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Research on three-stage dynamic relationship between carbon emission and urbanization rate in different city groups

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ABSTRACT

China is in a stage of rapid new urbanization, carbon emissions in regions the urbanization stages of which are different exhibit different characteristics. Based on the environmental Kuznets Curve, this paper calculates the carbon emissions of 32 provinces in China over 1978–2014 by *IPCC*. Using the Auto-regression Distributed Lag Model, we analyze the three-stage dynamic relationship between carbon emissions and urbanization rate in different city groups. And the influence of energy intensity and energy structure on this relationship is analyzed. Our finding shows that: The relationship between urbanization rate and carbon emissions is a three-stage dynamic relationship. In the provinces of Cluster 1 where the proportion of the service industry is the most and the urbanization rate is high, the shape of the three-stage curve is positive increase, positive decrease and negative increase; In the provinces of Cluster 2 which mainly depend on the manufacturing industry and have medium urbanization rate, the shape of the three-stage curve is positive decrease, positive increase and negative increase; In the provinces of Cluster 3 which mainly rely on the tourism industry and the husbandry industry and have lower urbanization rate, the shape of the three-stage curve is positive increase, positive increase and negative decrease. The decreasing effect of energy intensity on the carbon emissions is different significantly under different urbanization stages, and the decreasing effect is significant in the provinces of Cluster 1. The decreasing effect that energy structure has on carbon emissions is not significant, because the fossil fuels-dominated energy structure remains unchanged in China. Above all, this study can provide theoretical guidance for local governments to formulate carbon emission reduction plan in future.

1. Introduction

According to "*China Energy Statistical Yearbook 2016*[1]", energy consumption increased 8.7% from 2000 to 2016, energy intensity per GDP increased to 0.71 (tce) in 2016 from 0.37 (tce) in 2000. China has become the largest energy consumer and the second largest greenhouse gas emitter (Guo et al., 2017). As shown by the "*International Energy Outlook 2017*[2]" published by International Energy Agency, the proportion of fossil fuel consumption in total global energy supply is 80%. Up to 2040, the proportion would still be more than 75%. Moreover, Fog and haze broke out in China in 2013, and people are suffering from the pain of environment pollution. Under these circumstances, reducing carbon emissions has become a priority in the new urbanization process in China, which is of particular importance for coping with the increasing stress from energy crisis and global warming (Lena et al., 2017). In 2014, *China's Conference on Urban Development and Planning* put forward the new urbanization plan from four aspects (population, economy, land and society). Energy saving and carbon emission reduction is particularly important. In the new urbanization process, the concept of low carbon consumption would be educated, eco-friendly industries would be developed, industrial upgrading would be promoted, and clean development and ecology protection would be encouraged. Therefore, reducing carbon emissions has become the top priority of China's current economic work.

The process of urbanization in China is different from developed countries. China's urbanization is a "passive" process, which is led by local government policies. For different city groups, carbon emissions are increasing with the increase of urbanization rate, but the increasing rates are different. According to *China Statistical Yearbook 2011–2016*, in Jiangsu province, urbanization rate increased from 60.61% to 67.14%, carbon emissions increased to 1.553 billion tons from 1.374 billion tons, and the increasing rate of carbon emissions decreased from 8.56% to 6.89%. In Shandong province, urbanization rate increased from 49.71% to 59.02%, carbon emissions increased from 0.843 billion

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[1] http://www.stats.gov.cn/tjsj/ndsj/1
[2] http://www.iea.org/2

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tons to 1.637 billion tons, and the increasing rate of carbon emissions increased to 16.24% from 12.53%. In Gansu province, urbanization rate increased from 36.12% to 44.7%, carbon emissions increased from 0.053 billion tons to 0.108 billion tons, and the increasing rate of carbon emissions increased from 19.32% to 22.31%. On the basis of comparing the relationship between urbanization, carbon emissions and the increasing rate of carbon emissions in Jiangsu, Shandong and Gansu, we find the relationship between urbanization rate and carbon emissions in China is not completely in accord with the Kuznets Curve, but is a three-stage dynamic relationship.

Therefore, in this paper, we use the Auto-regression Distributed Lag model (ADL) to analyze the three-stage dynamic relationship between urbanization rate and carbon emissions. And the influence of energy structure and energy intensity on reducing carbon emissions under different levels of urbanization process is analyzed. Through the analysis of this paper, we could understand the influence of China's urbanization on reducing carbon emissions more clearly.

The remainder of this study is organized as follows. Section 2 is literature review. We review some of relative research literature and present the research ideas of this paper. Section 3 is model and data. We analyze the influence of urbanization rate, energy structure and energy intensity on carbon emissions. And the hypothesis of this paper is put forward; the source of data is descripted. Section 4 is results. Using the ADL model and the simultaneous equations model, we test the three-stage dynamic relationship between urbanization and carbon emissions. Section 5 is discussion. We analyze the reasons of the three-stage dynamic relationship, and the influence of energy intensity, energy structure and economic structure on this relationship are taken into consideration. Lastly, Section 6 is the conclusion.

2. Literature review

Researches on the relationship between urbanization and carbon emissions mainly focus on two aspects: the correlation and the influence mechanism. The correlation between urbanization and carbon emissions could be divided into three categories: positive correlation, negative correlation and no correlation. Wu et al. (2011), using the panel data model and the section data of 112 countries, analyzed the five types of relationship between economic development and carbon emission intensity. They found that urbanization could increase carbon emissions in some countries which are at a stage of rapid industrialization. Ji et al. (2013) studied the influence of the level of regional foreign trade development on CO_2 emissions in 32 Chinese provinces. Due to the impact of city openness on foreign trade, urbanization could reduce carbon emissions significantly in the long-term, and it is not significant in the short-term. Chikaraishi (2015) discovered that there is significant correlation between the lifestyle of urban residents and the decrease of carbon emissions in developed countries. Xu and Zhang (2016) pointed out that raising the quality of urbanization has positive effect on reducing carbon emissions in China. Sheng and Guo (2016) discovered that the impact of urbanization on CO_2 emissions in short-run is lower than in long-run. This result indicates that the process of urbanization would have a long-lasting impact on the growth rate of CO_2 emissions. Ding and Li (2017) found out that the relationship between urbanization and carbon emissions has a significant spatial heterogeneity. The relationship is positive in eastern regions and negative in western regions. Zhang et al. (2017), based on the extended STIRPAT theoretical frameworks, employed the two-way fixed effects model to do analysis. Their results show that there is an inverted U-shaped relationship between urbanization and carbon emissions and the turn point is around 73.80%.

Studies about the influence mechanism of urbanization on carbon emissions mainly involve the influence of lifestyle, transportation, economic growth and technology. Cortés-Borda et al. (2014), based on the E3IOT database which covers 487 EU economic sectors, using the multiple regression model, analyzed the correlation between urbanization rate and carbon emissions in Europe. The result shows that carbon emissions could be reduced effectively through increasing taxes. Lin and Ouyang (2014) examined the determinants of energy demand in China and forecasted China's energy demand. The results demonstrate that the severe problems of CO_2 emissions will be led by the coal-dominated energy structure of China. Li et al. (2015) presented that there is a unidirectional causal relationship between urbanization and both direct and indirect household CO_2 emissions. And for one percent increase of urbanization, the direct and indirect household CO_2 emissions would increase 2.9% and 1.1% respectively. Yuan et al. (2016) studied the effects of urbanization, consumption ratio and consumption structure on household indirect CO_2 emissions in China. The results show that the expansion of urbanization and the upgrade of consumption structure play important roles in the growth of household indirect emissions. Bai et al. (2016) proposed that, with the consideration of regional differences, differentiated measures and KPIs should be taken to promote low carbon roadmap led by local governments. Georgina (2017) pointed out that two main obstacles that have prevented the decarbonizing of transport sector are the absence of a global legally binding deal and the high relative cost of clean vehicle/energy technologies. Cao et al. (2017) investigated the influence of carbon trading price and low carbon subsidy policy on carbon emission reduction level of a manufacturer. They discovered that the carbon emission reduction level increases as the carbon trading price increases, whereas it is independent of the unit low carbon subsidy.

In recent years, scholars mainly focus on the influence of regional industry structure and urban scale. Xu (2014) examined the influence of urbanization on carbon emissions in China. The results show that the relationship between urbanization and carbon emissions is a U shape curve in eastern regions and an inverted U shaped curve in the central and western regions. Chen et al. (2014) studied the spatiotemporal dynamics of carbon intensity from energy consumption in China. They discovered that energy intensity, energy structure, industrial structure and urbanization rate were the dominating factors shaping the spatiotemporal patterns of China's carbon intensity from energy consumption. Alam et al. (2016) analyzed the relationship among carbon emissions, economic growth, energy consumption and population growth. For India and Brazil, they found the relationship between CO_2 emissions and population growth is statistically significant; For China and Indonesia, the relationship is statistically insignificant in both the short-run and long-run. Rafiq et al. (2016) studied the influence of urbanization on both CO_2 emissions and energy intensity in emerging economies, discovering that renewable energy seems to be dormant and non-renewable energy increases in these economies. Population density and affluence increase emissions and energy intensity. Yan et al. (2017) presented that the cooperation between cities which can be achieved through policy can significantly reduce carbon emissions. Sun et al. (2017) proposed there are four strategies to optimize carbon emission transfer structures in different industries to achieve both carbon emission reduction and economic development. Vitor et al. (2018) examine the volume of carbon dioxide emissions by lag of the emissions and by the Gross Domestic Product for the BRICS. They found that the main causes of the variation of CO_2 emission in time t are the emission of CO_2 in time t-2 in China.

In summary, in most studies, the relationship between urbanization and carbon emissions is a two-stage relationship, but the three-stage relationship between them is rarely involved. Second, the statistics of urbanization rate and carbon emissions lack of uniform standards, thus studies about the comparison analysis of the relationship between the two in other countries have little guiding significance to China. Because the process of urbanization is not balanced in China, we should use province time series data to study the relationship between urbanization and carbon emissions to analyze the differences. Third, when analyzing the influence of urbanization on carbon emissions, the mediator effect of energy intensity and energy structure is not considered. In this paper, the relationship between urbanization and