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Examining the socioeconomic determinants of CO_2 emissions in China: A historical and prospective analysis

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ABSTRACT

This paper explores the socioeconomic determinants of CO2 emissions in China from a historical and prospective perspective. Through the study, we developed a comprehensive analysis framework, using time series data on China's economic structure, energy consumption structure, income, urbanization, FDI, and total trade for the period 1980–2014 in order to perform our analysis. Firstly, the results of ADF test indicated that the surveyed variables were stationary and integrated of I(1), a finding that was further confirmed by the results of a KPSS test. Subsequent Johansen cointegration results found that there existed no less than one cointegrating relationship between the surveyed variables, and the results of a VECM model suggested that all of the selected socioeconomic factors exerted important influences in determining the value of the dependent variable, CO_2 emissions. The Granger causality tests demonstrated the existence of a bidirectional causal link between CO_2 emissions and the economic structure, and between CO_2 emissions and the energy consumption structure. A unidirectional causal link was also located that runs from CO_2 emissions to GDP, urbanization to CO_2 emissions, and CO_2 emissions to trade. No causal link was found to exist between CO_2 emissions and FDI. In addition, impulse response functions and variance decomposition analysis revealed that the energy consumption and economic structures can be expected to continue to exert strong and significant forecasted impacts on CO_2 emissions in the future, while the impact of FDI and total trade is expected to be of increasingly limited magnitude. The impact of GDP is also likely to be evident in the future. These results hold important implications for governmental policy decisions pertaining to the reduction of China's CO_2 emissions.

1. Introduction

Since the Industrial Revolution and the increasing intensity of human activities related to socioeconomic development which it necessitated, the atmospheric concentration of CO_2 has risen sharply. The CO_2 emissions produced by humans—which predominantly come from the combustion of fossil fuels—have in turn led to climate change, which now adversely affects both human beings and the environment (Fang et al., 2015; Shan et al., 2016, 2017; Wang et al., 2017). Socioeconomic development itself is, however, necessary for improving living standards and social welfare, and governments are as a result required to maintain steady, if not rapid, rates of economic growth. States therefore face a dual challenge in both attempting to curb the consumption of energy sourced from fossil fuel and thus emissions levels, while simultaneously maintaining economic growth (Fang et al., 2015; Wang et al., 2015a). China has been the largest developing nation and the country's economy has increased exponentially since the economic reform in 1978. Statistics show that China's GDP rose by an average of more than 9% each year over the past nearly forty years (Wang et al., 2014; Guan et al., 2016; Wang and Liu, 2017). This rapid increase has, however, been achieved through massive increases in energy consumption and a concomitant growth in CO_2 emissions. In fact, a 2013 statistical report published by the International Energy Agency notes that China consumed most of the coal produced globally in 2012, confirming the country's status as the largest energy consumer and CO_2 emitter (Liu et al., 2013). Despite the rapid pace of its development, China has not yet completed the historical task of industrialization and urbanization. In coming decades, millions of people can thus be expected to move from rural areas to cities, and large-scale infrastructure projects will increase the demand for energy, necessitating the production of even greater volumes of CO_2 (Wang et al., 2013b). Without the implementation of mitigation measures, CO_2 emissions in China are estimated to rise by more than a half in the following fifteen years (Liu et al., 2015) and the country is facing significant pressure from the international community with respect to reducing emission levels.

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Under intensifying pressure to mitigate CO_2 emissions levels, the Chinese government has undertaken a range of emission reduction measures in recent years, including the establishment of emission reduction targets (Wang et al., 2013a). In its the Eleventh Five-Year Plan (2006–2010) period, China planned to reduce its energy intensity by an average of 20% across the nation's provinces. In addition, the nation's Twelfth Five-Year Plan (2011–2015) period plans that energy intensity will be cut by 16% and CO_2 emission intensity will be reduced by 17%. In 2014, in a joint announcement with US on climate change, the Chinese government announced that its CO_2 emissions would begin to decline after 2030 (Liu et al., 2015). However, the outlook for CO_2 emissions in China is not optimistic: existing policies do not provide sufficient support to meet targets, and these goals can only realistically be achieved if China has begun to promotes low-carbon development. With the aim of aiding in this task, the main goal of the present research is to explore the factors that determine CO_2 emission levels in China. To do so, we have designed and implemented a comprehensive framework for emissions analysis.

The reminder of this research is organized as follows. Section 2 briefly reviews existing empirical research on the impact factors of CO_2 emissions. Section 3 displays the original data, describes the methodological issues pertinent to the study, and introduces the empirical results arrived at through the research. Section 4 sets out the main conclusions and suggests a series of policy implications.

2. Literature review

The factors influencing CO_2 emissions in both developed and developing countries have become the subject of extensive research efforts in recent years. A number of quantitative analysis methods have been created and utilized to examine the impact factors of CO_2 emissions from a range of perspectives. Among the models used, Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA) constitute the two most influential and frequently used methods (Yao et al., 2015). Representative models used in conjunction with these methods include the IPAT model, the STIRPAT model, the LMDI method, and input-output analysis (Brizga et al., 2013a; Brizga et al., 2013b).

An extensive body of existing literature has found economic growth and technological progress to be the two most significant impact factors in relation to CO_2 emissions. For example, in a study based on provincial paned data, Wang et al. (2016a) found economic growth to be an important driving impact factor in the growth of CO_2 emissions, while the technology level was found to produce an inhibiting effect in relation to CO_2 emissions. Taking Beijing as an example and using an improved STIRPAT model, an earlier study by Wang et al. (2012) similarly found economic growth to have positively influenced the CO_2 emissions, while the technology level was revealed as also having had a negative impact on CO_2 emissions. Wang et al. (2013a) arrived at similar results in their study of Guangdong province. Using the generalized divisia index method, Shao et al. (2016) found the economic scale effect to be the primary contributor in increases in the CO_2 emissions. Using a combination of decomposition analysis and scenario analysis, Yi et al. (2016) have undertaken research suggesting that technological advancement is always the most important driving factor in decreasing carbon intensity. In addition to these existing studies, a growing number of scholars are presently working to estimate the casual links between GDP growth and CO_2 emissions. For instance, Wang et al.'s study of China's provinces (Wang et al., 2014) found that a one-way positive causal link runs from GDP growth to CO_2 emissions. Similar studies have also been undertaken by Sebri and Ben-Salha (2014) in BRICS countries; by Kasman and Duman (2015) in new EU member and candidate countries; by Salahuddin and Gow (2014) in Gulf Cooperation Council countries; and by Al-mulali et al. (2013) in Latin America and the Caribbean. The empirical results of these studies are mixed and thus inconclusive in explaining the exact nature of the casual links at work in this relation.

Urbanization, industrialization, and other socioeconomic indicators also exert an important role in relation to CO_2 emissions. A large number of existing studies have proposed that a linear relation exists between urbanization and CO_2 emissions, however the form of the relation is a matter of dispute amongst scholars. For instance, whilst Liddle and Lung (2010) and Wang et al. (2016a,b,c) found a positive linear link between urbanization and CO_2 emissions, Fan et al. (2006) demonstrated a negative linear link between urbanization and CO_2 emissions. Again, while Martinez-Zarzoso (2011) found an inverted U-shaped relationship between urbanization and CO_2 emissions in a study of a selection of developing countries, Ozturk and Al-Mulali (2015) were able to discount the EKC hypothesis in their study of Cambodia. In an expansive study, Wang et al. (2013a,b) used an extended STIRPAT model to examine the impacts of population, the urbanization level, the economic level, and the industrialization level on CO_2 emissions; their results indicated that population is in fact the most important influencing factor of CO_2 emissions. Using LMDI model, Guo et al. (2015) estimated the impact of population structure on CO_2 emissions in China, concluding that changes in the population age structure, population education structure, and population occupation structure negatively impact on CO_2 emissions, whilst the effects of population change, urban and rural structure change, and population scale all positively correlate with CO_2 emissions. In addition, using state-to-state migration data in U.S., Hoesly et al. (2015) found that population shifts affect energy use and emissions. Taking India as an example, Ohlan (2015) examined the effects of population density, energy use, GDP growth, and trade openness on CO_2 emissions. He found that population density exerted strong positive influences on CO_2 emissions, and was the main influencing factor in CO_2 emissions changes.

A range of additional indicators have also been employed in analyzing the determinants of CO_2 emissions. For instance, Wang et al. (2016a) estimated the effect of China's energy consumption structure on CO_2 emissions, finding that it exerted a significant positive impact in relation to CO_2 emissions. Wang et al. (2013a) found the economic structure to be positively correlated with CO_2 emissions in Guangdong province; the same results were arrived at by Wang et al. (2012) in a study of Beijing. Chaabouni et al. (2016) investigated the link between CO_2 emissions and health expenditure, finding a unidirectional causality to exist from CO_2 emissions to health expenditures. Using an econometric technique, Salahuddin et al. (2013) found a significant negative relationship to exist between CO_2 emissions and financial development. A study by Shahbaz et al. (2013) suggests that trade openness could reduce the growth of energy pollutants and have a positive relationship with environmental quality. In addition, Omri et al. (2014) explored the casual relation between FDI (foreign direct investment) and CO_2 emissions, and found there was a bidirectional causal relationship between FDI and CO_2 emissions. Perhaps as a result of the selection of very different study areas and study periods or the use of divergent research methods and variables, the empirical results of the existing literature on CO_2 emissions therefore paint a picture of a mixed relationship between CO_2 emission levels and various impact factors.

Although these existing literature have enriched our understanding of the key impact factors of CO_2 emissions, they have also to a large extent failed to provide evidence in relation to how the impacts of variables on CO_2 emissions will change in coming decades, as well as how these variables change in response to external shocks. Such changes, we note, are possible to investigate through the use of impulse response analysis and variance decomposition techniques. Responding to this deficiency, this research employs a comprehensive analysis framework in order to investigate the potential determinants of CO_2 emissions in China, relying on data for the period 1980–2014. The research results are intended to provide theoretical guidance and an evidence base the realization of energy saving and emission reduction targets.