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Energy-related GHG emissions for inland and municipal economy in Chongqing: Factor dynamics and structure decomposition

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Abstract

As the largest and most populous city in China, Chongqing has a unique municipal economy structure and challenges in GHG emissions abetment that are greater than those of other cities. This paper quantifies sources of emissions growth in Chongqing using an IO-SDA framework. The twelve components studies are classified into three categories: change in intensities, production linkages, and final demand. The results show that the crucial factor of GHG emissions reduction is change of intensities, and the main cause of emissions growth is expansion of final demand.

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Keywords: GHG emissions; input-output analysis; structure decomposition analysis

1. Introduction

China has been the world's largest greenhouse gas (GHG) emitter since 2009[1].The evolution of GHG emissions in China therefore deserves more attention than those of other countries. As Chongqing is the largest and most populous city in China, and also one of the six old industrial bases, study on the unique variation in GHG emissions of Chongqing can provide new insight into the GHG emissions

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reduction of extra-large cities and help to find a way to balance urbanization, industrialization and emissions reduction in under-developed cities.

A number of researchers have applied classic input-output structural decomposition analysis (IO-SDA) techniques to study China's national-level energy intensity [2]-[7]. Except the research of Beijing's GHG emissions [8]-[9], the IO-SDA model has however, rarely been applied to provincial-level analysis. This is because IO-SDA model requires time series input–output tables and sectoral energy use data that are usually incomplete at the provincial level. This study explores the determinants of GHG emissions in Chongqing, the largest and most populous city in China. To our best knowledge, such GHG emissions studies for Chongqing are very limited [10]-[11]. For the purpose of the study, we collect latest available data and use an IO-SDA framework to quantify sources of GHG emissions growth in Chongqing. The results contribute mainly to the analysis of the driving forces of the change in GHG emissions, in this case in Chongqing over the period 2002-2012 using the IO-SDA model. Here the whole economy rather than selective industries are studied, giving a global picture of change in economic-activity related emissions. At the same time, the relative contributions of socio-economic factors are investigated from both production and final demand perspective [12].

2. Methodology

According to IO method [13], the equation for total GHG emissions can be presented as:

$$\mathbf{G} = \hat{\mathbf{T}}\mathbf{X} = \hat{\mathbf{T}}\mathbf{L}\mathbf{y}, \quad (1)$$

where $\mathbf{G}$ is the GHG emissions (CO_2 equivalent) from all sectors; $\mathbf{T}$ is the $n \times 1$ vector of emission intensities representing the GHG emissions per unit output, the symbol "$\hat{\ }$" indicates a diagonal matrix; $\mathbf{X}$ is the vector of output; $\mathbf{I}$ is the identity matrix; $\mathbf{A}$ stands for the technology coefficient matrix; $\mathbf{y}$ is the $n \times 1$ vector of sectoral final demand; $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ represents Leontief inverse.

The emission intensity of each sector can also be expressed as follows:

$$\mathbf{T} = \frac{\mathbf{G}}{\mathbf{X}} = \frac{\mathbf{G}}{\mathbf{E}} \cdot \frac{\mathbf{E}}{\mathbf{X}} = \mathbf{C} \cdot \mathbf{N}, \quad (2)$$

where $\mathbf{E}$ is the $n \times 1$ vector of energy consumption in each sector measured as standard coal equivalent; the symbol "$\cdot$" and "—" mean element-by-element multiplication and division, respectively; $\mathbf{C}$ is the $n \times 1$ vector of GHG emission intensities that is associated with the energy consumption of each industry; $\mathbf{N}$ is the $n \times 1$ vector of energy consumption intensities associated with output of economic sector.

According to Wood [2], Leontief inverse $\mathbf{L}$ is decomposed into forward linkages $\mathbf{F}$, industrial structure $\mathbf{S}$, and backward linkages $\mathbf{B}$. Hence, defining

$$\mathbf{F} = \widehat{\mathbf{L}\mathbf{v}}, \quad (3)$$

$$\mathbf{B} = \frac{\mathbf{L}}{(\mathbf{L}\mathbf{v})(\mathbf{v}'\mathbf{L})}, \quad (4)$$

$$\mathbf{S} = \widehat{\mathbf{v}'\mathbf{L}}, \quad (5)$$

where $\mathbf{v}$ is an n-element column vector of 1's. The Leontief inverse $\mathbf{L}$ can be obtained as:

$$\mathbf{L} = \mathbf{FSB}. \quad (6)$$

The sectoral final demand $\mathbf{y}$ can be rewritten as:

$$\mathbf{y} = \mathbf{kmfP} + \mathbf{uwD}, \quad (7)$$

where $\mathbf{k}$ is the $n \times d$ matrix, and its element k_{id} represents the share of sector i's final consumption in consumption category d; $\mathbf{m}$ is the vector of length d, and its elements represent the shares of different types of final consumption in the total final consumption; $\mathbf{f}$ is per-capita measure of final consumption;