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The potential for reducing China's carbon dioxide emissions: Role of foreign-invested enterprises☆

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ABSTRACT

In this paper, we discuss the possible role of foreign-invested enterprises in the reduction of China's carbon dioxide emissions by employing a time-series of unique input–output tables that distinguishes firm ownership and processing exports. The comparisons of carbon emission intensities indicate that although Chinese-owned enterprises experienced much faster upgrades of emission-intensity-related technologies since 1992, foreign-invested enterprises continued to outperform Chinese-owned enterprises by 10–110% in terms of sectoral emission intensities until 2010. Therefore, China may have reduced its carbon dioxide emissions by 1200–1400 million tonnes during 1992–2010, if Chinese-owned enterprises could have duplicated the emission-intensity-related technologies of the corresponding foreign-invested enterprises. More specifically, China should prioritize the adoption of the thermal and wind power generation technologies of the U.S., the photovoltaic system and related national electric grid upgrading technologies of Germany, the mineral and metal production and carbon emissions control technologies of Japan, and the machinery and transportation technologies of Europe. In an ideal scenario that assumes Chinese-owned enterprises would have eventually adopted the world's leading technologies, China could have reduced its total carbon dioxide emissions by about 50% in 2010. From a policy perspective, as foreign-invested enterprises are quite widespread; they can serve as very effective and efficient channels for technology transfer from developed to developing countries.

1. Introduction

Ever since the economic reforms in 1978, China has experienced unprecedented economic growth, with an annual GDP growth rate at 9.77%. Due to high dependency on coal for energy consumption, this economic growth also led to burgeoning growth of carbon dioxide (CO_2) emissions in mainland China (abbr. as China in the following). In 1990, China emitted only 2178 million tonnes (Mt) of CO_2, accounting for 10.12% of the world total. In 2010, these emissions have reached 7997 Mt, accounting for 25.38% of the world total (U.S. Energy Information Administration, 2014). Given China's significant contribution to carbon emissions, climate change researchers have extensively studied potential ways to reduce China's CO_2 emissions. Many studies have focused on the positive contributions of "backward" regions and sectors with high carbon intensities toward carbon intensity reductions as well as the role of renewable energy sources (Wu et al., 2005; Fan et al., 2007; Guan et al., 2008; Zhang and Cheng, 2009; Du et al., 2013; Liao and Cao, 2013; Xu et al., 2014a). Significant importance is given to reducing carbon intensity; as of 2011, in terms of purchasing power parities, China's economy was still thrice as carbon intensive as those of Japan and Europe and twice as carbon intensive as that of the U.S. (Fig. 1a).

Some international organizations and agreements, such as the Kyoto Protocol's Clean Development Mechanism (CDM), the UN's Global Environment Facility (GEF) under the UNFCCC framework, the World Bank's Clean Technology Fund (CTF), have been focused on financing technology transfers from developed countries to developing countries (see Ghosh and Watkins (2009) for a thorough review). One often-neglected aspect, however, is the role of foreign-invested enterprises (FIEs) in technology transfer. Evidence from other developing countries suggests that FIEs, which are mostly sourced from developed countries, generally pollute less than their indigenous counterparts in developing countries for the same

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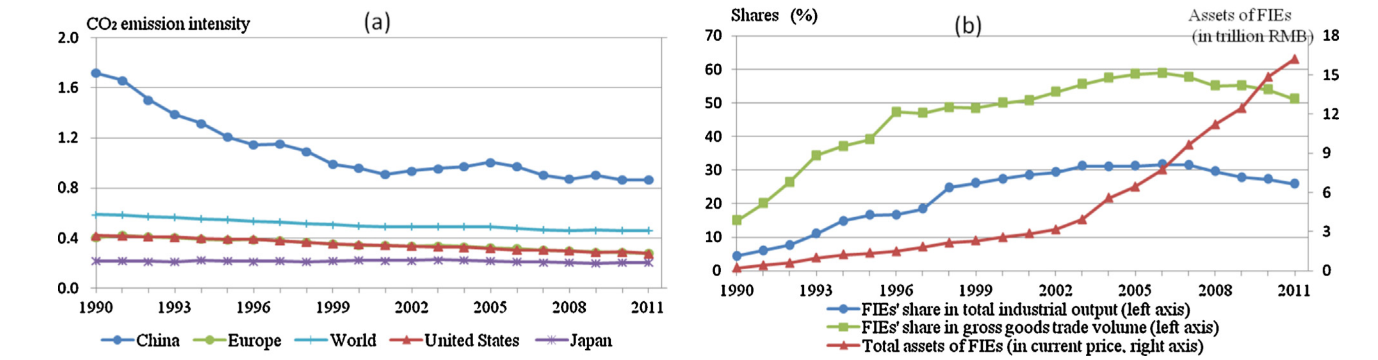

Fig. 1. (a) Comparisons of CO_2 emission intensities between China, the main advanced economies, and the world average using purchasing power parities (in tonnes of CO_2 per thousand year 2005 USD). (b) The performance of FIEs in China: FIEs' share in China's total industrial output of scale-above enterprises (+491% between 1990 and 2011), FIEs' share in China's gross goods trade volume (+240% between 1990 and 2011), and total assets of FIEs in China (in current trillion RMB).
(a) Data are sourced from U.S. Energy Information Administration (http://www.eia.gov). (b) Data are sourced from the National Bureau of Statistics of China (http://www.stats.gov.cn).

output production (Mielnik and Goldemberg, 2002; Eskeland and Harrison, 2003; Peterson, 2008). This might also be the case in China, as over 80% of foreign direct investment (FDI) inflows to China come from advanced economies such as Japan, the U.S., the European Union, and the Special Administrative Regions of Hong Kong, Macau, and Taiwan. Due to the lack of official statistics on energy use and air pollution by firm ownership, however, to our knowledge, hardly any studies have discussed the CO_2 reduction potentials of China from the viewpoint of the size of the emission intensity gap between FIEs and Chinese-owned enterprises (COEs).

To fill the gap, numerous studies have analyzed the statistical relationship between China's CO_2 emissions and aggregate foreign direct investment (FDI) at the macro level. Based on econometric estimations, these studies suggest a positive spillover of FDI (and FIEs) on reducing energy consumption and CO_2 emissions in China (Liang, 2008; Elliott et al., 2013; Lee, 2013; Zhang et al., 2014). Using unpublished firm-level data, Wang and Jin (2002) and Jiang et al. (2014a) found that FIEs in China polluted less than state-owned enterprises (SOEs) in 1999 and 2006–2007, respectively. All the above-mentioned studies, however, fail to capture temporal changes in the emission intensity gap between FIEs and COEs. In the 1990s, FIE-related outputs and trade continuously expanded in China, and in the 2000s, FIEs persistently accounted for more than 25% and 50% of China's total industrial output of scale-above enterprises (that with annual main operating revenues above 5 million RMB) and goods trade, respectively (Fig. 1b). Meanwhile, China has significantly reduced its CO_2 emission intensity, particularly in the 1990s. In contrast, the emission intensities of advanced economies remained relatively stable (Fig. 1a). Accordingly, there arise a series of questions: Did the CO_2 emission intensity gap between COEs and FIEs decrease over the past two decades? If so, to what extent did it decrease, and did this rate vary from the 1990s to after 2000? Assuming the same decreasing rate persisted, when would China catch up with other developed countries in terms of emission intensity? More importantly, how does this relate to China's potential for CO_2 emissions reduction?

By taking into account the heterogeneity of trade mode and firm ownership, this paper adapted the traditional environmental input–output (EIO) framework, to answer these questions. The use of the EIO model has been widely accepted to trace CO_2 emissions along the production chain (Davis et al., 2011; Peters et al., 2012; Feng et al., 2013; Kanemoto et al., 2012, 2014; Lenzen et al., 2013). The traditional EIO model, however, fails to consider the heterogeneity of firm ownership and thus is unable to stress upon the role of FIEs in China's emissions. In addition, China is characterized by a high proportion of processing exports (exceeding 50% of China's gross exports), for which firms import parts and components from abroad under favorable tariff treatment and assemble them for export. As a result, the productions of processing exports have much lower energy consumption and CO_2 emission intensities than normal productions. Without appropriate distinction of firm and trade type, the traditional EIO model may distort the picture of China's CO_2 emission patterns (Dietzenbacher et al., 2012; Su et al., 2013; Jiang et al., 2014b). Therefore, we adapted the traditional EIO model and compiled a time-series of "new" environmental input–output tables that distinguishes firm ownership (i.e., distinguishes FIEs from COEs) and trade mode (i.e., distinguishes processing exports from normal production), to study the issues pertaining to China's emissions. To our knowledge, this is the first time that the heterogeneity of firm ownership has been considered in the EIO framework. To reflect the temporal changes in China's context, our study covers the period 1992–2010, and we have compiled a series of "new" input–output tables for the benchmark years, namely the years when official survey-based input–output tables were available for China (1992, 1997, 2002, 2007 and 2010) (NBSC, 2014).

The paper is organized as follows. In Section 2, we describe the new environment input–output (EIO) model and related data compilations. In Section 3, we analyze the emission intensity gap between FIEs and COEs and changes to it from 1992 to 2010. In Section 4, we introduce a series of scenarios that assume COEs could use technologies as advanced as that used by FIEs, to discuss the potential for CO_2 emissions reductions in China. In the process, we also differentiate FIEs by their source country to provide more specific policy implications. In Section 5, we summarize our findings and conclude the paper.

2. Method and data

Given that the production of processing exports emits relatively less CO_2, previous studies have suggested that an input–output table distinguishing trade modes, rather than the traditional EIO model, should be employed when measuring CO_2 emissions embodied in China's exports (see, e.g., Dietzenbacher et al., 2012; Su et al., 2013; Weitzel and Ma, 2014). Considering the heterogeneity of firms, Ma et al. (2015) further distinguished firm ownership, in addition to trade mode, to measure the gross national income linked to China's exports. In this paper, we adapt the table presented by Ma et al. (2015) and classify production in China into three classes: normal production by COEs (C), normal production by FIEs (F), and processing exports (P) (hereafter abbreviated as "CFP table"). The adaption is mainly based on two