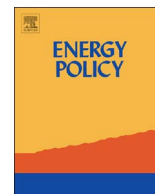




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# Does energy and CO<sub>2</sub> emissions performance of China benefit from regional integration?

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## ABSTRACT

Low energy and carbon efficiency and widespread market segmentation are two stylized facts of China's regional economies. This paper evaluates energy and CO<sub>2</sub> emissions performance using a newly developed non-radial directional distance function, and China's regional integration is investigated using a price approach. The study points to evidence that: (1) most provinces do not perform efficiently in terms of energy use and CO<sub>2</sub> emissions with performance gaps among regions becoming larger, indicating regional segmentation; (2) magnitude of regional integration has increased dramatically, while China's eastern provinces are less integrated in domestic side due to their convenience to international openness; (3) regional integration has significant and robust positive effects on energy and CO<sub>2</sub> emissions performance with over 70% of effects coming from artificial barriers, rather than geographical distance; (4) international openness is also beneficial for promoting energy and CO<sub>2</sub> emissions performance, but cannot substitute for regional integration because of China's specialization in energy-intensive manufacturing in the global economy. Based on the empirical findings, we suggest that central government should continue to encourage regional integration given that local governments have incentives to fragment because it is a way of promoting energy and CO<sub>2</sub> emissions performance and stimulating economy at the same time.

## 1. Introduction

### 1.1. Background

There are two stylized facts in China's economic research. The first is the low energy and CO<sub>2</sub> emissions performance. China has overtaken US as the biggest energy consumer and CO<sub>2</sub> emitter in the world. The primary energy consumption of China was over 2800 million tonnes of oil equivalent (Mtoe) in 2013 while CO<sub>2</sub> emissions were over 9.5 billion tonnes. The corresponding figures for the US were 2266 Mtoe for primary energy and 5.9 billion tonnes for CO<sub>2</sub> emissions. Meanwhile, China's gross domestic product (GDP) was only 55.8% of US in 2013. The over-consumption of energy and related CO<sub>2</sub> emissions due to low energy efficiency and carbon efficiency are big challenges for China's sustainable development, especially in the process of industrialization and urbanization (Zhu et al., 2015a).

Fig. 1 displays the historical trends of China's energy intensity and carbon intensity in comparison with European Union (EU), US, Japan,

India and world average. Here, energy intensity and carbon intensity are defined as energy consumption and CO<sub>2</sub> emissions per unit of GDP (Lin and Li, 2014). Although China's energy intensity and carbon intensity are both declined dramatically in near decades, they are still quite large according to international comparison, even about 60% larger than those in India. Previous studies, such as Fan et al. (2007), Lin and Ouyang (2014), Zhu et al. (2015b), also particularly pointed out China's large energy and carbon intensity. It is therefore urgent for China to improve energy and CO<sub>2</sub> emissions performance for reducing energy consumption and mitigating CO<sub>2</sub> emissions.

The second stylized fact is the widespread market segmentation among China's provinces. After implementing economic reform in 1978, China has gradually become an extroverted economy through international openness, but on the domestic side, market integration has been impeded. Similar to the prisoner's dilemma in game theory, *beggar-thy-neighbour* policies are quite common in each province because local governments have a clear incentive to keep their production of scarce raw materials to themselves or to prevent the

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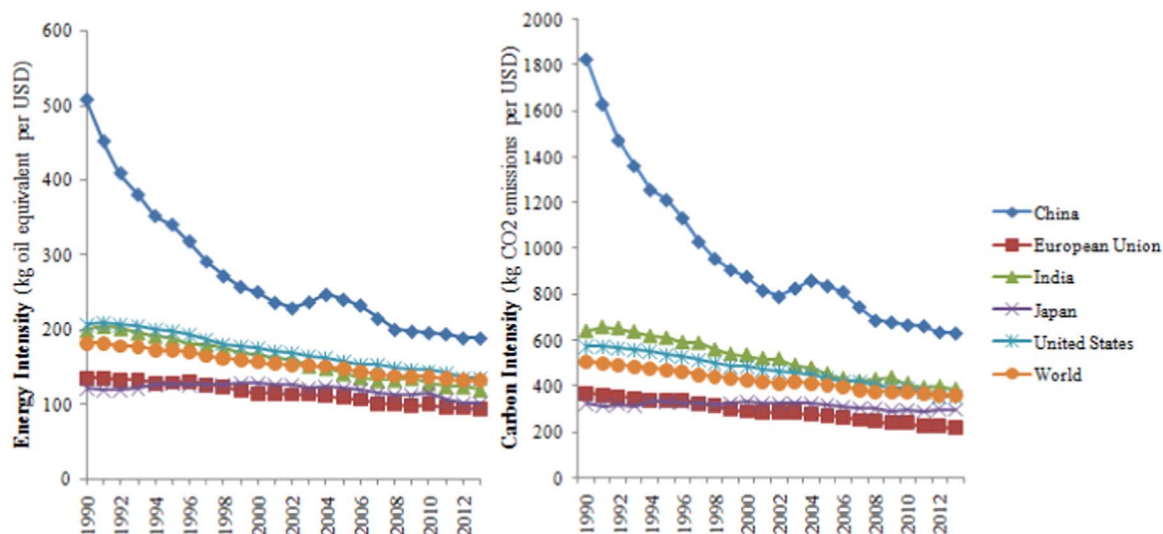


Fig. 1. China's energy intensity and carbon intensity and international comparison. Note: Data are obtain from World Bank and British Petroleum. GDP is measured by constant 2011 US dollars (USD).

inflow of goods produced in other provinces. It is worth noting that although there is widespread local protectionism, the magnitude of market segmentation is declining and China's regional markets are becoming more and more integrated.

The objectives of this paper are: (1) to evaluate the energy and CO<sub>2</sub> emissions performance of each province in China and construct regional integration indices; and (2) to use the panel data constructed in step one to investigate whether energy and CO<sub>2</sub> emissions performance would benefit from regional integration.

## 1.2. Motivation and contribution

The large and rapidly increasing energy consumption and CO<sub>2</sub> emissions have made energy efficiency and CO<sub>2</sub> emissions efficiency in China become the subjects of intense discussion. Many studies have attempted to investigate energy efficiency and CO<sub>2</sub> emissions efficiency in China's regions and industries (see, [Hu and Wang \(2006\)](#) and [Lin and Yang \(2014\)](#)). However, the literature usually measures energy efficiency and CO<sub>2</sub> emissions efficiency separately. One of the most recent contributions to the evaluation of energy and carbon efficiency is [Zhang et al. \(2014\)](#), which propose two non-radical directional distance functions (NDDF) for conducting both energy and CO<sub>2</sub> efficiency analysis simultaneously in a single model. [Lin and Du \(2015\)](#) apply this method for evaluating China's regional energy and CO<sub>2</sub> emissions performance. They find that China's efficiencies in energy use and CO<sub>2</sub> emissions are still at the low stage in most regions.

Another strand of literature focuses on analyzing how economic factors affect energy efficiency or carbon efficiency, such as [Chen and Golley \(2014\)](#) and [Lin and Yang \(2014\)](#). However, to the best of our knowledge, the question of whether energy and CO<sub>2</sub> emissions performance could benefit from regional integration is still unanswered empirically.

Regional integration has positive effects on energy and CO<sub>2</sub> emissions performance for at least four mechanisms. First, economic unification encourages the competition among provinces, and thus enterprises have more incentives to invest in research and development (R&D) on energy efficiency. [Melitz and Ottaviano \(2008\)](#) develop a monopolistically competitive model to show that market size affects the toughness of competition. [Grossman and Helpman \(2015\)](#) also stress the importance of competition in a large scale. Second, regional integration could achieve scale economy which has been stressed by previous literature as a source of productivity growth ([Tybout and Westbrook, 1995](#); [Tybout, 2000](#); [Biesebroeck, 2005](#)). Third, the diffu-

sion of technological progress and managerial experience is limited by regional barriers ([Córdova and Moreira, 2003](#); [Peluffo, 2013](#)), while regional integration could promote performance by eliminating the barriers. Lastly, regional integration encourages specialization according to comparative advantage ([Grossman and Helpman, 2015](#)), which has been regarded as the main source of productivity growth since [Adams Smith](#). Due to the severe of resource depletion and global warming, the productivity incorporating energy input and CO<sub>2</sub> emissions has become more and more important ([Chen and Golley, 2014](#)). To the best of our knowledge, there is no literature on the effect of regional integration on energy and CO<sub>2</sub> emissions performance.

Given the previous literatures, there are three issues to be addressed. First, most studies have conducted energy efficiency and CO<sub>2</sub> emissions efficiency analysis separately, but the evaluation of energy and CO<sub>2</sub> emissions performance in a single framework is still limited. Second, increasing regional integration is a significant trend of China's regional economies and there is no literature studying its potential impact on China's energy and CO<sub>2</sub> emissions performance. Third, the literature has shown that international openness is good for improving energy/carbon efficiencies ([Taskin and Zaim, 2001](#); [Lin and Du, 2015](#)), but the question of whether international market could substitute domestic markets in promoting energy and CO<sub>2</sub> emissions performance is still unanswered.

To address the first issue, the recently developed NDDF proposed by [Zhang et al. \(2014\)](#) is adopted in this paper to measure China's provincial energy and CO<sub>2</sub> emissions performance simultaneously. Unlike [Lin and Du \(2015\)](#), both the unified efficiency and energy-environmental performance of each province in China are evaluated<sup>2</sup> in our paper. The two are applied to estimate the effects of regional integration on energy and CO<sub>2</sub> emissions performance to check the robustness of our results.<sup>3</sup>

To investigate the second issue, two works have been conducted: (1) we use the price approach proposed by [Parsley and Wei \(2001a\)](#) to construct the panel data of regional integration of provinces because price convergence is the most common indicator of market integration ([Xu, 2002](#)). (2) Local protectionism has been particularly identified by filtering the underlying effects of geography. In a country as large as

<sup>2</sup> The definition of the unified efficiency and energy-environmental performance are shown in [Section 3](#).

<sup>3</sup> The weight vector used in calculating the energy and CO<sub>2</sub> emissions performance might influence the results even conclusions. Thus, a sensitivity analysis using different weights is desirable to show that the weights of contraction ratios may not significantly change the efficiency scores and their relationship with regional integration.

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