Low Carbon Economy, 2017, 8, 31-39
http://www.scirp.org/journal/lce
ISSN Online: 2158-7019
ISSN Print: 2158-7000

Research on Carbon Emission of Residents' Consumption
—Based on the City of Guangzhou

Jingshu Zou

Jinan University, Guangzhou, China
Email: 1556004764@qq.com

How to cite this paper: Zou, J.S. (2017) Research on Carbon Emission of Residents' Consumption—Based on the City of Guangzhou. *Low Carbon Economy*, **8**, 31-39.
https://doi.org/10.4236/lce.2017.81003

Received: March 10, 2017
Accepted: March 28, 2017
Published: March 31, 2017

Abstract

Carbon dioxide can cause greenhouse effects and that have a bad effect on the lives of residents. With the continuous improvement of economic development level, the consumption structure of residents is also changing, and then the carbon dioxide emission produced by residents is also changing. Therefore, this paper used LMDI decomposition method to calculate and analyze the indirect energy consumption of Guangzhou residents carbon emissions, which creatively used the LMDI method in the study of urban residents on the carbon emissions. At the same time, the research of this paper is helpful to strengthen the residents' awareness of carbon emission reduction. This paper first explored the factors that affect the indirect energy carbon emissions of residents, then defined the research frame of residents' indirect energy carbon emission, and therefore accounted for the indirect energy consumption of residents. According to the demographic characteristics of the population of Guangzhou, the emission from residents' carbon consumption is further divided into urban consumer carbon emissions and rural consumer carbon emissions. The research results are as follows: The main factor that stimulates the carbon dioxide emission of Guangzhou's residential indirect energy consumption is per capita income; the main factor that suppresses the emission is the intensity of energy consumption Population size, per capita income, and the resident consumption structure have a stimulating effect on the emissions of carbon dioxide from Guangzhou's residential indirect energy consumption of urban and rural residents. The intensity of energy consumption and the emission intensity of carbon dioxide have a suppressing effect on the emissions of carbon dioxide from Guangzhou's residential indirect energy consumption of urban and rural residents. Urban and rural population structure has a stimulating effect on the emissions of carbon dioxide from Guangzhou's residential indirect energy consumption of urban residents, but has a suppressing effect on rural residents.

Keywords

Residents Indirect Energy Consumption Carbon Emissions, Guangzhou City, LMDI

1. Introduction

Chinese government has set a strategic goal of reducing carbon intensity by 40% to 45% by 2020. Carbon dioxide is the most important part of greenhouse gases, and human activities produce carbon dioxide. Climate warming will cause heat wave invasion, changes in the pattern of drought and flood. Environment we live and our social economic development will have a serious impact.

China's carbon emissions research has made rapid progress since 2006. However, China's research on carbon emissions is mainly focused on reducing carbon emissions in high energy-consuming industries, ignoring the impact of consumer spending on carbon emissions. With the rapid development of China's economy and the continuous transformation of society, China's consumption patterns continue to change, the resulting carbon emissions are changing. Therefore, to explore the issue of consumer carbon emissions, is conducive to strengthening our understanding of consumer carbon emissions, is conducive to improving China's carbon emission reduction policies and decision-making targeted and operational.

As to the study of residents of indirect living energy consumption growth factors, Li Yanmei *et al.* [1] implied input-output method research. Feng Ling *et al.* [2] used the CLA method to quantify the indirect energy consumption and carbon emission changes of urban residents in China from 1999 to 2007, and analyzed their potential influencing factors. Yao Liang *et al.* [3] used the LCA method to account for the implied carbon emissions of residents in China in 1997, 2002 and 2007. Zhang Jilu [4] implied factor decomposition method to analyze China's domestic consumption of indirect carbon emissions, and analysis of domestic consumption of carbon emissions factors and the impact of each factor. Therefore, this paper uses LMDI decomposition method, the urban level as a research perspective, with originality. Considering that most of the previous studies have focused on the carbon footprint of energy consumption [5], this paper focuses on the carbon emissions of indirect energy consumption.

2. Research Methods

LMDI (logarithmic mean weight division index method) is the use of timing variables of the two endpoints of the logarithmic average as the decomposition of the weight ratio, the weight Equation is:

$$L(x,y)=\begin{cases}(y-x)/(\ln y-\ln x), if\ \ x\neq y\\ x, if\ \ x=y\end{cases}$$

So

$$\omega_i = \frac{L\left(V_i^0, V_i^t\right)}{L\left(V^0, V^t\right)} = \frac{\left(V_i^t - V_i^0\right) / \left(\ln V_i^t - \ln V_i^0\right)}{\left(V^t - V^0\right) / \left(\ln V^t - \ln V^0\right)}$$

Substituted the weight equation into the exponential decomposition formula:

$$\begin{aligned}\frac{V^t}{V^0} &= \exp\left(\sum_i \omega_i \ln \frac{X_{1i}^t}{X_{1i}^0}\right) \cdot \exp\left(\sum_i \omega_i \ln \frac{X_{2i}^t}{X_{2i}^0}\right) \cdots \exp\left(\sum_i \omega_i \ln \frac{X_{ni}^t}{X_{ni}^0}\right) \\ &= \exp\left(\sum_i \omega_i \ln \frac{X_{1i}^t X_{2i}^t \cdots X_{ni}^t}{X_{1i}^0 X_{2i}^0 \cdots X_{ni}^0}\right) \\ &= \exp\left(\sum_i \frac{\left(V_i^t - V_i^0\right) / \left(\ln V_i^t - \ln V_i^0\right)}{\left(V^t - V^0\right) / \left(\ln V^t - \ln V^0\right)} \ln \frac{V_i^t}{V_i^0}\right) \\ &= \exp\left(\frac{\ln V^t - \ln V^0}{V^t - V^0} \sum_i V_i^t - V_i^0\right) \\ &= \frac{V^t}{V^0}\end{aligned}$$

From the above equation we can see that LMDI is a complete decomposition method, it will not produce residuals, the data contains zero is no problem. At the same time, due to the characteristics of exponential operations, LMDI is divided into multiplication and decomposition of two, two forms can be converted between each other.

3. Data Source

At present, China's energy intensity and carbon intensity are measured using energy intensity and carbon intensity per unit of GDP. However, this paper does not simply compare the eight consumer expenditure contents with the energy consumption and output data of the China Energy Statistical Yearbook, but rather 18 industrial sectors related to these consumer expenditure contents (among the industry sectors corresponding to the consumption expenditure contents) are selected from 23 industrialized sub-sectors in Guangzhou Statistical Yearbook (form 2003-2014) (see Table 1). Guangzhou residents consumption expenditure projects and production departments linked. The energy intensity and carbon intensity of consumption expenditure are calculated as follows:

$$EI_i = \frac{\sum_i^n E_{i,n}}{\sum_i^n I_{i,n}},\quad CI_i = \frac{\sum_i^n C_{i,n}}{\sum_i^n I_{i,n}},$$

EI_i represent the energy intensity of the i-th consumer spending; n represent the number of industrial parts corresponding to the content of consumer expenditure; $E_{i,n}$ represent the amount of consumption energy of the nth industry sector corresponding to the consumption expenditure of category i; $I_{i,n}$ represent the output value of the nth sector of the i-type consumer expenditure corresponds to the output value; CI_i represent the i-th consumer spending should be the amount of carbon emissions in the nth sector.

Guangzhou residents living in various consumer spending content of indirect energy carbon emissions are calculated as follows:

Table 1. Directly related to the household consumption expenditure activities.

Consumer Spending Content	Directly Related Departments
Food	Agricultural and sideline food processing industry; Food manufacturing industry; Wine, Beverage and refined tea manufacturing industry
Clothes	Textile industry, Textile and garment, Apparel industry; Leather, Fur, Feathers and their products and footwear industry
Medical insurance	Pharmaceutical manufacturing industry
Education, Culture, Entertainment and Service	Paper and paper products; Reproduction of the printing and recording Media; Culture, Education, Industry, Sports and entertainment
Home equipment supplies and services	Wood processing and wood, Bamboo, Rattan, Brown, Grass products industry; Furniture manufacturing industry; Metal products industry
Miscellaneous goods and services	tobacco products industry
Traffic communication	Oil processing, Coking and nuclear fuel processing industry; Rubber and plastic products industry
Live	Electricity, Heat production and supply; Water production and supply

$$E_{ind} = \sum_i \left(EI_i \times X_i\right) \times P,\ C_{ind} = \sum_i \left(CI_i \times X_i\right) \Big/ \times P$$

E_{ind} represent Guangzhou residents living energy indirect energy consumption; C_{ind} represent Guangzhou City residents living indirect energy consumption total carbon emissions; X_i represent Guangzhou City residents per capita expenditure of consumer expenditure; P represent the population of Guangzhou residents.

This paper multiplies the physical quantity of coal, fuel oil, gasoline and diesel in the main energy consumption of industrial sub-sectors above the scale of Guangzhou City, and multiplies the carbon dioxide emission factor to obtain the carbon dioxide emission. Electricity and heat generated by the indirect CO_2 emissions are still calculated in accordance with the method of electric carbon sharing, that is, the first year of the country to calculate the thermal power generation and heating CO_2 emissions, and then according to the various departments of Guangzhou City, the terminal power and heat consumption The proportion of electricity and heat consumption in the country, respectively, calculated by the various sectors of electricity consumption and thermal consumption of indirect CO_2 emissions.

4. Guangzhou Residents Indirect Energy Consumption Carbon Emissions LMDI Decomposition

$$C = \sum_{ij} C_{ij} = \sum_{ij} P \frac{P_i}{P} \frac{Q_i}{P_i} \frac{Q_{ij}}{Q_i} \frac{E_{ij}}{Q_{ij}} \frac{C_{ij}}{E_{ij}} = \sum_{ij} PF_i H_i I_{ij} J_{ij} K_{ij}$$

C represent Guangzhou city residents indirect energy consumption total CO_2 emissions; P represent the population of Guangzhou residents; i represent Guangzhou urban and rural population structure, including urban residents and rural residents; *j* represent Guangzhou residents living and drinking items, including food, clothing, transportation and communications, health care, home appliances and services, education, culture and entertainment services, residential, miscellaneous goods and services; P_i represent population of urban residents or rural residents in Guangzhou; Q_i represent consumption of urban residents or rural residents in Guangzhou; Q_{ij} represent Guangzhou urban residents or rural residents of the consumer spending; E_{ij} represent Guangzhou cty residents or rural residents of the consumption of energy consumption; C_{ij} represent consumption of CO_2 from consumption of urban residents or rural residents in Guangzhou; $F_i = \frac{P_i}{P}$ represent population structure of urban and rural areas in Guangzhou; $H_i = \frac{Q_i}{P_i}$ represent per capita consumption level of urban or rural Residents in Guangzhou; $I_{ij} = \frac{Q_{ij}}{Q_i}$ represent Guangzhou residents' consumption structure ; $J_{ij} = \frac{E_{ij}}{Q_{ij}}$ represent energy consumption intensity of Guangzhou; $K_{ij} = \frac{C_{ij}}{E_{ij}}$ represent CO_2 Emission intensity in Guangzhou, representing the Guangzhou energy structure and CO_2 emission coefficient.

Therefore, the amount of change in CO_2 emissions can be broken down into: ΔC_1, ΔC_2, ΔC_3, ΔC_4, ΔC_5, ΔC_6, represent the contribution of six factors, such as population size, urban and rural population structure, per capita consumption level, residents' consumption structure, energy consumption intensity and CO2emission intensity. Use R and 0 to represent two comparison objects, according to the LMDI method, CO_2 emissions change can express:

$$C = C_R - C_0 = \Delta C_1 + \Delta C_2 + \Delta C_3 + \Delta C_4 + \Delta C_5 + \Delta C_6$$

The above formula 6 variables for different residents living consumption of CO2specific formula is as follows:

$$\Delta C_1 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{P^R}{P^0}\right)$$

$$\Delta C_2 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{F_i^R}{F_i^0}\right)$$

$$\Delta C_3 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{H_i^R}{H_i^0}\right)$$

$$\Delta C_4 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{I_{ij}^R}{I_{ij}^0}\right)$$

$$\Delta C_5 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{J_{ij}^R}{J_{ij}^0}\right)$$

$$\Delta C_6 = \sum_{ij} \frac{C_{ij}^R - C_{ij}^0}{\ln C_{ij}^R - \ln C_{ij}^0} \ln\left(\frac{K_{ij}^R}{K_{ij}^0}\right)$$

i represent the population type of one year in Guangzhou, including urban residents and rural residents of two categories ;j represent Guangzhou residents living and drinking items, including food, clothing, transportation and communications, health care, home appliances and services, education, cultural and entertainment services, living, miscellaneous goods and services a total of eight types; R and 0 represent two years; C_{ij}^{R} 、 C_{ij}^{0} represent year R and year 0 Guangzhou urban residents or rural residents j class energy CO_2 emissions, the unit is 10,000 tons of standard coal; P^{R} 、 P^{0} represent year R and year 0 Guangzhou residents population, the unit for the million people; F_{i}^{R} , F_{i}^{0} represent year R and year 0 Urban and Rural Population Structure in Guangzhou; H_{i}^{R} , H_{i}^{0} represent year R and year 0 Guangzhou Urban residents or rural residents per capita consumption level, unit is yuan; I_{ij}^{R} , I_{ij}^{0} represent year R and year 0 Guangzhou urban residents or rural residents consumption structure; J_{ij}^{R} , J_{ij}^{0} represent year R and year 0 urban residents or rural residents in Guangzhou energy consumption structure strength, in ton/yuan; K_{ij}^{R} , K_{ij}^{0} represent years R and year 0 Guangzhou urban residents or rural residents energy consumption intensity, in kg/kg.

For the 2002-2003 China residents indirect energy consumption of CO_2 emissions trends, the cumulative effect of time series:

$$
\begin{aligned}
(\Delta C_1)_{0,R} &= (\Delta C_1)_{0,r} + (\Delta C_1)_{r,r+1} + \cdots + (\Delta C_1)_{R-1,R} \\
(\Delta C_2)_{0,R} &= (\Delta C_2)_{0,r} + (\Delta C_2)_{r,r+1} + \cdots + (\Delta C_2)_{R-1,R} \\
(\Delta C_3)_{0,R} &= (\Delta C_3)_{0,r} + (\Delta C_3)_{r,r+1} + \cdots + (\Delta C_3)_{R-1,R} \\
(\Delta C_4)_{0,R} &= (\Delta C_4)_{0,r} + (\Delta C_4)_{r,r+1} + \cdots + (\Delta C_4)_{R-1,R} \\
(\Delta C_5)_{0,R} &= (\Delta C_5)_{0,r} + (\Delta C_5)_{r,r+1} + \cdots + (\Delta C_5)_{R-1,R} \\
(\Delta C_6)_{0,R} &= (\Delta C_6)_{0,r} + (\Delta C_6)_{r,r+1} + \cdots + (\Delta C_6)_{R-1,R}
\end{aligned}
$$

4.1. Influencing Factors of Indirect Energy Consumption of Urban Residents in Guangzhou

We should look at this form from the following point of view: A positive numbers indicate a stimulating effect, the bigger the value, the stronger the stimulating effect. A negative number indicates a repressive effect, the bigger the absolute value of the negative number, the stronger the inhibitory effect.

From Table 2 we can see that, on the whole, population size, urban and rural population structure, per capita consumption level, the consumption structure of residents of urban residents in Guangzhou City, indirect energy consumption of carbon emissions have stimulated; energy consumption intensity, CO_2 emission intensity On the urban residents of Guangzhou City, indirect energy consumption of carbon emissions have an inhibitory effect.

During the period from 2002 to 2013, the total amount of CO_2 emissions from indirect consumption of urban residents in Guangzhou increased by 71,570.67 million tons of standard coal. 49.45% from the per capita consumption level; 25.03% from the consumer structure; population size and urban and rural popu-

Table 2. Indirect energy consumption of urban residents in Guangzhou from 2002 to 2013.

Influencing	ΔC1	ΔC2	ΔC3	ΔC4	ΔC5	ΔC6
2002-2003	839.28	−38.93	−40752.10	17993.84	17131.95	45627.13
2003-2004	1900.06	54.16	32935.57	−26059.59	20865.06	−90076.11
2004-2005	1319.63	7348.75	6110.64	−4863.46	25488.35	−38123.73
2005-2006	1007.88	−7685.33	3449.03	−276.03	−1248.39	−19993.78
2006-2007	1061.66	100.33	11831.87	2060.72	−13061.05	−529.27
2007-2008	818.74	46.06	4830.33	3391.88	−14971.86	3905.60
2008-2009	973.10	241.84	5388.31	812.81	−5865.41	7436.01
2009-2010	1820.44	1749.81	8882.61	7592.61	−36995.60	144249.43
2010-2011	2478.18	960.40	−40822.79	13861.50	−33163.06	133863.92
2011-2012	1329.15	1222.55	40130.51	3377.64	−48943.69	−223363.45
2012-2013	575.40	139.59	3410.87	21.12	−4883.24	3214.03
2002-2013	14123.54	4139.23	35394.85	17913.04	−95646.94	−33790.22

lation structure contribution rate was 19.73% and 5.78%, respectively. Inhibition of urban residents in Guangzhou indirect energy consumption of CO_2 emissions to reduce the total amount of 129,437.15 tons of standard coal. Among the factors that inhibit the indirect energy consumption of urban residents in Guangzhou, 73.89% came from energy consumption intensity and 26.11% were derived from CO_2 emission intensity. Therefore, the decisive factor in stimulating the CO_2 consumption of urban residents' indirect energy consumption is the per capita consumption level. The decisive factor in restraining the indirect energy consumption of urban residents in Guangzhou is energy consumption intensity.

4.2. Influencing Factors of Indirect Energy Consumption in Rural Residents of Guangzhou

From Table 3 we can see that, on the whole, population size, per capita consumption level, the consumption structure of residents of urban residents in Guangzhou City, indirect energy consumption of carbon emissions have stimulated; urban and rural population structure, energy consumption intensity, CO_2 emission intensity On the rural residents of Guangzhou City, indirect energy consumption of carbon emissions have an inhibitory effect.

During the period from 2002 to 2013, the indirect energy consumption of rural residents in Guangzhou increased by 31,263.84 million tons of standard coal, and 90.79% of the factors that stimulated the indirect energy consumption of rural residents in Guangzhou were from the per capita consumption level. Size and the consumption structure of the residents were 5.64% and 3.57% respectively. 51.71% of the factors contributing to the CO_2 consumption of indirect energy consumption in rural areas of Guangzhou were from energy consumption intensity; 34.98% were from CO_2 emission intensity and 13.31% were from

Table 3. Indirect energy consumption of rural residents in Guangzhou City in 2002-2003.

Influencing	ΔC1	ΔC2	ΔC3	ΔC4	ΔC5	ΔC6
2002-2003	359.30	85.99	35680.91	−946.21	15987.22	19546.97
2003-2004	735.53	−108.21	10302.84	−2428.82	427.36	−35073.60
2004-2005	463.94	−18958.65	7903.26	858.98	6378.61	−13355.22
2005-2006	371.75	19442.14	1166.88	−591.76	29.22	−7378.27
2006-2007	370.80	−160.78	2484.62	−301.47	−3539.92	−187.15
2007-2008	271.33	−70.50	2301.51	1001.88	−4839.69	1293.33
2008-2009	324.82	−377.43	1468.96	1037.48	−2723.13	2483.08
2009-2010	638.81	−3032.48	5348.90	−1568.05	−8726.46	50725.77
2010-2011	1035.63	−2100.13	12934.13	5240.59	−13316.36	56227.68
2011-2012	574.34	−2897.29	5635.67	825.07	−20564.35	−97663.87
2012-2013	204.85	−284.86	875.17	254.12	−1985.13	1144.20
2002-2013	5351.10	−8462.19	86102.85	3381.80	−32872.64	−22237.09

urban and rural population structure. Therefore, the decisive factor in stimulating the CO_2 consumption of indirect energy consumption of rural residents in Guangzhou is the per capita consumption level. The decisive factor in restraining the indirect energy consumption of rural residents in Guangzhou is energy consumption intensity. This is consistent with the decisive factors that affect the indirect energy consumption of urban residents in Guangzhou.

4.3. Influencing Factors of Indirect energy Consumption in Guangzhou Residents

The comparison of the influencing factors of indirect energy consumption CO_2 consumption between urban residents and rural residents in Guangzhou, we can see that, on the whole, the population size, the level of per capita consumption, the consumption structure of residents in Guangzhou urban and rural residents living energy consumption of CO_2 emissions are stimulated, energy consumption intensity, CO_2 emission intensity of Guangzhou urban and rural residents indirect energy consumption CO_2 emissions Have an inhibitory effect. Urban and rural population structure of urban residents in Guangzhou City, indirect energy consumption of CO_2 emissions have stimulated the role of urban residents in Guangzhou City, indirect energy consumption of CO_2 emissions have an inhibitory effect. This is due to the increase in the number of rural residents as a result of the increasing population of urban residents, so that the urban and rural population structure has an inhibitory effect on CO_2 emissions from rural residents' indirect energy consumption.

5. Conclusion and Prospect

5.1. Conclusion

On the whole, the population size, the per capita consumption level and the consumption structure of the residents are stimulating the indirect energy consumption of urban and rural residents in Guangzhou. The energy consumption intensity and CO_2 emission intensity of the urban and rural residents in Guangzhou are the indirect energy consumption Have an inhibitory effect. Urban and rural population structure of urban residents in Guangzhou City, indirect energy consumption of CO_2 emissions have stimulated the role of urban residents in Guangzhou City, indirect energy consumption of CO_2 emissions have an inhibitory effect.

5.2. Prospect

In this paper, the standard that I choose the factors of the indirect energy consumption of residents will be more allow for data availability. I hope that I will further study the influence of other factors on the indirect energy consumption of residents.

References

[1] Li, Y.M. and Zhang, l. (2008) Structural Decomposition Analysis of Indirect Living Energy Consumption of Chinese Residents. *Resource Science*, No. 6, 890-895.

[2] Feng, L., Lin, T. and Zhao, Q.J. (2011) Analysis on Dynamic Characteristics of Energy Consumption and Carbon Emission of Urban Residents. *Chinese Population*, *Resources and Environment*, No. 5, 93-100.

[3] Yao, L., Liu, J.R. and Wang, R.S. (2011) A Comparative Analysis of Carbon Emissions Contained by Urban and Rural Residents in China. *Chinese Population*, *Resources and Environment*, No. 4, 25-29.

[4] Zhang, J.L. (2012) Research on China's CO_2 Emission from Consumption Perspective. Huazhong University of Science and Technology.

[5] Zhu, Q., Peng, X.Z., Lu, Z.M. and Yu, J. (2010) Estimation and Analysis of Energy Consumption of Chinese Residents in China from 1980 to 2007. *Journal of Safety and Environment*, No. 2, 72-76.