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China's energy saving potential from the perspective of energy efficiency advantages of foreign-invested enterprises

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ABSTRACT

The paper investigates the energy saving potential associated with firm ownership-related differences in energy efficiency such as those between domestically and foreign-owned firms. Because of a gap in official statistics this topic has barely been touched upon in the scholarly literature. This paper employs a new energy input–output table that distinguishes firm ownership (Chinese owned enterprises, COEs; and foreign-invested enterprises, FIEs) and trade mode (export processing and normal goods production) to analyze the energy efficiency advantage of FIEs in China in 2007. The results show that the total energy intensities of COEs in the industrial sector are generally 5%–35% higher than that of FIEs across industry groups. At an aggregate level, China could save up to 20.3% of its energy use, if industrial COEs could duplicate the energy use efficiency and production technology of FIEs. This gain would require major technology upgrades among COEs.

1. Introduction

More than three decades of rapid economic growth have made China the world's second largest economy and the largest energy consumer. By 2011, China accounted for 9.32% of world gross domestic product (GDP) and 19.76% of world total primary energy consumption.[1] Those shares rose to 12.33% and 22.40% respectively, in 2013. One of the consequences is that the total primary energy consumption per dollar of China's GDP in purchasing power parities (i.e. energy intensity), was almost twice that of the EU or Japan, and 46% higher than that of the world average in 2010 (U.S. Energy Information Administration, 2012). Thus the prospect that China could adopt energy saving technologies has received a great deal of attention both inside and outside the country.

Numerous sectoral and regional studies of energy efficiency have explored China's energy saving potential at the macro-economy level (see, e.g. Shi, 2007; Rao et al., 2012; Bian et al., 2013) or specific industries, such as chemical (Tian et al., 2012), paper production (Lin and Moubarak, 2014), iron and steel (Zhang and Wang, 2008), cement (Hasanbeigi et al., 2013), transportation (Wang et al., 2014), buildings (Xu et al., 2013), petroleum refining (Liu et al., 2013) and electricity (Meng et al., 2014). One often neglected issue is the size of and explanations for the energy efficiency gap between foreign-invested enterprises (FIEs) and Chinese owned enterprises (COEs). To be sure, several studies have found that FIEs in developing countries generally have higher energy efficiency than their indigenous counterparts (Mielnik and Goldemberg, 2002; Eskeland and Harrison, 2003; Peterson, 2008; Jiang et al., 2014). Along similar lines, a number of studies using aggregate foreign direct investment (FDI) as a proxy found a positive impact of FDI (and FIEs) on the Chinese average level of energy efficiency (Fisher-Vanden et al., 2004; Yue et al., 2011; Zheng et al., 2011; Guo et al., 2013; Elliott et al., 2013). These results suggest that COEs may improve their energy efficiency and consequently reduce their energy consumption, by learning directly from FIEs or indirectly through technology spillover. However, due to a lack of data on energy use by firm ownership, this potential source of energy saving gain has not been well addressed in the literature.

Here we employ a new energy input–output table characterizing firm ownership (i.e. FIEs and COEs) and trade mode (i.e. processing exports and normal productions), to quantify the energy saving potential derived from whatever energy-related technology advantage FIEs have over COEs. Since inbound FDI mainly flows into China's industrial sector, the paper restricts itself to the energy saving potential when the energy use pattern of COEs in the industrial sector (i.e. mining, manufacturing

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[1] The GDP data are taken from the World Bank, and the energy consumption data are taken from BP Energy Statistics. In 2013, the Chinese GDP was 9240 billion US dollars, and the Chinese total primary energy consumption was 2852 million tons oil equivalent.

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and utilities) mirrors that of FIEs. The sharpened focus is nevertheless representative of China as a whole as its industrial sector accounted for about 70% and 95% of China's production energy and coal use, even though that sector accounted for only 50% of China's GDP in 2010.

The paper is organized as follows: in Section 2 we introduce the model and data compilation; in Section 3 we analyze the energy intensity gap among FIEs and COEs, and discuss the resultant energy saving potential; and in Section 4 we summarize our findings and conclude.

2. Methodology: a new energy input–output model distinguishing firm type and trade mode

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 and Blair (2009) chapter 9 for a review). The traditional EIO framework, however, does not distinguish the heterogeneity of firm ownership[2] and trade mode, which may lead to considerable bias when it comes to China. In order to measure the domestic value-added content of Chinese exports, a series of pioneering papers, including those by Lau et al. (2006), Dean et al. (2011), Koopman et al. (2012) and Chen et al. (2012), distinguish Chinese production activity by trade mode (export processing and normal production) in IO tables.[3] The difference may be crucial for the energy-climate issues as well. For example, Dietzenbacher et al. (2012), Su et al. (2013) and Weitzel and Ma (2014) have found that the CO_2 emissions embodied in China's exports would be overestimated if the distinction of production activities between processing and non-processing exports is not appropriately addressed.

These pioneer works however barely deal with the heterogeneity of firm ownership. The production chain and sales structure vary to a large extent between FIEs and COEs in China, even for the same product. According to a recent input–output survey conducted by the National Bureau of Statistics for the year 2007, for each 1000 Yuan of manufacturing output (excluding agriculture and services) COEs required 700 Yuan domestic intermediate inputs and 62 Yuan of imported intermediate inputs, while FIEs required only 528 Yuan of domestically produced intermediates but 283 Yuan imports per 1000 Yuan of output. For each 1000 Yuan of sales, COEs obtained 808 Yuan by sales inside China and 192 Yuan by exports, while FIEs obtained only 284 Yuan by sales inside China and 716 Yuan by exports. The energy intensities vary as well. The first economic census (for the year 2004) indicated that FIEs were 5%–70% less energy intensive than COEs in producing the same amount of specific industrial outputs in 2004 (See Appendix Table A for the energy intensities by firm ownership and industry group in 2004). Out of 30 broad industry groups, there are only two exceptions, tobacco and refined petroleum & nuclear fuels, for which the energy intensities of FIEs are higher than that of COEs. Since FDI is restricted in these two industries,[4] the scale of their FIEs is very small, with negligible influence on the overall energy intensity advantage of FIEs.

The energy intensity advantage of FIEs over COEs, however, could be largely attributable to the fact that FIEs in China mainly involve in processing activities. In general, export processing requires much less energy per unit of output than does normal production (Dietzenbacher et al., 2012; Su et al., 2013). According to customs statistics, export processing accounted for above 70% of FIEs' exports in China during the years 2000–2010. In contrast, export processing accounted for less than 35% of COEs' exports.[5]

To quantify the energy efficiency advantage of FIEs and the resultant energy saving potential, we start from a new non-competitive input–output table[6] compiled by Ma et al. (forthcoming) which distinguishes trade mode and firm ownership. The basic scheme is described in Table 1. On an ownership and trade mode basis, four classes of production are distinguished: normal production (i.e. non-processing exports and domestic use) by COEs (CN); normal production by FIEs (FN); processing exports by COEs (CP); and processing exports by FIEs (FP). The new IO table considers not only the heterogeneity of firm ownership (COEs versus FIEs), but also the differential production roles played by COEs and FIEs in terms of export processing and normal productions. In the new IO table, X represents gross output, EX represents gross exports, Z represents intermediate inputs, Y represents total final demand except for exports, M represents imports, V represents value added, and E represents energy use. The superscripts C and F represent COEs and FIEs, respectively, and P and N represent processing and normal production, respectively. For example an element in Z^{CFP}, namely, denotes the intermediate inputs produced by COEs in industry *i* and used by FIEs in industry *j* for processing exports. It should be noted that Chinese regulations require that the imported inputs into the processing trade are tariff-free only if the goods they produce are exported (that means the imported inputs are effectively re-exported as outputs in the processing trade). Therefore the (row) sales of processing exports (P) of class l (=C, F) are zero in intermediate use and final domestic use. Hereafter, Table 1 is abbreviated as the DFPN table. Aggregation over the ownership and trade mode in the DFPN table yields the ordinary non-competitive national IO table that distinguishes domestic use and imports.

In extending the ordinary Chinese national IO table to account for different input usage across ownership, we take full advantage of the new IO data compiled by Ma et al. (forthcoming). The starting point of Ma et al. (forthcoming) is the official IO table complied by the National Bureau of Statistics of China (NBSC) for year 2007. Second, they matched *two* large industrial firm-level datasets: one is the Annual Surveys of Industrial Production (ASIP) with detailed firm-level information on firm ownership, outputs, value-added, etc., complied by NBSC; the second dataset is the firm-level export and import data for 2007, from China's General Administration of Customs (CGAC), which provides information on firm-specific import of intermediate inputs and total export. The match of firms from these two datasets generates a sample with 301,774 industrial firms. Third, Ma et al. separated these industrial firms into four production types (by ownership and trade mode). Then they obtained value added and output data for each of the four production types (by firm ownership and trade mode) and by sectors. Fourth, based on the trade statistics from CGAC, they estimated the data of exports, imports for final demand, and

[2] The current Chinese statistical system divides the enterprises into three main types by their registration status, those that are Chinese owned enterprises (COEs); Hong Kong, Macao and Taiwan-invested enterprises (HMTs); and Foreign-invested enterprises (FIEs). More specifically, COEs include state-owned, collective enterprises, joint-stock cooperative enterprises, joint ventures, limited liability companies, joint stock limited and private enterprises. FIEs include foreign joint ventures, Sino-foreign cooperative enterprises, wholly foreign-owned enterprises and joint stock limited company, for which the foreign capital accounted for more than 25% of registered capital. HMTs are defined in a similar manner as FIEs. In the present paper, HMTs and 'pure' FIEs are referred to as FIEs since they have similar technologies.

[3] Export processing refers to the trade where firms import parts and components from abroad under favorable tariff treatment, and assemble them for export. In this paper, we use 'normal production' to refer to production activities other than export processing, including production for domestic use and non-processing exports.

[4] See Catalogue for the Guidance of Foreign Investment Industries (2011 version), available at the official website of the Ministry of Commerce, Peoples' Republic of China, http://english.mofcom.gov.cn/article/policyrelease/aaa/201203/20120308027837.shtml.

[5] See Appendix Table B for detailed statistics on trade flows by firm ownership.

[6] The Chinese national input–output table released by the National Bureau of Statistics of China (NBSC) is a competitive input–output table, in which intermediate inputs include both domestically and imported products. When a competitive input–output table is employed, the energy use embodied in the final demand based on an EIO model would include both the Chinese own (domestic) energy use linked to the productions of final demands and foreign energy use embodied in China's imports. This is not the case for a non-competitive input–output table, however, in which intermediate inputs include only the domestic products. As our focus in this paper is Chinese own (domestic) energy use, we restrict ourselves to a non-competitive input–output table in this paper. For the readers who are interested in the detailed difference between competitive and non-competitive input–output models, please refer to Su and Ang (2013).