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Sensitivity analysis of China's energy-related CO_2 emissions intensity for 2012 based on input–output Model

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Abstract

This paper employed a sensitivity analysis based on the input-output model to identify the key sectors and main productive linkages between activity branches in terms of CO_2 emissions in China. In particular, we established the Chinese energy-input-output table for 2012. Based on the input-output data, sensitivity analysis, is introduced to probe into two major drivers, i.e., the emissions intensity coefficient (c) and technology coefficient (B). The results show that (1) Regarding the driver c, the top six emissions-intensity sectors are tested to be the key sectors which will cause the highest emissions. (2) For B, the emissions intensity is the most sensitive to the technology change of the Production and supply of electric power and heat industry (n4) with direction transaction relation. (3) With respect to the values of two elasticity indicators for B, these sectors with a higher "structure-relevant" have a lower "technology-relevant". This implied that the technology coefficient has more influence on the CO_2 emission intensity of n4 after considering the structural impact of final demand. Emphatically, the analytical method used in this study can provide valuable information for planners and decision makers to formulate feasible and practical industrial policies with implications for CO_2 emissions.

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Keywords: Sensitivity analysis, Input-output model, CO_2 emissions intensity, China

1. Introduction

China's rapid economic growth is bringing wealth and prosperity, however, the economic achievements have required significant natural resources inputs and larger CO_2 emission (Tang et al., 2016; Yuan et al., 2015). In a

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global context, China has become the largest CO_2 emitter in the world, and also one of the countries with the greatest energy consumption (Guan et al., 2012; Tang et al, 2017). The input-output (IO) model (Leontief, 1936) is a classical and rational method for analysing energy-related CO_2 emissions (Igos et al., 2015), and can be easily applied to all sectors regardless of the length and complexity of their production process (Zhu et al., 2012). Another reason of applying input–output model in this paper is that: both the direct CO_2 emission generated by the sector production and the indirect CO_2 emission rooted in the initial input of the sectors can be considered simultaneously (Hondo et al., 2002). Additionally, the sensitivity analysis combined with input-output model can be used to identify the impact of changes in the sensitive coefficients on CO_2 emissions or emissions intensity from different economic sectors. The superiorities of sensitivity analysis based on I–O model (Yan et al., 2016) are: (1) it allows us to carry out an ex-ante analysis which can serve as an effective tool in quantifying key coefficients changes to CO_2 emissions; (2) the dependence and proportional relationship among various sectors can be revealed; (3) data complexity of this method is relatively low.

Recent papers trend to applied the sensitivity analysis based on the IO model to capture the sensitive coefficients of CO_2 emissions and emissions intensity. Actually, the IO based model has been widely applied to exploring the drivers of China's CO_2 emissions intensity, and emissions intensity coefficient and Leontief effect were consistently identified as the top two key factors. For example, regarding the emissions intensity coefficient, a leading driver according to the previous studies, the sensitivity analysis can reveal the key sectors which will cause the greatest growth in CO_2 emissions (Tarancón and Del Río, 2007). As for the Leontief effect (or technology coefficient), the sensitivity analysis can discover the essential sector linkages leading to the highest emissions. Sensitivity analysis of Leontief effect has been conducted for different countries, such as Japan based on the database for 1990 (Hondo et al., 2002), Spain for 1995 (Tarancón and Del Río, 2007) and 2005 (Tarancón et al., 2011), and China for 2010 (Yuan and Zhao, 2016; Yan et al., 2016).

Therefore, this paper especially introduces this effective analysis method, sensitivity analysis, to identify the most sensitive transaction, in terms of impact of key coefficients changes on CO_2 emissions intensity, in the high emissions-intensity sectors. In particular, this promising approach was employed to provide a specific, ex-ante analysis for exploring the essential sector-level elements of the two key drivers, i.e., emissions intensity coefficient and technology coefficient. The rest of the paper is organized as follows. Section 2 describes the methodology. The data and main results are reported in Section 3. Finally, Section 4 presents the conclusions.

2. Methodology

To investigate China's CO_2 emission intensity changes, the sensitivity analysis based on the input–output model proposed by Tarancón (Tarancón and Del Río, 2007) has been used to explore how the change of technology or demand influences the CO_2 emission intensity. First, the basic input–output model is provided in Subsection 2.1. Second, the module of sensitivity analysis about emissions intensity coefficient change is detailed introduced in Subsection 2.2. Finally, the sensitivity analysis on technology coefficient change is formulated in Subsection 2.3.

2.1 Basic Input-Output Model

In a monetary IO model, the output of sector *i* is computed based on the following balance equation:

$$\sum_{j=1}^{n} z_{i,j} + y_i = x_i , \tag{1}$$

where $z_{i,j}$ represents the intermediate input from sector *i* to sector *j* in the monetary unit, y_i is the final demand of sector *i*, and x_i is the total output of sector *i*. The direct consumption coefficient matrix $A= [a_{i,j}]=[z_{i,j}/x_j]$ denotes the technical coefficients matrix, where $a_{i,j}$ is the direct consumption of sector *j* on sector *i*;