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Regional disparity in energy intensity of China and the role of industrial and export structure

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ABSTRACT

In this paper we decompose the China's regional disparity of energy intensity into the contributions of pure energy intensity gap and the difference in both industrial structure and export structure by trade regimes. Our decompositions suggest that the high energy intensities in western and central regions are mainly attributable to the high sectoral energy intensity, which accounts for more than half of the overall energy intensity gap. In contrast, the low energy intensities in coastal regions are mainly attributable to low sectoral energy intensity and to high proportions of output in relatively "clean" rather than energy intensive industries. A high proportion of processing exports also contribute positively to the low energy intensities of coastal regions, but the magnitude is very small, less than 6%. Our decomposition results provide policy implications for energy saving across Chinese regions.

1. Introduction

Ever since the opening up policy and economic reform in 1978, the Chinese economy has witnessed an economic boom characterized by rapid industrialization. One of the consequences is China's enormous energy consumption and high dependency on energy imports. As the world's largest energy consumer, China alone accounts for 23.0% of global totals consuming 2971 million tonnes oil equivalent (toe) of primary energy in 2014 (BP, 2015). On one hand, the large energy consumption may aggravate the energy crisis facing China given the limited energy supplies. Assuming that China remains at the level of year 2014, China's proved reserves can only sustain for 29.56, 11.92 and 25.72 years for coal, oil and natural gas, respectively. On the another hand, the huge primary energy consumptions together with high dependency on coal also make China the world's largest emitter of Greenhouse Gas (GHG). By 2014, China accounted for 27.5% of global totals emitting 9761 million tonnes of CO_2 (BP, 2015). To meet the objective of the United Nations Framework Convention on Climate Change (UNFCCC) to avoid exceeding a 2 °C global warming limit, China has submitted its pledge ahead the Paris conference, planning to cut its greenhouse gas emissions per unit of gross domestic product by 60–65% from 2005 levels until 2030. Therefore, a significant improvement of energy efficiency is required to achieve the energy saving and emissions reduction goal (see also, Liu et al., 2016; Yang and Teng, 2016).

Another fact about China's energy consumptions is that its regional energy intensity (that is its energy consumption per unit of GDP or output, EI) is very uneven, with coastal regions having far lower energy intensities than central and western regions (Fig. 1a). In 2010, the energy use per GDP of Ningxia was 33.1 tonnes of coal equivalent (tce)/million Yuan, five times of Guangdong at the level of 6.6 tce/million Yuan. This fact implies that eliminating the differences in energy intensities among regions may be a possible way to reduce the total energy consumption. In fact, the literature suggests that up to 30% of energy saving potential at both the aggregate (see, e.g. Rao et al., 2012; Bian et al., 2013; Liu et al., 2016) and sectoral levels (see, e.g., Shao, 2017) can be reduced by eliminating the differences in energy intensities between inland and coastal locations. However, the first important thing to explore is why so large energy intensity gaps among regions exist.

Intuitively, the regional disparity of energy intensity is determined by both the pure energy intensity gap and the difference of industrial structure. Their contributions to the regional energy

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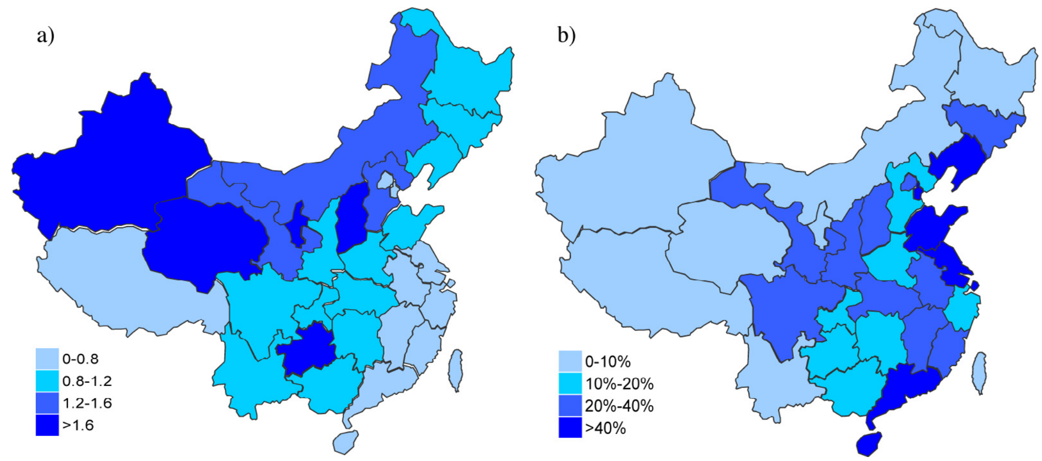

Fig. 1. The regional distributions of (a).energy intensity, 2010, in tonnes of coal equivalent per 10000 RMB of GDP; (b) share of processing exports in total commodity exports, 2010, in%.

intensity disparity has important implications for China's energy saving and emissions reduction policies. If it is the case that the industrial structure contributes substantially to the regional EI disparities, then improvements in overall EI should be the focus of China's energy saving policies. If regional EI differences are not chiefly due to industrial structures but to a "pure" inter-regional energy intensity gap, then an emphasis on energy-related technology transfer across regions could contribute in an important way to energy saving.

Some studies have demonstrated that regional energy intensity is significantly influenced by the industrial structure (see, e.g. Li et al., 2013; Jiang et al., 2014; Ma, 2015; Yan, 2015; Herrerias et al., 2016). However, studies based on a detailed sectoral breakdown are generally lacking because official Chinese energy statistics for regional primary energy use in China are limited to 6 major industry or sectoral groups.[1] In these literatures, the industrial structure is often indicated by the proportions played by industry or services in total GDP, which is a too broad category to give real insight into regional differences in energy intensity. Therefore a re-examination of the contribution of industrial structure to energy intensity differences, one based on a detailed sectoral breakdown, is justified.

Another often neglected factor in the existing literature is the proportion of processing exports in the regional economy.[2] It has been found that processing exports have far lower energy intensities than other production activities, even within the same industry group (see, e.g. Su and Ang, 2010; Dietzenbacher et al., 2012; Jiang et al., 2015). Similarly the distribution of processing exports is also quite uneven among regions, mainly concentrated in the coastal region (Fig. 1b). For example in 2010, over half of South coast exports can be attributed to processing exports, while the northwest share is less than 10%. Su and Ang (2010) have suggested that the low energy intensity of coastal regions in China is attributable to their high proportion of processing exports. However, the literatures – to our knowledge – fails to further quantify how much differences in processing exports contributes to differences in regional energy intensity.

Given the importance of this issue, this paper aims to quantify the impact of both industrial structure and export structure on regional disparity of energy intensity, at a more disaggregated level by employing index decomposition method. To this end, we introduce a unique inter-regional input-output dataset that distinguishes Chinese economy into 8 regions (Northeast, Northern Municipalities, North Coast, East Coast, South Coast, Central, Northwest, and Southwest), 2 production types (processing exports and ordinary productions), and 17 industry groups (IRIOP table for abbreviation, please refer to Appendix table A in Supplementary information for the classification).[3] With this unique dataset, we not only can take into account differences in regional energy intensity at a more detailed sectoral level (from 6 to 17 industry groups), but also account of the differences in regional shares of processing exports. In this context, we argue that our estimates provide more reliable policy implications, by answering the question whether the energy-related technology transfers across regions matters for the energy saving and emission reductions in China as a whole.

The paper is organized as follows. In Section 2 we briefly review the current studies on regional energy intensity; in Section 3 we introduce our model and data sources; in Section 4 we present our decomposition results, and discuss its validity. In Section 5 we provide a sensitivity analysis of the biases of decomposition results when industry group and production type are aggregated. In Section 6 we summarize the paper.

2. Literature review

We roughly divide the relevant literature into two streams. The first stream has paid attention on quantifying regional energy efficiency performance, based on Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis(DEA) methods (e.g. Hu and Wang, 2006; Wei et al., 2009; Wang et al., 2012; Bian et al., 2013; Li and Lin, 2015). They argue the regional energy efficiency should be measured as the total factor energy efficiency (TFEE), with consideration of labor and capital inputs, rather than simple energy intensity (i.e. energy consumption per GDP or output).[4] Hu and Wang (2006), for example, evaluated TFEE of 29 provinces in China for the period

[1] They are Agriculture; Industry; Construction; Transport, storage & post; Wholesale, retail trade, hotel & restaurants; and other services.

[2] The processing exports refer to the business activity of importing all, or part of, the raw and auxiliary materials, parts and components, accessories, and packaging materials from abroad in bond, and re-exporting the finished products after processing or assembly by enterprises within mainland China. In this paper, the processing exports include the productions for both the exports of Processing with imported Materials and the exports of Processing & Assembly.

[3] The region division follows suggestion by State Information Center and National Bureau of Statistics of China when they jointly compiled Chinese inter-regional input-output table. Please refer to Zhang and Qi (2012) for more detail.

[4] More specifically, the TFEE is measured by dividing the required minimum energy input by the actual energy input. The required minimum energy input is indicated by the production frontier where for the same capital and labor input, together