}}\right)$$

G_i is the spatial Gini coefficient of industry I, J represents the region (province). For the limitations of coverage, the table of spatial Gini coefficient of manufacturing sub-industries from 2012 to 2016(As Krugman (1991) proposed, $0<G<0.02$ is low agglomeration, $0.02<G<0.05$ is moderate agglomeration, $G>0.05$ is high agglomeration.) is not attached here.

According to data calculated, there are 14,14,15,16,15 industries respectively from 2012 to 2016 which are low cluster moderate cluster industries are 8,8,8,7,7 and high cluster industries are 6,6,5,6,6 respectively. Among them, Tobacco Industry (C16), Leather, Fur, Feathers, Its Products and Footwear Industry (C19), Computer Communications and Other Electronic Equipment Manufacturing (C39), Instrument and Meter Manufacturing Industry (C40) and Comprehensive Utilization of Waste Resources (C42), this five are always in high level in the sample period. Metal Products Machinery and Equipment Repair Industry (C43) is in high lever only except 2014, while Automobile Manufacturing (C36) is in moderate lever except little decline in 2015.And Food Manufacturing Industry (C14) is transformed from low to moderate. Others are in moderate or low cluster level.

3.2 Carbon Emission Intensity

Every unit of gross national product (GNP) produced carbon emissions is the intensity of carbon emissions [11]. With Formula: $Q=A/B$.

Hereinto, Q is the carbon emissions intensity, A is the industry carbon emissions, and B is the gross output value of each manufacturing sub-industry. For the limitations of coverage, the table of Carbon Emission Intensity is not attached here.

According to calculation, during sample period, carbon emissions intensity of Chemical Raw Materials and Chemicals Manufacturing Industry (C26), Manufacture of Non-metallic Mineral Products (C30) and Smelting and Calendaring of Ferrous Metals (C31) are in higher level, among which, C31 is the highest with increase tendency. Though, C30 and C26 have stronger intensity bur appear a decline tendency in general. There are 9 industries whose carbon emissions intensity are in lower level, all values of those are under 0.01. Among them, Computer Communications and Other Electronic Equipment Manufacturing (C39) is the lowest and decrease gradually. Besides, there are 16 industries like Wine, Beverage and Refined Tea Manufacturing (C15), Tobacco Industries (C16), Textile Industry (C17), etc. which have relative weaker intensity with decline trend.

4. Methodology

4.1 Correlation Analysis

The correlation coefficient between spatial Gini coefficient and carbon emission intensity of 28 manufacturing sub-industries in 28 provinces of China have been calculated as shown in table 1.

Table 1. Correlation Coefficient of Annual Spatial Gini Coefficient and Annual Carbon Intensity

	R(G, Q)		R(G, Q)		R(G, Q)		R(G, Q)
C13	0.5722	C20	-0.7876	C29	0.6053	C36	0.4659
C14	-0.6207	C21	-0.2597	C30	-0.1972	C37	0.0059
C15	-0.5780	C22	0.9651	C31	0.9231	C38	0.5078
C16	-0.8332	C23	0.0551	C32	0.4250	C39	0.6833
C17	0.7711	C24	0.9795	C33	-0.3447	C40	0.4742
C18	0.1990	C26	-0.4389	C34	0.7892	C42	-0.7735
C19	0.4215	C27	-0.6823	C35	0.9131	C43	-0.1485

From table 1, there are 17 industries have positive correlation between spatial Gini coefficient and carbon emission intensity, among which Culture, Education, Labor, Sports and Entertainment Products Manufacturing (C24) has the strongest positive correlation and Paper Making and Paper Products Industry(C22) is just next to C24. Besides, Smelting and Calendaring of Ferrous Metals (C31), Special Equipment Manufacturing (C35) etc., those 7 industries also have a relatively stronger positive correlation with correlation coefficient all above 0.5. There are 11 industries which appear a strong negative correlation, and the strongest one is C16 with coefficient -0.8332. According to results above, it can be concluded that there exists a definitely correlation between spatial Gini coefficient and carbon emission intensity of China’s manufacturing industries.

4.2 Regression Analysis

To make the relationship clear, a Cobb-Douglas production function model was built for further study: $Q = EG^{\beta}$.

Q represents carbon emissions intensity, E represents the impact on the intensity of carbon emissions by other factors, and G is the spatial Gini coefficient. Logarithmic model was adopted for validity and rationality of the empirical results: $\ln(Q)=\ln E+\beta\ln(G)$.

The results of regression analysis are shown in Figure 1 at the end of the paper.

Dependent Variable: LNQ?
Method: Pooled Least Squares
Date: 12/04/18 Time: 16:51
Sample: 2012 2016
Included observations: 5
Cross-sections included: 28
Total pool (balanced) observations: 140

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.307989	0.600219	-7.177362	0.0000
LNG?	-0.055344	0.152886	-0.361998	0.7181
Fixed Effects (Cross)				
_C13--C	0.159252			
_C14--C	0.569283			
_C15--C	0.818157			
_C16--C	-1.427861			
_C17--C	0.481413			
_C18--C	-0.747919			
_C19--C	-0.775720			
_C20--C	0.253771			
_C21--C	-0.984816			
_C22--C	1.418691			
_C23--C	-0.717699			
_C24--C	-1.070499			
_C26--C	2.296386			
_C27--C	0.518034			
_C29--C	-0.051378			
_C30--C	2.946008			
_C31--C	3.574963			
_C32--C	0.825554			
_C33--C	-0.321417			
_C34--C	0.127324			
_C35--C	-0.620676			
_C36--C	-1.063309			
_C37--C	-0.760671			
_C38--C	-1.564709			
_C39--C	-2.410644			
_C40--C	-1.483006			
_C42--C	-0.043869			
_C43--C	0.055356			
Fixed Effects (Period)				
2012--C	0.267387			
2013--C	0.144370			
2014--C	-0.027471			
2015--C	-0.097531			
2016--C	-0.286755			

Effects Specification

Cross-section fixed (dummy variables)
Period fixed (dummy variables)

R-squared	0.985732	Mean dependent var	-4.090786
Adjusted R-squared	0.981464	S.D. dependent var	1.370593
S.E. of regression	0.186601	Akaike info criterion	-0.317078
Sum squared resid	3.725716	Schwarz criterion	0.376309
Log likelihood	55.19545	Hannan-Quinn criter.	-0.035306
F-statistic	231.0012	Durbin-Watson stat	2.278278
Prob(F-statistic)	0.000000		

Figure 1. Panel Data Regression

5. Conclusion

(1) From figure 1, it can be clearly seen that there are 15 industries with negative values which means the increase of industrial agglomeration level leads to carbon emission intensity reduction. Most of those industries are capital, technology intensive whose agglomeration makes significant contributions to carbon emission reduction.

(2) The other 13 industries appear positive values indicating that increase of industrial agglomeration level leads to more carbon emission. Those are more energy-intensive, which need consume much energy during its production and operation, increased industrial agglomeration lead to stronger carbon emissions intensity and further aggravate environmental pollution.

In general, the overall result of emission reduction in manufacturing industry is relatively significant. Base on the study, there are some suggestions: firstly, rationally improve industrial agglomeration to reduce carbon emissions; secondly, actively promote low-carbon upgrading within the agglomeration area; thirdly, gradually accelerate the development of new energy sources, actively develop new environmental protection technologies and develop new materials.

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