China Economic Review 34 (2015) 225–235

Contents lists available at ScienceDirect

China Economic Review

The energy efficiency advantage of foreign-invested enterprises in China and the role of structural differences

Xuemei JIANG [a,*], Kunfu ZHU [a], Christopher GREEN [b]

[a] Academy of Mathematics and System Science, CAS, Beijing, China
[b] McGill University, Montreal, Canada

ARTICLE INFO

Article history:
Received 23 June 2014
Received in revised form 19 November 2014
Accepted 19 November 2014
Available online 2 December 2014

JEL classification:
D57
Q53

Keywords:
Total energy intensity
Foreign-invested enterprises
Chinese owned enterprises
Final demand structure
Input–output table

ABSTRACT

In this paper, we use a unique input–output table that distinguishes trade mode and firm ownership to discuss the relative advantage of foreign-invested enterprises (FIEs) in Mainland China. It is found that FIEs outperform Chinese owned enterprises (COEs) in terms of total energy intensity by 16.97%, 14.97% and 42.89%, respectively, for the processing, non-processing and overall production in the industrial sector. Further decompositions show that structural differences across industries (and trade mode) contribute positively and account for 65.33%, 26.28% and 81.93% of the relative advantage of FIEs for processing, non-processing and overall production. Failure to capture heterogeneity across trade mode may lead to distortion of the picture of how final demand structure differences influence the energy efficiency advantage of FIEs over COEs in China.

1. Introduction

Ever since the opening up policy and economic reform in 1978, China[1] has developed very rapidly, with an annual growth rate of gross domestic product (GDP) above 9.0% in last 35 years. In 2010, China surpassed Japan and became the world's second largest economy. Meanwhile, China's energy consumption has grown rapidly. In 2010, China's total primary energy consumption reached 106.43 exajoules (EJ/yr). China's massive growth in energy consumption has raised sustainability concerns in both domestic and international presses, since China's energy reserve is far below the level of its consumption. The natural gas and oil reserves of China, for example, only account for 2% and 1.4%, respectively, of world totals. Even China's seemingly abundant coal reserves account for only 11.1% of the global total (BP, 2013).

It is not surprising therefore that China's energy efficiency has long been a topic of investigation. There are two main indicators: (a) single factor energy intensity measured by energy use per unit of GDP/output, and (b) total factor energy efficiency which considers capital and labor inputs as well as energy (see Wang, Zeng, Wei, and Zhang (2012) and Hu (2014) for the recent reviews). There are numerous evaluations of China's temporal energy efficiencies across industries (see, e.g. Sinton & Levine, 1994; Shi, Bi, & Wang, 2010; Zhao, Yang, & Ma, 2014) and over regions (see, e.g., Hu & Wang, 2006; Shi, 2007; Wei, Ni & Shen, 2009; Song & Zheng, 2012). These studies have used either the single or total factor energy efficiency indicators. Additional studies have

* Corresponding author at: Academy of Mathematics and Systems Science, CAS, Siyuan Building (Rm. C512), No. 55 Zhongguancun East Road, Beijing, China. Tel.: +86 10 6261 1259.
E-mail address: jiangxuem@gmail.com (X. Jiang).
[1] Without specification, China in this paper represents Mainland China only.

http://dx.doi.org/10.1016/j.chieco.2014.11.009
1043-951X/

decomposed the factors driving energy efficiency change (see, e.g. Huang, 1993; Sinton & Levine, 1994; Garbaccio, Ho, & Jorgenson, 1999; Fisher-Vanden, Jefferson, Liu, & Tao, 2004; Fisher-Vanden, Jefferson, Ma, & Xu, 2006; Shi, Bi, & Wang, 2010).[2]

Due to a lack of official published data on energy use by ownership, there are relatively few investigations — to our knowledge — that analyze the energy efficiency of foreign-invested enterprises (FIEs) in China. The evidence from other countries suggests that FIEs in developing countries typically have higher energy efficiencies than do their indigenous counterparts (see, e.g. Mielnik and Goldemberg, 2002; Eskeland and Harrison, 2003; Peterson, 2008). As a result, the importance of technology transfer from developed countries to developing countries in energy saving and climate mitigation has been widely recognized (Dechezlepretre, Glachant, Hascic, Johnstone, & Meniere, 2011; Dimitrov, 2010; Ghosh & Watkins, 2009; Ockwell & Mallett, 2012). If this is also the case in China, then there is a substantial potential for China to reduce its energy consumption via technology transfer and/or spillovers from FIEs to Chinese owned enterprises (COEs).

It is likely that many FIEs in China employ more energy efficient technologies, especially as over 80% of FDI inflow to China is sourced from advanced economies such as U.S., EU, Japan, and Chinese Hong Kong, Taiwan and Macau. In this context, policymakers may naturally attach importance to technology transfers from FIEs to COEs.

But the mere observation that FIEs in China have lower energy intensities than COEs does not necessarily mean that FIEs are more energy efficient than COEs in the same industries undertaking similar activities. For example, FIEs in China have very specific final demand structures, ones that reflect the evolution of Chinese policies since the beginning of the reform era at the end of the 1970s. Most FIEs are found in manufacturing and undertake export processing, for which most of the raw materials and components are imported (duty-free) from other countries. FIEs in China are responsible for processing and assembling these components and re-exporting the goods. In 2007, for example, over 2/3 of FIEs' outputs were exported, and among FIEs' exports, export processing accounted for about 70% of the total. Dietzenbacher, Pei, and Yang (2012) have suggested that export processing in China mainly involves package and assembly activities. These activities tend to consume much less energy (and generate less carbon emissions) than the production per unit of 'normal' production (i.e. production other than processing exports, including non-processing exports and production for domestic use).

Thus the overall efficiency advantage of FIEs over COEs might be largely attributable to the high proportion of export processing among FIEs and not to an inherent energy efficiency advantage of FIEs over COEs. But, in addition, it is also possible that FIEs are disproportionately represented in 'clean' (that is, low energy-intensity) industries. This could give the illusion of greater energy efficiency than COEs, and would do so even if it were the case that FIEs are not more energy-efficient than COEs within each industry. These possibilities imply that the relative energy intensity/efficiency performance of FIEs may be distorted. In so doing, the energy-saving gains from public policies that promote technology transfer/spillover in China could be exaggerated.

In order to detect the factors explaining why FIEs in China appear more energy efficient than COEs, we introduce a new input–output table that distinguishes firm ownership (Chinese owned and foreign-invested enterprises) and trade mode (processing exports and normal use). We use this tool to evaluate the energy efficiency advantage of FIEs by each production type. By splitting production type by trade mode, we can quantify the extent to which FIEs outperform COEs due to a 'pure' technology advantage within each industry and trade mode. In this way, we can more adequately address the potential role of FIEs in China's energy saving picture.

In carrying out this task single-factor, rather than total factor energy efficiency is employed, due to a lack of capital and labor statistics by firm ownership. An input–output model is used to calculate the *total* energy intensity (TEI) per unit of final demand, which includes energy use of upstream industries.

The paper is organized as follows: in Section 2 we introduce the model and data compilation; in Section 3 we evaluate energy efficiencies indicated by *TEI* per unit of final demand across firm ownership, trade mode and industries, and decompose the relative advantages of FIEs into their determinants. In Section 4 we summarize our findings and conclude.

2. Methodology: a new energy input–output model

2.1. Methodology

With its detailed description of production chains at the industry level, the Energy Input–Output (EIO) Framework has been widely adopted to analyze energy use issues (see Miller & Blair (2009) chapter 9 for a review). The traditional EIO framework, however, does not distinguish FIEs and COEs and cannot be used directly for our purposes. Production chains and sales structures vary to a large extent between FIEs and COEs in China, even for the same kind of trade mode.

In Table 1 we compare the flow of imports and exports of COEs (including state-owned, collective, and private firms) and FIEs (including both wholly foreign-owned firms and joint ventures) in 2007. It is clear that FIEs tend to use more imported intermediate goods (inputs) than COEs. For each US $1000 imports goods by state-owned enterprises, US $107 is used as intermediates in the production of goods entering into the export processing trade. This estimate compares to US $735 that is used as intermediates in production of non-processing trade and domestic production. In contrast, for each 1000 US$ imports of wholly foreign-owned firms, US$ 581 is used as intermediates for processing trade and only US$ 181 is used in 'normal' production. With respect to sales, the outputs of FIEs are mainly sold as processing exports, while the outputs of COEs are mainly sold as domestic use and non-processing exports. The energy use intensities vary largely as well. China's first economic census indicated that the energy intensity

[2] For more information about China's energy economy and the related studies, please refer to Ma, Oxley, and Gibson (2010), Ma and Oxley (2012) for the throughout reviews.