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Urbanization and industrialization impact of CO_2 emissions in China

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ABSTRACT

This study investigates the causal linkage among CO_2 emissions per capita, energy intensity, real GDP per capita, industrialization (share of industrial value added in GDP), urbanization (share of urban population in total population), and share of renewable energy consumption in China over the period from 1970 to 2015. We employ autoregressive distributed lag (ARDL) technology to test the co-integration and short- and long-run estimates, and apply the vector error correction model (VECM) to analyze the directional causality among the time series data. The estimates of long-run parameters indicate that 1% augments of energy intensity, real GDP, industrialization, and urbanization increase CO_2 emissions by 1.1%, 0.6%, 0.3%, and 1.0%, respectively. Long-run feedback Granger causalities exist among emissions, real GDP, and industrialization. Thus, our main policy suggestions are as follows: (i) to encourage green and sustainable urbanization, as it increases economic growth but not at the expense of environmental degradation; (ii) to strategically adjust and optimize the industrial structure; (iii) to improve the efficiency of energy use and technological innovation; and (iv) to increase the proportion of renewable energy in total energy consumption.

1. Introduction

Global warming is a common global challenge faced by the international community and all countries. According to the Intergovernmental Panel on Climate Change (IPCC, 2001), Earth's surface warmed by approximately 0.6 °C over the twentieth century, which is directly attributed by almost all scientists to greenhouse gas (GHG) emissions, of which 73% is carbon dioxide (CO_2) emissions (Zhang et al., 2017). As the biggest newly industrialized country and second largest economy in the world, China's huge economic growth over the past few decades has been accompanied by enormous CO_2 emissions and environmental degradation. According to the Global Carbon Project (GCP, 2016), China was the source of 29% of total global CO_2 emissions in 2015 as the largest emitter, at nearly twofold that of the second-placed United States (15%). Given this, China has recently proposed several emission-reduction commitments. In 2016, prior to the G20 Hangzhou summit, China announced its ratification of the Paris Agreement. Moreover, China has targeted peak CO_2 emissions by 2030 at the latest, and to reduce its carbon intensity/GDP ratio by 60%–65%, compared with the 2005 level, and to increase its share of clean energy/total energy to 20%. By 2014, carbon intensity had been reduced by 33.8% compared to 2005, and the share of clean fuels in total energy use had risen to 11.2% (NDRC, 2015). Use of renewable energy can be reliable for mitigation of CO_2 emissions. The characteristic of renewable energy is safe, clean, and inexhaustible, compared with traditional energy (Tariq et al., 2017).

According to the WB (2016), China's urban population has increased rapidly from 142.4 million (17.4% of total population) in 1970 to 762.6 million (55.6%) in 2015 and is projected to further increase to 76% by 2050 (UN, 2015). Fig. 1 presents the trend urban and rural populations in China over this period. The urban population goes up steadily, while rural decreasing. Urban and rural populations got the same size, with nearly 664 Million in 2011, then urban population has passed rural population. Urbanization will increase economic growth by raising economic output and consumption. The increasing urban population will raise the demand for basic infrastructure, such as building, transportation, and supporting facilities, as well as the environmental pollution, especially GHG emissions.

Currently, China is at the peak of industrialization and hence with inputs of enormous energy. Despite the economic benefits China has accrued from its rapid industrialization, it has strained resource sources as labor, materials, and investment, and has incurred significant environmental degradation. According to Sadorsky (2013), this variable will be used by industrial value added (% of GDP), which represents the internal manufacturing specialization.

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Nomenclature

ADF	augmented Dickey–Fuller
ARDL	autoregressive distributed lag
BP	British Petroleum
BRICS	Brazil, Russia, India, China, and South Africa
CCR	canonical co-integrating regression
CO_2	carbon dioxide
CUSUM	cumulative sum
CUSUMSQ	cumulative sum of squares
DOLS	dynamic ordinary least squares
DW	Durbin-Watson
ECT	error correction term
FMOLS	fully modified ordinary least squares
GDP	gross domestic product
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
MENA	Middle East and North African
NDRC	National Development & Reform Commission of China
OLS	ordinary least squares
PP	Phillips–Perron
SIC	Schwarz information criteria
VAR	vector auto-regression
VECM	vector error correction model
WB	World Bank

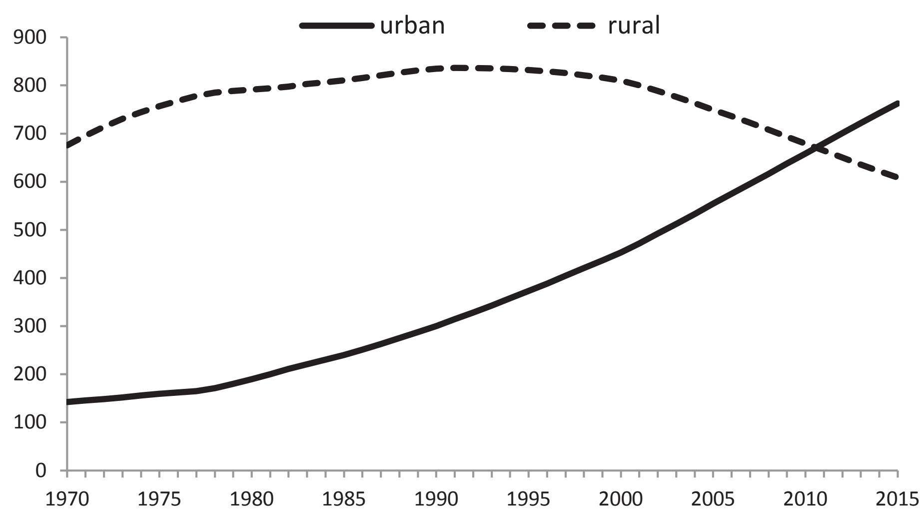

Fig. 1. The urban and rural population in China, 1970–2015 (Million) (World Bank, 2016).

The purpose of this paper is to explore the impact of energy intensity, real GDP, industrialization (share of industry value added in GDP), urbanization (share of urban population in total population), and share of renewable energy on CO_2 emissions for China over the period from 1970 to 2015. We aim to make the following four contributions to the literature. First, to the best of our knowledge, ours is the first study to examine the nexus of emissions and economic growth, by taking urbanization, industrialization, energy intensity, and share of renewable energy into consideration for China over the longest period from 1970 to 2015. Second, we use autoregressive distributed lag (ARDL) technology, which is more efficient and provides consistent evidence from a small sample (Pesaran et al., 2001). Third, the share of renewable energy in total energy use is used to analyze the impact of energy structure on emissions (Lin et al., 2016), as this may give some implications for optimizing China's energy structure. Fourth, energy intensity is considered as the main determinant for CO_2 emissions growth (Ouyang and Lin, 2017). We expect the study findings to not only enrich the existing literature, but also expand our understanding of their relationships to guide policymaking in terms of urban planning, industrial transformation, energy efficiency, and energy structure optimization.

2. Literature review

In the past few decades, some empirical studies have investigated the linkage among CO_2 emissions, economic growth, and renewable energy. By ARDL, fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), and canonical co-integrating regression (CCR), Danish et al. (2017) conclude that renewable energy plays a negative role but non-renewable energy a positive role, in Pakistani emissions. The evidence from the vector error correction model (VECM) suggests that policymakers should enlarge the investment in renewable energy projects, so as to mitigate climate change. By panel FMOLS technology, Apergis and Payne (2014) indicate that the developments of output and CO_2 emissions stimulate renewable energy use in Central American countries. Some implications are given that policymakers should focus on cost-effective renewable energy sources and technologies. Employing panel ordinary least squares (OLS), FMOLS, and DOLS, the empirical results of Liu et al. (2017a) indicate that both economic growth and renewable energy negatively impact on CO_2 emissions in BRICS.

Several other empirical papers explore the causal linkage among urbanization or industrialization, CO_2 emissions, and economic growth. For instance, Al-Mulali and Ozturk (2015) investigate the factors influencing environmental pollution in fourteen Middle East and North African (MENA) countries from 1996 to 2012. Their FMOLS results indicate that energy use, urbanization, and industrialization positively impact on environmental degradation in the long-run. In addition, other variables Granger cause CO_2 emissions in the short- and long-run, but other factors have different causal directions. The authors present some policy suggestions to control environmental pollution based on their analysis outcomes. Bekhet