Journal of Cleaner Production 204 (2018) 607–617

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Does industrial transfer within urban agglomerations promote dual control of total energy consumption and energy intensity?

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ARTICLE INFO

Article history:
Received 26 March 2018
Received in revised form
28 August 2018
Accepted 31 August 2018

Keywords:
Industrial transfer
Dual control
Total energy consumption
Energy intensity
Multi-regional input-output
Beijing-Tianjin-Hebei urban agglomeration

ABSTRACT

As the world's largest energy consumer, China has set the dual goal of controlling both its total energy consumption and intensity in the 13th Five-Year Plan. As one of the most economically active types of regional units in China, urban agglomerations, composed of adjacent cities with close trade interlinks, play a vital role in energy consumption. Existing studies have provided empirical evidence of industrial transfer as a consequence of urban agglomerations, while a few have focused on whether such industrial transfers could promote the dual goal of controlling both total volume of energy consumption and intensity of all the cities within an urban agglomeration. To bring clarity to this issue, this paper attempts to measure industrial transfer and its impact on total energy consumption and intensity of the Beijing-Tianjin-Hebei urban agglomeration by developing a multi-regional input-output model. The results indicate there is mutual industrial transfer between any two cities within the urban agglomeration. Consequently, total energy consumption has increased by 6258.78 thousand tons of standard coal equivalent while energy intensity has declined by 0.19 tons coal equivalent/thousand Yuan. Finally, a few policy recommendations about dual control of total energy consumption and intensity for urban agglomerations have been proposed. Our study enhances understanding of the critical role of industrial transfer in executing dual control of total energy consumption and energy intensity of urban agglomerations, thus assisting policymakers in finding ways to achieve sustainable urban transitions.
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1. Introduction

As one of the largest energy consumers, China attaches great importance to energy conservation. In the Comprehensive Work Plan for Energy Saving and Emission Reduction in the 13th Five-Year Plan released in 2017, China first proposed to establish a control mechanism for achieving its dual goal of reducing total energy consumption and intensity. That is, by 2020, the national energy intensity (energy consumption per unit of GDP) will be 15% lower than that in 2015. In addition, total energy consumption is kept within 5 billion tons of standard coal equivalent. A shift from controlling energy intensity in the past to controlling total energy consumption and intensity shows the Chinese government's firm determination to implement its agenda for energy conservation and environmental protection.

The target for the dual control of total energy consumption and intensity in the 13th Five-Year Plan has been decomposed into various regions in China. As one of the most dynamic and potential regional units in China (Chen et al., 2017), urban agglomeration is the main unit of energy consumption, and it also has the highest energy consumption intensity. Adjacent cities with close economic links have become increasingly reliant on each other in energy consumption (Wang and Chen, 2016). Industrial transfer is the most direct economic link in urban agglomerations. Thus, it is necessary to evaluate whether industrial transfer within an urban agglomeration promotes dual control of total energy consumption and intensity.

Industrial transfer is the inevitable outcome of economic

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https://doi.org/10.1016/j.jclepro.2018.08.342
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development. Since World War II, several large-scale industrial transfers have happened worldwide. In the 1950s, labour-intensive and resource-based industries were transferred from the United States to Japan and Germany as foreign direct investment or international trade. In the 1970s and 1980s, these industries were transferred from Japan to the Southeast Asian countries and regions including Hong Kong, Taiwan, Singapore, and South Korea. Since the 1990s, large-scale industrial transfers have taken place from developed countries, such as the United States, Europe, and Japan to China, which has become the 'world's factory'. With the practice of international industrial transfer continued, studies on international industrial transfer began in the 1930s (Xu et al., 2017), and several related studies have continued to emerge (Akamatsu, 1962; Vernon, 1966; Kojima, 1978; Lewis, 1978; Krugman, 2002). Some researchers (Abbes et al., 2015; Omri and Kahouli, 2014; Rahman and Mamun, 2016) revealed the positive effects of industrial transfer on economic growth. Meanwhile, the adverse effects of energy consumption transfer in the course of industrial transfer began to attract attention. Some researchers provided evidence for the transfer of embodied energy consumption that may lead to an increase in total energy consumption of the host country which accepts industrial transfer (Omri and Kahouli, 2014; Yang et al., 2014). However, this view was challenged by other studies with the argument that industrial transfer can reduce energy consumption or energy intensity by promoting technological progress in the host country (Nadia and Seema, 2016; Li and Qi, 2016).

While China accepts transfer of international industries from developed countries, industrial transfer between domestic regions also exists due to significant regional differences. This phenomenon of regional industrial transfer has begun to attract attention since the 1990s (Cui, 1990). On the one hand, regional industrial transfer is likely to promote economic growth of the transfer-in region (Yuan, 2013). On the other hand, it also increases the region's energy consumption (Zhang et al., 2013, 2016). Therefore, its impact on reducing energy intensity may be partially positive (Pan et al., 2014) and partially negative (Wang et al., 2013). Most of the Chinese studies on regional industrial transfer and its impact on energy consumption focused on eight regions (Xiao et al., 2014), or Eastern, Central, and Western regions (Wang et al., 2013), or the 30 provinces (Xu et al., 2017). A few studies have focused on urban agglomerations such as the Yangtze River Delta (Yuan, 2013) and the Pearl River Delta (Chen et al., 2017).

At present, no agreement has been reached on how to measure industrial transfer (Yin et al., 2016). Many studies adopted foreign direct investment (FDI) to represent international industrial transfer (Fujita and Hu, 2001; Wei et al., 2009; Christian, 2013). Some researchers used the Gini coefficient (Wen, 2004; Jin et al., 2016), Herfindahl index (Zhang and Liang, 2010) or Location Quotients (Feng et al., 2010; Savona and Schiattarella, 2004) to measure regional industry transfers. Input-output analysis has been widely used to measure industry transfer between countries or regions. Compared with other methods mentioned above, input-output analysis is more comprehensive in considering the input and output relationship between industries, and provides accurate estimates of results (Wiedmann, 2009; Weinzettel et al., 2014). The transfer of industries or polluting industries among the eight regions of China was measured using input-output models (Liu et al., 2011; Yin et al., 2016). The input-output method, including SRIO (Huang and Zhao, 2018) and MRIO (Pan et al., 2018; Wang et al., 2017; Deng et al., 2016; Román et al., 2016) models, is further used to measure energy consumption embodied in the process of industrial transfer (Zheng et al., 2011; Yang et al., 2014; Wu and Chen, 2017; Zhang et al., 2013, 2016).

This paper proposes a framework for assessing industrial transfer between cities within the urban agglomeration using a multi-regional input-output (MRIO) model and further measures the impact of industrial transfer on total energy consumption and intensity of the urban agglomeration. The contributions of this paper to the literature are: (a) defining the industrial transfer between cities within urban agglomeration from the perspective of final demand; (b) compiles the MRIO table for the BTH (Beijing-Tianjin-Hebei) urban agglomeration in 2012 by using the Gravity Model; and (c) applying MRIO analysis to measure industrial transfer and its impact on total energy consumption and intensity in urban agglomeration.

The remainder of this paper is organized as follows. Section 2 gives the definition and measurement of industrial transfer between cities within the urban agglomeration from the perspective of final demand. Section 3 applies the MRIO method to measure the change in total energy consumption and intensity due to industrial transfer. Section 4 presents the results of an empirical study using 2015 data for the BTH urban agglomeration. Section 5 presents the main conclusions of the study and policy implications.

2. Definition and measurement of industrial transfer

2.1. Definition of industrial transfer in an urban agglomeration

Urban agglomerations are cities that are based on a megacity, with at least three or more metropolitan areas or large cities in a given geographical area (Fang et al., 2018). Urban agglomerations are important carriers to participate in the transfer of world or national economic centres (Fang, 2014). Cities are highly integrated within an urban agglomeration (Fang and Yu, 2017). The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China articulates the development of 19 urban agglomerations including accelerating the Beijing, Tianjin, and Hebei cluster. Industrial transfer promotes reshaping or coordinating urban agglomerations. By actively undertaking industrial transfers, cities can marshal key resources and gradually form growth poles. When the economy develops to a certain degree, it will radiate outward through industrial transfer and drive the development of other neighbouring cities.

Although there are several definitions of industrial transfer, there is no consistent concept. The definition of industrial transfer can be divided into two categories: narrow sense and broad sense. The former mainly refers to spatial migration or expansion of industrial production facilities, such as relocation of enterprises between two places or direct investment from one area to another. In a broad sense, industrial transfer is the result of re-selection of industrial location caused by the growth or decline of competitive advantage among interregional industries during a certain period; eventually, regional division of labour and interregional trade are formed. Some scholars consider industrial transfer as the process of changing industrial output caused by changes in demand between regions (Liu et al., 2011; Yin et al., 2016).

From the perspective of final demand, this paper defines industrial transfer between cities in the urban agglomeration as the output of one city caused by final demand from another city. Assume that there are two cities (C1 and C2) in the urban agglomeration. There is trade between C1 and C2. As shown in Fig. 2, total output of C1 (TO^1) has four components: D^1 (final demand of C1); P^1 (intermediate demand of C1); D^2 (final demand of C2); and P^2 (intermediate demand of C2). Further, intermediate demand P^1 can meet the final demand of C1 (D^{11}) as well as that of C2 (D^{21}). Moreover, intermediate demand P^2 can meet the final demand of C2 (D^{22}) as well as that of C1 (D^{12}). Thus, based on the final demand perspective, the amount of industrial transfer from city 2 to city 1 equals the output of city 1 resulting from the final demand of city 2

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