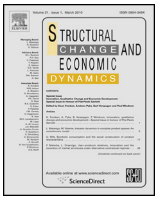
Structural Change and Economic Dynamics xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Structural Change and Economic Dynamics

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



Supply-side structural effects of air pollutant emissions in China: A comparative analysis

Rui Xie[a], Fangfang Wang[a], Julien Chevallier[b,c,*], Bangzhu Zhu[d,e,*], Guomei Zhao[a]

[a] College of Economics and Trade, Hunan University, Hunan, PR China
[b] IPAG Business School, IPAG Lab, 184 Boulevard Saint-Germain, 75006 Paris, France
[c] Université Paris 8, LED, 2 avenue de la Liberté, 93526 Saint-Denis cedex, France
[d] School of Management, Jinan University, Guangdong, PR China
[e] Business School, Nanjing University of Information Science & Technology, Nanjing 210044, PR China

ARTICLE INFO

Article history:
Received 19 January 2017
Received in revised form 13 February 2018
Accepted 18 April 2018
Available online xxx

JEL classification:
N50
N70
N90
057

Keywords:
Ghosh input-output model
Air pollution
Structural decomposition analysis
Supply-side structure
China
International comparative analysis

ABSTRACT

China's air quality has become a major issue affecting people's livelihood and continues to deteriorate in recent times. It is an important issue of common concern for economists and policymakers to explore the drivers of the growth of air pollution emissions and the deteriorating environmental quality in China. From the perspective of supply-side structures, this paper adopts Ghosh input-output model to decompose the factors affecting the changes of air pollutant emissions into economic activities, economic structures, allocation structures and emission intensity. Using this model, we conduct a structural decomposition analysis of air pollutant emissions in China, India, USA, and Japan for 1995–2009. The results reveal that China's economic structure initially promoted air pollutant emissions, but later played a role in reducing them. Further, whereas in Japan and particularly, China, allocation structures were found to be a key factor in increasing air pollutant emissions, in America and India, it played a critical role in reducing emissions. Our findings suggest that adjusting the distribution structure of intermediate products is crucial to reduce air pollution.

1. Introduction

China's economy has rapidly grown since the reform and opening up policy, and since then, has surpassed that of Japan, becoming the second largest economy in the world in 2010. However, China economic development is largely dependent on the extensive input of factors, such as labor, capital, and resources, and industrial sectors with high energy consumption, and thus, is subject to severe environmental pollution and energy shortage (Yang et al., 2014; Xie, 2014). In particular, since 2013, the Beijing-Tianjin-Hebei region, Pearl River Delta, and Yangtze River Delta have been frequently experiencing haze, indicating increasing threats to the climate, human health, and development of a harmonious society (He et al., 2013).

Preliminary research on the causes of haze in China attributes its formation to two factors. First is the obstruction in the horizontal flow of air and the lack of diffusion given static weather conditions, an external cause which cannot be controlled by human behavior. Second, oxysulfide (SOx) and oxynitride (NOx) emissions from fire coal, motor vehicles, and industrial production, which convert into secondary particulate pollutants through chemical reactions in the air and further aggravate the formation of haze (He et al., 2013; He and Jiang et al., 2014). Therefore, a fundamental method to curb haze is to strictly control SOx and NOx emissions and prevent the formation of secondary particulate pollutants.

According to the World Input-Output Database (WIOD), China's total air pollutant emission (total emission including SOx and NOx) was 35.40 Mt in 1995. While this figure decreased to 32.87 Mt in 2001, it surged in 2009 to 65.77 Mt, increasing by more than 100%. Therefore, an in-depth exploration of the factors affecting China's air pollutant emissions is needed to control the formation of haze and the severe deterioration of air quality. The method of decomposition is often used to analyze the factors influencing envi-

---

* Corresponding authors.
E-mail addresses: julien.chevallier@ipag.fr (J. Chevallier), wpzbz@126.com (B. Zhu).

https://doi.org/10.1016/j.strueco.2018.04.005

Please cite this article in press as: Xie, R., et al., Supply-side structural effects of air pollutant emissions in China: A comparative analysis. Struct. Change Econ. Dyn. (2018), https://doi.org/10.1016/j.strueco.2018.04.005

ronmental pollution and classify various factors contributing to the total change of pollutant emission (Ang, 1995; Ang et al., 2003; Su et al., 2017; Meng et al., 2017). The two strains of the decomposition methods are the index decomposition analysis (IDA) and structural decomposition analysis (SDA).

In analyzing the factors influencing energy use and pollutant emission, IDA further categorizes total effects as independent effects using aggregated sector data. Many scholars have adopted IDA to analyze changes in energy intensity, carbon emissions and pollutant emissions (Ang and Liu, 2001; Lyu et al., 2016; Meng et al., 2018). Specifically, IDA methods enjoy relatively lower requirements for data and are convenient to operate. But IDA method is unable to conduct an in-depth analysis of direct effects and indirect effects among economic activities, and not allowed for a detailed decomposition of economic structures. SDA methods can overcome some of the drawbacks of IDA method (Su and Ang, 2012, 2016), which examine direct and indirect effects using Leontief and Ghosh inverse matrices (Hoekstra and Van den Bergh, 2003). SDA method is applied in conjunction with the input-output model to examine factors underlying energy intensity and pollutant emissions (Rose and Casler, 1996; Nie et al., 2016; Wang et al., 2017; Mi et al., 2017). However, SDA method requires large amounts of data, as SDA method decomposes changes in various indicators using the input-output model and data from corresponding input-output tables, which distinguish between a range of technological and final demand effects.

With improvements in input-output tables, a growing number of researchers are applying the SDA model to analyze factors influencing the environment. Therefore, this article also uses this method. Many studies have used the Leontief model to examine the factors affecting environment pollutants from a demand-side perspective. Weir (1998) and Rormose and Olsen (2005) used the SDA model to identify factors underlying Danish pollutant emissions including CO_2, SO_2, and NOx during 1966–1988 and 1980–2002. Guan et al. (2008, 2009) explored the factors influencing China's carbon emission growth during 1981–2002 and 2002–2005. Wood (2009) investigated the causes of greenhouse gas emissions in Australia from 1974 to 2005. Using SDA, Zhang (2009) analyzed the historical change trend for China's carbon intensity related to energy for 1992–2006. Li et al. (2014) and Xie (2014) determined the factors contributing to the growth in China's energy consumption and use. Li and Wei (2015) determined factors affecting China's carbon emission and Zhang et al. (2015) did similar research for China's pollutant levels, including COD, NH3-N, SO_2, and NOx. Su and Ang (2017) used the SDA method to analysis the aggregate embodied energy and emission intensities. Based on spatial SDA, Meng et al. (2017) proposed an alternative input-output to elucidate inter-regional spillover effects in determining China's regional CO_2 emissions growth. Su et al. (2017) used the input-output (I-O) method to analyze the city state's carbon emissions from the demand perspective and used the SDA method to investigate the drivers of emission changes, which was the first comprehensive analysis of Singapore's emissions using the I-O framework. However, few articles have used Ghosh input-output model to analyze air pollution issues from a supply-side perspective (e.g. Zhang, 2010).

Table 1
Basic form of single regional input-output table.

Output		Intermediate Demand		
Input		Sector 1 ... Sector 35	Final Demand	Total Output
Intermediate Input	Sector 1	Z	F	X
	.			
	.			
	Sector35			
Value Added		V		
		...		
		V^n		
		V^{ROW}		
Total Input		X		
		...		

China's economic structure is undergoing major transformations, as a result of which its demand management faces limitations such as imbalances between domestic and external demands or investment and consumption. Against this background, supply policies can be used as a tool (Cai et al., 2008; China's Economic Growth Report, 2010; Zhang, 2010) by the government to exercise direct control and reduce policy uncertainties and risks. Thus, this study examines the factors influencing pollutant emissions from a supply-side perspective and accordingly, offers policy suggestions to reduce emission and conserve energy.

This study makes the following contributions: (i) we provide an analysis of the factors influencing air pollution, and (ii) we address the key issue of increased haze formation in China. We adopt the SDA approach using Ghosh input-output model from a supply-side perspective. Then, using WIOD's input-output tables for 40 countries with 35 consolidated sectors for 1995–2009 and air pollutant data including SOx and NOx, we compare the different factors between developed and developing countries. It provides an international reference for China's efforts to control haze.

The remainder of this paper is organized as follows. Section 2 details the theoretical model and data. Sections 3 and 4 analyze air pollution emissions and the factors affecting them. Section 5 offers a summary and policy suggestions.

2. Theoretical model and data

2.1. Data source and explanation

We adopt single regional input-output table data for two developing countries, China and India, and two developed countries, the United States and Japan, from the World Input-Output Database (WIOD) for 1995–2009. Table 1 presents the basic form of the table.

SOx and NOx are key precursor pollutants contributing to the formation of haze (He and Jiang et al., 2014). Thus, we retrieve emission data for SOx and NOx for 1995–2009 from environmental accounts by WIOD and combine the data for both by sector. We then use them as indicators to measure air pollutant emissions.

In Table 1, $Z$is the matrix of intermediate inputs and z_{ij} denotes the input demand for sector i from sector j. $V$is a value-added row vector and v_i represents the value added for sector i. $F$is the final demand (used) column vector. $X$is the output column vector and x_i denotes the total output of sector i.

2.2. Theoretical model

Consider the column identity of a typical input-output table in monetary terms:

$$X = H^T X + V^T, \tag{1}$$

Then, Eq. (1) can be rewritten as

$$X^T = V(I - H)^{-1} = VG, \tag{2}$$

In Eq. (2), we present Ghosh's (1958) model, where H is the direct distribution matrix in which $h_{ij} = z_{ij}/x_i$. Here, h_{ij} represents the share of distributed output from the ith sector to the jth sector. $G = (I - H)^{-1}$ is the Ghosh inverse matrix that indicates the dependence between the production sector and the sector that uses its products. Ghosh's supply-driven input-output model takes primary inputs (sectoral value-add) as the starting point and accounts for both direct and indirect relationships between sectors.

Please cite this article in press as: Xie, R., et al., Supply-side structural effects of air pollutant emissions in China: A comparative analysis. Struct. Change Econ. Dyn. (2018), https://doi.org/10.1016/j.strueco.2018.04.005