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Decoupling effect and sectoral attribution analysis of industrial energy-related carbon emissions in Xinjiang, China

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ABSTRACT

As the gateway of "the Belt and Road", it is of great significance for Xinjiang to fulfill the carbon reduction target without compromising the steady socio-economic development. A comprehensive understanding of the decoupling relationships between industrial growth and carbon emissions as well as its driving factors is helpful to make targeted recommendations. In this paper, decoupling analysis, index decomposition analysis, and attribution analysis were applied to analyze the decoupling effect, driving factors, and contributions of sub-sectors to each driving factor, respectively. Some conclusions were drawn. (1) Xinjiang's decoupling relationships between industrial growth and carbon emissions experienced three stages, *i.e.,* "negative decoupling, weak decoupling, and negative decoupling". Xinjiang's industrial sector was in relatively unsustainable period after 2008. (2) From 2000 to 2014, energy intensity promoted the decoupling process, and industrial structure and energy structure were the main factors which inhibited the decoupling process. But after 2008, all driving factors showed negative influences. (3) After 2008, *fuel processing*, *textile*, and *mining and quarrying* were primarily responsible for the energy intensity's negative influence; *fuel processing* was primarily responsible for energy intensity's negative influence; *production and supply*, *smelting and pressing of metals*, and *chemicals* were primarily responsible for industrial structure's negative influence. (4) This paper suggests that Xinjiang should make targeted carbon reduction policies at sub-sector level.

1. Introduction

Global warming, which is primarily caused by fossil energy use, has attracted widespread attention. In order to avoid the potential damages to natural ecosystem and the survival of human beings, the international community has come to an agreement that the average increase of global temperature should be kept below 2 degrees Celsius by the end of this century (Conte Grand, 2016). China has become the world's largest emitter of carbon emissions (Zhang and Da, 2015, Shao et al., 2016a). Due to the high-speed industrialization and urbanization, more energy will be consumed, and it is inevitable for China to emit more carbon emissions in the foresee future (Xu et al., 2016). Under such a circumstance, Chinese government has made effort to address the climate change and decrease carbon intensity. Before the Copenhagen conference in 2009, Chinese government promised to reduce its carbon intensity by 40–45% by 2020 in comparison with the 2005 level (Qiu, 2009). In 2014, a joint announcement on climate change was issued with United States, and China made a promise that the carbon emissions peak would be achieved before 2030(David, 2014). During the period of Thirteen Five-Year Plan (2016–2020), the government supported some provincial regions to be the first to achieve the carbon emissions peak (Cheng, 2016, Shao et al., 2016b). Fulfilling the carbon reduction target without compromising the steady socio-economic development highlights the urgency and importance of studies on the relationship between the economic growth and carbon emissions.

In recent years, more and more researchers have applied the decoupling model to analyze the relationship between economic growth and environmental changes. And these studies can be primarily divided into two aspects. Firstly, various environmental indicators, such as carbon dioxide, soot, waste water, and solid waste, were applied to examine the decoupling level (Climent and Pardo, 2007; Yu et al., 2017; Zhao et al., 2017). Secondly, many studies focused on exploring the

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influencing factors leading to the decoupling changes (Dong et al., 2016; Zhao et al., 2016; Jiang et al., 2016; Zhou et al., 2017; Zhang et al., 2017a). These studies analyzed the changes in decoupling states and factors' influences, but failed to explore the contribution of each individual sub-sector to decomposed factors. The attribution analysis model was proposed by Choi and Ang (2012) aiming to measure the contribution of each individual sub-sector to the effect of each decomposed factor. It is viewed as a perfect extension of the index decomposition analysis (IDA) model (Liu et al., 2015a). Some scholars have used the attribution analysis to do some analysis, and their studies focused on different countries or international organizations, *i.e.*, China (Liu et al., 2015a; Su and Ang, 2014; Wang et al., 2016a), Korea (Choi and Oh, 2014), Mexico (González and Martínez, 2012), and European Union (Fernández González, 2015; Fernández González et al., 2013, 2015). Combining the decoupling analysis and IDA models is more effective (de Freitas and Kaneko, 2011), but few studies incorporated both the decoupling analysis and attribution analysis. Until now, studies combining the decoupling index and attribution analysis were much scarcer, and only Wang et al. (2016b) used decoupling index and attribution analysis to conduct a deeper understanding of the decoupling states of industrial growth from carbon emissions and the driving factors in Taiwan. Besides, above studies using attribution analysis were not based on different stages. Conducting the analysis with different stages may have different conclusions. Thus, the study period is divided into different stages based on the decoupling states in this paper.

Energy consumption, carbon emissions, and the economic development are obvious different in different regions within China (Wang et al., 2014; Zhang et al., 2014). Without a sufficient understanding of the decoupling relationships at the provincial level, it is less effective to implement the national policies or strategies (Liu et al., 2012; Liu et al., 2015b). Due to its strategic location, Xinjiang becomes a crucial gateway in the second "Eurasian Land Bridge". And with the implement of "the Belt and Road", Xinjiang will play a more important role in social-economic cooperation with Russia, Central Asian countries, et al. Although these strategic policies promote Xinjiang's economic development, its economic development is still characterized by high energy consumption and high carbon emissions. To be a responsible country and sponsor nation of "the Belt and Road" (Wang et al., 2017a), China should pay enough attention to its energy-related carbon emissions in order to stop the regional environmental deterioration. Xinjiang, as the important region in "the Belt and Road", should set a good example to fulfill the carbon reduction target without compromising the steady socio-economic development. Since the implement of "Western Development" in 2000, Xinjiang's industrial sector had been growing fast on the basis of its abundant nature resources. Due to its important status of the energy base, Xinjiang plays an important role in providing energy products for the national and regional economic development, so it is also necessary to conduct an analysis. Over 2000–2014, the total carbon emissions increased from 21.41 million tons to 112.38 million tons with an annual growth rate of 13.01%, and > 80% of the energy-relative carbon emissions was emitted by the industrial sector[1]. Thus, the industrial sector should be the paid enough attention. Some studies were also conducted on Xinjiang's carbon emissions, e.g., Huo et al. (2015), Ma et al. (2013). But, the previous studies did not study the sub-sectors' contributions to the driving factors.

The differences between this paper and the existing researches mainly lies in the following aspects. Firstly, a depth study of attribution analysis was conduct at a provincial level. Secondly, according to the comparative attribution analysis of different stages, different conclusions may be drawn. Thirdly, studying the sub-sectors' contributions to each driving factors of Xinjiang industrial carbon emissions can help make more targeted policies.

[1] The data was calculated on the basis of *Xinjiang Statistical Yearbooks* (2001–2015).

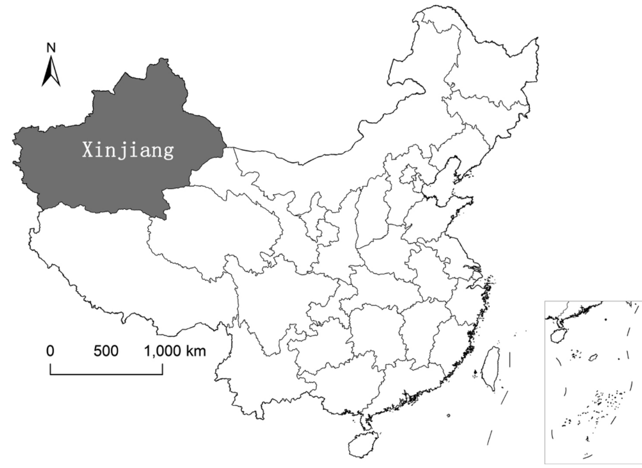

Fig. 1. Location of Xinjiang in China (This figure originates from the National Administration of Surveying, Mapping and Geoinformation).

In order to assist Xinjiang in decoupling industrial carbon emissions from industrial development, and achieving carbon reduction target and sustainable development, this paper aimed to conduct a deeper understanding of the decoupling relationship between Xinjiang's industrial growth and carbon emissions, and then recognize the influence of each driving factor and the contribution of each industrial sub-sector. Specifically, decoupling index model was applied to examine the decoupling relationship. Sato-Vartia Logarithmic mean Divisia Index (LMDI) model was applied to analyze the decomposed factors' influence on changes in industrial carbon intensity. Based on the decomposed results, this paper used attribution analysis to analyze the contribution of industrial sub-sectors to decomposed factors. In the end, targeted recommendations and policies can be made at sub-sector level.

2. Study area and methodology

2.1. Study area

Xinjiang, located in the northwest of China (Fig. 1), has an area of 1.66 million km^2 which accounts for about 1/6 of total land area of China. Based on the second national oil and gas resources evaluation, Xinjiang's predictive reserves of coal, oil, and gas accounted for 40%, 30%, and 34% of the national onshore gross reserves, respectively (Wang and Wang, 2015). Rich resources made industry, especially the energy-intensive industrial sectors, be the primary sectors. Rich resources promoted its economic development and it also caused damage to environment (Wang et al., 2017b; Wang and Wang, 2017).

2.2. Decoupling model

In order to solve the issues regarding the dependence of economic growth on material consumption, decoupling theory was proposed (Pang et al., 2014). The Word Bank and the Organization for Economic Cooperation and Development (OECD) explained decoupling concept, respectively. The Word Bank indicates that the decoupling, including both dematerialization and depollution, is the process of gradually reducing the economic activities' effects on the environment (Bruyn and Opschoor, 1997). OECD states that a decoupling relationship existed when the growth of environmental pressures was slower than that of economic development (OECD, 2005); and there is a negative decoupling relationship, when the growth of economic development was slower than that of environmental pressures. Tapio decoupling index and OECD decoupling index are the two models to examine the decoupling states, and these two decoupling indexes had also applied to analyze the decoupling relationships between economic growth and