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Industrial structure, energy-saving regulations and energy intensity: Evidence from Chinese cities

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ABSTRACT

Exploring the drivers of declining energy intensity is necessary in order to accelerate the transition to a low-carbon economy in China. To date, studies have typically adopted case analysis to link enterprise features and energy-saving performance. The impact of internal industrial configuration in terms of size and ownership structure on aggregate energy intensity remains to be examined. To fill this research gap, this paper tests the impact of the internal structure of industries on city-level energy intensity, by employing a unique panel dataset of 283 cities for the period 2005 to 2010. The Driscoll-Kraay method and instrumental variable are used to treat residual cross-sectional dependence and endogeneity, respectively. Results suggest that small-scale enterprises exerts a negative effect on energy intensity. A 1% increase in the output-value proportion of small-sized firms will lead to a decrease in total energy intensity of 0.067%. In contrast, the same change by medium enterprises will raise energy intensity by 0.031%. A negative and/or non-significant coefficient suggests that for most energy-intensive large and state-owned enterprises, China's 2006 top-down energy-saving regulation has been quite effective in targeting key energy-intensive enterprises in China. The findings reveal that state-owned enterprises (SOEs) can act as promoters of, rather than barriers to, low-carbon policy implementation in China. Given that the effectiveness of energy-saving regulation will be undermined as a result of diluted regulatory strength in each enterprise, market-oriented energy price reform is proposed as a fundamental driver for guaranteeing a continual decline in energy intensity.

1. Introduction

Energy intensity, defined as energy consumption per gross domestic product (GDP), represents an economy's level of dependence on energy resources. A continuous decline in energy intensity will shape the economic activities of a country towards a more sustainable mode. For a set of comparable countries or regions, higher energy intensity implies greater energy-saving potential, which is feasible both technically and economically. As a large country, China has experienced geographically asymmetrical progress in its economic reforms and implementation of the 'opening-up' policy (Fan, 1997). The varying developmental stages between coastal and inland regions have translated into different resource needs, giving rise to evident disparities in energy intensity at a local level (Ma, 2015). To facilitate a proper selection of policy intervention on energy conservation, it is essential to explore the underlying causes of local disparities in energy intensity. Meanwhile, a top-down energy intensity reduction target was assigned to each province and then to each city in China in 2006. A "veto power" was then attached to energy-saving targets from 2007 to guarantee implementation at local levels. Accordingly, an assessment of the effectiveness of existing energy-saving regulation can help make further improvements to energy-saving policies, towards a more proper regulatory structure.

Instead of adopting a case study, this paper uses a unique panel dataset of 283 Chinese cities from 2005 to 2010 to examine the impacts of enterprise size and ownership structure on aggregate energy intensity. Inner industrial structure related to size includes the share of large, medium, and small enterprises of the industrial total in terms of both gross output value and quantity. Industries can also be divided by ownership structure into SOEs, non-SOEs, and foreign enterprises. Several control variables are included: income level and its quadratic term, FDI, economic structure, energy-intensive industries, and energy prices. In addition to the two-way

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fixed effects estimation method, the instrumental variable and the Driscoll-Kraay consistent standard error methods (Driscoll and Kraay, 1998) are also used to consider issues of endogeneity due to income and residual cross-sectional dependence respectively.

The empirical results validate our main hypotheses that enterprise size and ownership structure exert different impacts on total energy intensity across China. The share of medium-sized enterprises typically pushes up total energy intensity, whereas that of small enterprises has the opposite effect. Given that large enterprises are much more energy intensive than otherwise, a negative coefficient implies that energy-saving regulations targeting large enterprises were effective during the 11th Five-Year Plan (FYP, i.e. 2006–2010). In terms of ownership structure, domestic enterprises have a positive impact on energy intensity. Although SOEs are much more energy intensive, the insignificant coefficient for SOEs demonstrates that energy-saving regulation can be more easily passed on to SOEs than non-SOEs, thanks to the political pecking order. In this process, SOEs typically provide more support to obey energy-saving regulation than non-SOEs do after defining an energy-saving obligation for local authorities. New points can be reached that SOEs can facilitate better implementation of low-carbon policies in China, beyond the traditional view that they typically undermine the effectiveness of environmental regulation (Cai et al., 2016; Hering and Poncet, 2014). Against the background that coal consumption by industries accounts for the bulk of total energy usage in China, the drivers for China's declining energy intensity are primarily associated with measures to reduce coal consumption in key industrial enterprises in the future.

This study contributes to the existing literature in several respects. First, by using a unique city-level[1] dataset, local disparities can be captured to a greater extent than in studies modelling provincial-level data, guaranteeing more solid empirical results. To the best of our knowledge, there have been few studies that uses this dataset to examine the determinants of energy intensity in China. Second, case studies have typically been used to link enterprise size and ownership structure with energy-saving performance (Kostka et al., 2013; Liu et al., 2012; Price et al., 2010; Yang, 2010; Zhao and Ortolano, 2010), but have failed to provide a comprehensive view regarding how inner industrial features affect aggregate energy intensity across China. This study aims to bridge the gap by testing the impacts of enterprise size and ownership structure on energy intensity at an aggregate level. Third, together with target-based energy intensity reduction target for each local authority, a series of energy-saving policies have been promulgated since 2005 in China (Lo and Wang, 2013; Yuan et al., 2011; Zhou et al., 2010; Zhu and Ruth, 2015). This study provides a new perspective on evaluating the effectiveness of energy-saving regulations by comparing the differentiated impacts exerted by firm groups (different by size and ownership) on energy intensity.

The rest of the paper is structured as follows. Section 2 provides a brief literature review. Section 3 introduces the empirical model and estimation methods. Section 4 describes the data. Section 5 reports the empirical results, followed by the discussion provided in Section 6. The last section concludes with several policy implications made.

2. Literature review

A continuous decline in energy intensity will shape the economic activities of a country towards a more sustainable mode. Thus, energy economists have paid considerable attention to exploring the underlying drivers of a decline in energy intensity and its determinants (Adom, 2015; Cornillie and Fankhauser, 2004; Fisher-Vanden et al., 2004; Ma, 2015; Markandya et al., 2006; Metcalf, 2008; Mulder and Groot, 2012; Sadorsky, 2013). For example, Markandya et al. (2006) employed a panel dataset from 1992 to 2002 to investigate the relationship between the energy intensity of 12 transition countries of Eastern Europe and that of the EU15 countries. The estimation results show that the energy intensity of transition countries converges toward the EU average, indicating that technological differences diminish over time (Herrerias and Liu, 2013). Apart from a multinational perspective, national and sub-national studies have also emerged. For example, Adom (2015) used time series data to identity the determinants of declining energy intensity in Nigeria. Several factors, including oil price, FDI, and trade openness, are confirmed to facilitate the reduction.

In the context of China, many studies focus on the determinants of the disparity in energy intensity in China's provinces (Herrerias et al., 2013, 2016; Karl and Chen, 2010; Song and Zheng, 2012; Wu, 2012). Herrerias et al. (2013), for example, investigated the relationship between investment ownership and energy intensity across Chinese provinces, and the findings verified that both foreign and non-state investments play a role in the decline in energy intensity in China. To date, factors such as income level, economic structure, foreign direct investment (FDI), government expenditure, investment ownership, and urbanization rate are identified as principal determinants (Elliott et al., 2013; Herrerias et al., 2013; Jiang et al., 2014; Karl and Chen, 2010; Ma, 2015; Song and Zheng, 2012; Wu, 2012). Specifically, as represented by the industrial or tertiary share of value added in GDP, economic structure has typically exerted a significant impact on regional differences in energy intensity (Herrerias et al., 2013; Jiang et al., 2014; Karl and Chen, 2010; Ma, 2015).[2] The industrial sector consumes the majority of China's energy use, with its share reaching 69.1% in 2010.[3] To the best of our knowledge, few empirical studies examined how key features within the industrial sector determine local-level disparities in energy intensity.

Among the internal industrial features, enterprise size and ownership structure are two of the most relevant and have been examined intensively from the perspective of energy-saving performance at a firm level (Fisher-Vanden et al., 2004; Kostka et al., 2013; Liu et al., 2012; Price et al., 2010; Yang, 2010; Zhao and Ortolano, 2010). Energy-saving barriers faced by individual large-sized, or small- and medium-sized enterprises (SMEs) have been intensively investigated through case studies to reveal a systematic difference in adopting energy-saving measures (Gruber and Brand, 1991; Kostka et al., 2013; Liu et al., 2012; Price et al., 2010; Trianni and Cagno, 2012; Yang, 2010; Zhao and Ortolano, 2010). For small-sized firms, financial barriers might be higher, as banks are biased in favour of large firms (Nagesha and Balachandra, 2006), available energy-saving information might be more limited, and there are not usually even part-time energy experts in a company (Trianni and Cagno, 2012). The ownership structure of a firm can also affect energy-saving performance due to diverse decision-making efficiency and political pecking order. In state-owned enterprises (SOEs), inefficient decision-making and more severe political rent

[1] Note that a city in China refers to the administrative division a tier lower than the provinces. We use more detailed city-level data to model local disparities of energy intensity in China.

[2] Instead of focusing on the determinants of energy intensity, Zhang et al. (2014) examined the determinants of carbon emission intensity via the autoregressive distributed lag (ARDL) modelling techniques. They also found that industrial structure and urbanization are important driving factors.

[3] The ratio was calculated based on China's energy balance sheet drawn from China Energy Statistical Yearbook 2011.