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Evaluating carbon dioxide emissions in undertaking offshored production tasks: the case of China

Yanfang Lyu*

School of Mathematics & Center for Econometric Analysis and Forecasting, Dongbei University of Finance and Economics, Dalian 116025, China

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ABSTRACT

Emerging economies like China, India, and Mexico are becoming the world's manufacturing leaders through the engagement in offshoring production activities. In achieving this status, however, they have met with difficult environmental issues. This paper features an analysis of industry-level panel data to examine the link between different offshoring tasks in China and carbon dioxide emissions. Through this analysis, the environmental effects of offshored production are addressed. Specifically an input–output model is presented, thereby quantifying offshored production tasks in China. The results show that iron and steel, nonferrous metals (IS) and chemicals (CH) generate the most carbon dioxide during production of processed goods. Additionally, electrical machinery (EM) and general machinery (GM) generate a higher amount of carbon dioxide during production of parts and components. The results also show that those industries characterized by higher energy consumption have higher carbon dioxide (CO_2) emissions induced by offshoring. Given these results, it seems that any solutions geared towards reducing the energy consumption of entire manufacturing industries would be useful. Furthermore, the results of the analyses presented here indicate that China would be responsible for working with developed countries to reduce carbon dioxide emissions through cooperative environmental regulation. A globalization perspective is adopted to offer unique insight into the environmental issues faced by China. The results of this paper would provide quantified, actionable information for formulating practical industrial policies geared towards reducing carbon dioxide leakage.

1. Introduction

Offshoring, which is defined as the movement of home-based operations (e.g., production, sales, marketing, research and development) to foreign locations, has become increasingly common among today's globalized economies (Fleury and Fleury, 2009; Zorzini et al., 2014). Past research on the effects of offshoring has traditionally focused on the impact of economic factors, including productivity and employment (e.g., Paul and Yasar, 2009; Mitra and Ranjan, 2010; Schworer, 2013). More currently, however, researchers have paid increasing attention to offshoring's effects on the environment (Cadarso et al., 2010; Levinson, 2010; Michel, 2013). Although this line of research has been explored in a general sense, there has been little to no research to evaluate the effects of developed countries' offshoring production activities on ecological factors in countries with emerging economies.

Since China's accession to the World Trade Organization (WTO) in 2001, it has emerged as a popular destination for offshoring (Friedman, 2005). As such, it has become one of the most prominent production locations (Yan and Yang, 2010; Lv and Wang, 2012). This position comes at a cost, however, as China has become the world's largest emitter of anthropogenic air pollutants. A large portion of Chinese emissions result from manufacturing goods for foreign countries (Lin et al., 2014). As a result of these emissions, substantial amounts of Chinese pollution has traveled to other countries (including the United States) via the atmosphere.

In this paper, a new measurement tool is presented for illustrating the link between developed countries' offshoring of production activities to emerging economies and carbon dioxide (CO_2) emissions. This new tool, dubbed the "offshoring undertaking index", results from the use of an import-use matrix of input–output (I–O) table with embodied intermediate export data. This index will quantify the environmental effects of offshore production tasks both collectively and individually across industrial sectors.

Results of the analysis show that industries for which production tasks related to processed goods and parts and components are

* Tel.: +86 13478437832; fax: +86 411 84711610.
E-mail address: yanfang902@dufe.edu.cn.

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sent offshore generate more CO_2 emissions than other industrial sectors. The iron and steel, nonferrous metals, and chemical sectors generate substantial amounts of CO_2 emissions during production of processed goods because of its higher percentage of undertaking offshored tasks, and the sectors of electrical machinery and general machinery are generating a higher amount of CO_2 during production of parts and components offshored to China.

To address the issues outlined above, I have organized this paper into a series of interrelated sections. In the following section, I review extant literature as the conceptual basis for the research performed here. Following this, I develop the import-use matrix for the input–output model in Section 3. In Section 4, I describe the methods employed to collect data, outline and discuss the results of the analyses. In Section 5, I offer some concluding remarks.

2. Literature review

Some researchers have described Offshoring as one of the strongest and most influential trends in today's global economy (Rusten and Bryson, 2010), as well as defining phenomena of 21st century manufacturing. Given its prominence for contemporary companies, offshoring has attracted significant attention in academic, business, and social circles in both developed and developing economies (Da Silveira, 2014).

"Offshoring" is generally defined as foreign outsourcing (Feenstra, 2008). The Organization for Economic Cooperation and Development (OECD, 2007) clearly distinguishes between outsourcing and offshoring; Offshoring describes the outsourcing of tasks abroad, and covers two kinds of transferring activities: offshoring in-house and offshoring outsourcing. Offshoring in-house refers to the complete transfer of production activities abroad, but within the same group of enterprises. Offshoring outsourcing refers to the transfer of production activities to foreign, non-affiliated enterprises. In addition, offshoring can be distinguished as being related to production or services. Production offshoring can be carried out internally (offshore in-house production sourcing) or externally (offshore production outsourcing).

In recent years, production offshoring has become an increasingly viable option for firms of all sizes. Given this surge in interest in production offshoring, researchers and practitioners have begun to engage in discussions related to the potential risks and benefits of offshoring to developing countries (Kinkel and Maloca, 2009). Recent increases in production offshoring have resulted from the fragmentation of production processes or tasks, international distribution of manufacturing processes that add value to goods, and the creation of global supply chains between the United States, European countries, Japan, China, India, and other east Asian nations (Ahn et al., 2008; Wakasugi et al., 2008; Cadarso et al., 2010).

Whereas some research has focused on offshoring more generally, some scholars have investigated the different kinds of tasks that have been offshored as a result of trade liberalization and the development of various information technologies (Ito et al., 2007). The offshore execution of these tasks has positively contributed to growth in productivity among firms that engage in it (Ito et al., 2008). Grossman and Rossi-Hansberg (2008) proposed a theory of the global production process that identifies a productivity effect of task trade that benefits the factor whose tasks are more easily moved offshore. The authors concluded that in contrast to the distributional conflict that can result from reductions in the costs of trading goods, reductions in the costs of trading tasks can stimulate shared gains for all domestic factors. Lv and Wang (2013) disaggregated offshoring production into three principal types of offshoring tasks. These tasks respectively relate to primary goods, processed goods, and parts and components.

Some have suggested that an outsourcing index can be useful for illustrating the tendency for firms to engage in foreign offshoring. Feenstra and Hanson (1996, 1999), for example, operationalize outsourcing as the share of total purchases of non-energy materials that can be characterized as imported intermediate input. In turn, imported intermediate input (for a given industry) as the value of input purchases from each supplier industry multiplied by the ratio of imports to total consumption (imports plus shipments) in the supplier industry across all supplier industries. Ahn et al. (2008) quantified foreign outsourcing using information related to imported inputs from an input–output table for Japan and Korea. Imported intermediate inputs can be obtained directly from this input–output table.

In the 21st century, offshoring has become a key objective associated with China's industrial development. To this end, some researchers have claimed that China has already become "the whole world's manufacturing center" through offshoring (Lv and Wang, 2012). Given its prominence in Chinese industrial development, many researchers have already sought to evaluate the effects of offshoring production on developing countries' (like China's) domestic growth, productivity, or employment rates.

Consider, for example, that offshoring is often treated as a survival strategy for manufacturing industries or firms. Coucke and Sleuwaegen (2008) indicated that Belgian firms engaged in offshore production activities in countries outside the European Union. In doing so, these firms not only increased their chances for survival, but also improved their domestic production-related activities and created new jobs.

In a more nuanced treatment of the issue, Rodriguez-Clare (2010) evaluated whether offshoring affects poor countries differently from rich countries. He found that in the long run, rich countries enjoy perpetual economic gains from increased offshoring, but poor countries see their static gains partially eroded by a decline in their research efforts.

To date, productivity and employment have been the central foci in research concerning offshoring. Lv and Wang (2010) applied the panel data from China's main manufacturing industries to estimate offshoring's influence on total factor productivity. Their results suggest that outsourcing within China's manufacturing industry has not improved total factor productivity (TFP). Following Amity and Wei (2005), Lv and Wang (2011) further developed a theoretical framework that focuses on the association between offshoring and employment. As part of this framework, they delineated the different outsourcing routes and activities and constructed a dynamic panel data model based on the Cobb–Douglas (C–D) function (Cobb and Douglas, 1928). In doing so, the authors estimated outsourcing's comprehensive effect on employment rates among China's key industries. Ultimately, this analysis showed that international outsourcing (or offshoring) would positively influence long-term employment within China.

Although past research has focused chiefly on economic issues as they relate to offshoring, as China adopts a more prominent role in the global production value chain, it faces serious environmental challenges. As a reflection of these challenges, more recent research has explored the degree to which China is responsible for carbon dioxide emissions and other pollution as a result of its production activities. For instance, Lopez et al. (2013) evaluated the trade relationship between Spain and China to test the pollution haven hypothesis and analyze the degree to which the transformation of global production chains and international trade has affected global emissions. Their findings support that the fall of trade barriers implies a transformation of global production chains that, in turn, cause an increase in global emissions. Jacob et al. (2013) concluded that the European Union's imports from and exports to China would increase leakage by shifting China's production from the