Income distributions and environmental emissions in China

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Abstract

Current evidences suggest that the vast majority of growth in CO_2 emissions comes from the developing world, and that China plays a major part in that growth. Residential consumption has significant potential to affect environmental emissions, including direct and indirect emissions, while income is an important determinant of residential consumption. This paper examines the impact of income on China's residential consumption and environmental emissions. To measure the effect of income on residential consumption, we use panel data analysis to evaluate the partial marginal effect and then calculate the contribution of income. To evaluate the relation between consumption pattern and the CO_2 emissions, we combine input-output tables, CO_2 emissions factors, and the regression results obtained from the above step into a new variation of environmental input-output model.

we use the data from national statistical survey and Chinese input-output tables (IOTs) for 1987, 1990, 1992, 1997, 2002, 2007, and 2010 to calculate the emissions caused by the shape of income distribution

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though consumption structure. Moreover, we simulate scenarios and evaluate the environmental emission changes considered the option consumption structure. The results show that the residential income has a relatively strong impact on the residential consumption and the consumption contributes to reduce the environmental emissions. Specifically, the environmental emissions will reduce compared with the income distribution changes in the future.

key words: resident income; Structural decomposition analysis; Carbon dioxide; Environmental extended Input-output analysis

1 Introduction

Current evidences suggest that the vast majority of growth in CO_2 emissions comes from the developing world, and that China plays a major part in that growth. Residential consumption has significant potential to affect environmental emissions, including direct and indirect emissions, while income is an important determinant of residential consumption. This paper examines the impact of income on China's residential consumption and environmental emissions. To measure the effect of income on residential consumption, we use panel data analysis to evaluate the partial marginal effect and then calculate the contribution of income. To evaluate the relation between consumption pattern and the CO_2 emissions, we combine input-output tables, CO_2 emissions factors, and the regression results obtained from the above step into a new variation of environmental input-output model.

Several researchers indicate that affluence is the major determinant of the environmental effects of household consumption (Lenzen, 1998; Kerkhof et al., 2009; Wiedenhofer et al., 2011). Many studies have focused on the role of consumption in environmental load. Munksgaard et al. (2000) introduced the impact of household consumption on CO_2 in Danish. Druckman and Jackson (2009) based around a quasi multi regional input output (QMRIO) model to illustrate the carbon footprint of UK households. Pachauri and Jiang (2008), Liu et al. (2009), and Donglan et al. (2010) calculated household indirect energy consumption and CO_2 emission in China and India. However, to the best of our knowledge, few researchers have studied the impact of the income on CO_2 emission changes.

Structural decomposition analysis (SDA) is a powerful tool for studying economic structural changes (Dietzenbacher and Los, 1998). SDA is also widely used to address the environmental issues (Casler and Rose, 1998; De Haan, 2001). Some environment-related SDA studies have focused on China in particular. For example, Peters et al. (2007) used SDA to analyze the causes of China's recent growth in energy consumption and associated emissions. Zhang (2009) undertook an SDA of historical changes in energy-related carbon intensity for China. Using the Eora multi-region input-output (MRIO) database, Lan and Malik (2013) decomposed changes in the energy consumption of China and Russia into six key determinants.

Accordingly, to investigate the impact of income on consumption and environmental performance, we propose an extended version of SDA to separate income effect in changes in total sectoral carbon dioxide (CO_2) emissions. To estimate the contribution of the income effect on consumption, we conduct a regression analysis based on Keynes consumption theory.

The remainder of this paper is organized as follows. Section 2 introduces the method employed in this study, Section 3 discusses the data and results, and Section 4 concludes.

2 Method

2.1 Step 1: CO_2 emission consumption

The effects of household consumption on CO_2 emissions include direct and indirect emissions. Direct emission comes from household energy consumption and directly cause emission. Indirect emission refers to emissions embodied in various commodities and services consumed by households. The total CO_2 emission can be expressed as:

$$Q = Q_d + Q_i, \tag{1}$$

where Q is the total CO_2 emission, Q_d is the direct CO_2 emission, and Q_i is the indirect CO_2 emission.

The direct CO_2 emission can be expressed as:

$$Q_d = cf_h e, \tag{2}$$

where c is a vector of CO_2 emission factors, whose ith entry c_i denotes the CO_2 emission factor of the ith fuel, f is a vector of fuel structure whose element f_k denotes the share of fuel k in the total amount of energy consumption, and e is the total energy consumed by the households.

The indirect CO_2 emission can be expressed as:

$$Q_i = cf_i \hat{E}(I - A)^{-1} yi), \tag{3}$$

where f_i is the matrix of fuel structure, y is the consumption.

2.2 Step 2: Keynes consumption theory

The basic regression is expressed as:

$$coms_{it} = \alpha + \beta_i inc_{it}, \tag{4}$$

where $i = 1, 2, 3, ..., n$ stands for the number of economic sectors; $t = 1, 2, 3, ..., T$ stands for time; **coms** is a vector of consumption, while **inc** is resident income. We employ the least squares regression to evaluate the marginal propensity of consumption (MPC), β.

2.3 Step 3: structural decomposition based on the contribution of the PD effect

Using the coefficient β_i obtained from the previous steps and employing an extension of the average of two polar decompositions, we disaggregate the direct and indirect sectoral CO_2 emission changes into those caused by changes in emissions intensity and technology, the MPC effect, the income factor, and the autonomous consumption factor. The decomposition is as follows:

$$\begin{aligned}\mathbf{\Delta Q_d} &= \widehat{\mathbf{c}_1}\mathbf{f}_1\mathbf{e}_1 - \widehat{\mathbf{c}_0}\mathbf{f}_0\mathbf{e}_0 \\ &= \underbrace{[\widehat{\mathbf{\Delta c}}\mathbf{f}_1\mathbf{e}_1 + \widehat{\mathbf{\Delta c}}\mathbf{f}_0\mathbf{e}_0]/2}_{\mathbf{E}_c} + \underbrace{[\widehat{\mathbf{c}_0}\mathbf{\Delta f}\mathbf{e}_1 + \widehat{\mathbf{c}_1}\mathbf{\Delta f}\mathbf{e}_0]/2}_{\mathbf{E}_f} \\ &+ \underbrace{[\widehat{\mathbf{c}_0}\mathbf{f}_0\mathbf{\Delta e} + \widehat{\mathbf{c}_1}\mathbf{f}_1\mathbf{\Delta e}]/2}_{\mathbf{E}_e},\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta Q_i = &\underbrace{(\Delta c f_{i1} E_1 L_1 y_1 + \Delta c f_{i0} E_0 L_0 y_0)/2}_{\mathbf{E}_c} + \underbrace{(c_0 \Delta f E_1 L_1 y_1 + c_1 \Delta f E_0 L_0 y_0)/2}_{\mathbf{E_F}} \\ &+ \underbrace{(c_0 f_{i0} \Delta E L_1 y_1 + c_1 f_{i1} \Delta E L_0 y_0)/2}_{E_E} + \underbrace{(c_0 f_{i0} E_0 \Delta L y_1 + c_1 f_{i1} E_1 \Delta L y_0)/2}_{E_L} \\ &+ \underbrace{(c_0 f_{i0} E_0 L_0 \Delta\beta inc_1 + c_1 f_{i1} E_1 L_1 \Delta\beta inc_0)/2}_{E_\beta} + \underbrace{(c_0 f_{i0} E_0 L_0 \beta_0 \Delta inc + c_1 f_{i1} E_1 L_1 \beta_1 \Delta inc)/2}_{E_I} \\ &+ \underbrace{(c_0 f_{i0} E_0 L_0 \Delta\alpha + c_1 f_{i1} E_1 L_1 \Delta\alpha)/2}_{E_\alpha}\end{aligned} \tag{6}$$

where $\mathbf{\Delta Q}$ is a vector recording changes in total sectoral CO_2 emissions, d and i represent the changes in direct and indirect CO_2 emissions, respectively; $\mathbf{E}_c$, $\mathbf{E}_F$, $\mathbf{E}_E$, $\mathbf{E}_L$, $\mathbf{E}_\beta$, $\mathbf{E}_I$, and $\mathbf{E}_\alpha$ are vectors recording changes in sectoral CO_2 emissions caused by changes in emissions intensity, energy structure, energy intensity, technology changes, the MPC effect, the income, and autonomous consumption, respectively.

$\mathbf{c}_0$ and $\mathbf{c}_1$ are the CO_2 emissions intensities in periods 0 and 1, respectively. We further decompose $\mathbf{\Delta y}$ into $\mathbf{\Delta}\beta\mathbf{inc}$ and α to represent the changes of consumption caused by resident income and autonomous consumption. So far, we have decomposed the changes in total sectoral CO_2 emissions into those caused by changes in emissions intensity ($\mathbf{E}_c$), energy structure $\mathbf{E}_F$, energy intensity $\mathbf{E}_E$, technology changes ($\mathbf{E}_L$), the resident income ($\mathbf{E}_I$), and autonomous consumption ($\mathbf{E}_\alpha$). Note that the decomposition can be considered as an extension of Dietzenbacher and Los (1997, 1998).

3 Data and Results

3.1 Step 1: the evaluation of MPC

We apply the method proposed in Section 2 to decompose the changes in total sectoral CO_2 emissions for China using the resident consumption and income data, Chinese IOTs between 1985 and 2010 for decomposition analysis. When using the SDA method, we adjust the prices in different IOTs to those for 2000 using the producer price index. In this study, we focus only on the 23 industry sectors in the Chinese IOTs. The original data in the analysis are sourced from the National Bureau of Statistics.

We observe that resident income turns out to be significant across the regression. For average, its coefficient is 0.709, suggesting that an increase in resident income by 1 unit will result in a 0.709 increase in consumption.

3.2 Step 2: structural decomposition based on MPC

We now decompose the changes in sectoral CO_2 emissions into different parts, namely those caused by changes in emissions intensity, energy structure, energy intensity, technology changes, the MPC effect, and autonomous consumption, using the previously obtained coefficient β and the Chinese IOTs for 1985 and 2010. Note that the energy intensities and energy structure data sourced from the National Bureau of Statistics (2003, 2011) and the CO_2 emission factors from the Intergovernmental Panel on Climate Change (2006).[1]

4 Concluding Remarks

Our results indicate that: (1)Most sector energy intensities in China remain significantly higher than those in other industrial countries. This implies that the potential reductions in sector energy intensities in China are still evident and that most of these reductions can be realized by the enforcement of the appropriate laws. At the same time, carbon emission multipliers of final consumed commodities are mainly determined by the sector energy intensities, as shown in this and previous studies. (2) Increases in indirect urban and rural emissions are mainly caused by urban and rural household consumption during the entire period studied.

[1] The "CO_2" in this paper does not include the other greenhouse gases except for carbon dioxide.

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