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Empirical Study on the Decomposition of Carbon Emission Factors in Agricultural Energy Consumption

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Abstract. The development of low-carbon agriculture is an effective way to maintain sustainable development of agriculture. By using Kaya's identities to study the factors affecting China's agricultural energy consumption carbon emissions, it is found that technical factors, low-carbon agricultural factors, rural living standards, and indirect urbanization. Factors and population size factors are important factors influencing the carbon emissions of agricultural energy consumption. Based on this, the paper uses LMDI index analysis method to decompose the above factors and the contribution rate. It is found that both technical factors and low-carbon technology factors can reduce agricultural carbon emissions, and the emission reduction ability of agricultural low-carbon technology factors is stronger than that. Agricultural technology factors. The total population change can drive carbon emissions positively, but the driving force is not strong. Urbanization indicators are driving a weaker positive for agricultural carbon emissions. To this end, the paper proposes that in the process of developing modern agriculture, it is necessary to strengthen the research and development of low-carbon agriculture technology, and promote the development of urbanization in an orderly manner in order to achieve the goal of low-carbon agriculture and sustainable development.

1. Introduction

At present, the research on agricultural carbon emissions in the academic circles mainly focuses on two areas of agricultural carbon emission measurement and agricultural carbon emission driving factor analysis. Decomposition analysis is an analytical method that can quantitatively decompose comprehensive indicator changes into several contributing factors. It has been widely used in energy and environmental system analysis, especially to measure the contribution of carbon dioxide (CO₂) emission change drivers. In order to explore the other factors that affect the agricultural carbon emissions in other studies, there are other factors that have an impact on agricultural carbon emissions. This study is based on Kaya's identity and uses its mathematical properties to influence the factors affecting agricultural carbon emissions. Decomposition introduces two factors that may affect the changes of agricultural carbon emissions, such as urbanization factors and changes in rural living standards, and explores the direction and extent of the impact of urbanization levels and rural living



standards on agricultural carbon emissions. Based on Kaya's identity, the LMDI exponential decomposition method is used to decompose the possible driving factors of agricultural carbon emissions caused by energy consumption, and to study its contribution rate. Taking into account the unconventional agricultural carbon emission drivers such as the speed and level of population urbanization, it will provide a more scientific and comprehensive basis for the formulation of low-carbon agricultural development policies and measures in the future [1].

2. Research and data processing methods

2.1. Carbon emission measurement method

This paper will use the IPCC method to measure the carbon emissions of China's agriculture from the perspective of energy consumption. Based on this, the calculation formula for the construction of China's agricultural carbon emissions is as follows:

$$T = \sum_{j=1}^n T_i = \sum_{j=1}^n t_i \beta_i \quad (1)$$

Where T is the total amount of carbon emissions, T_i is the carbon emission of the i type carbon source, t_i is the amount of the carbon source i , β_i is the carbon emission coefficient of each carbon source, and i, n is the type of energy and the type of energy number.

2.2. Kaya identity extension

Kaya's identity establishes a link between economic, policy, and demographic factors and CO_2 generated by human activities. The expression is:

$$CO_2 = \frac{CO_2}{PE_l} \cdot \frac{PE_l}{GDP} \cdot \frac{GDP}{POP} \cdot POP \quad (2)$$

Where CO_2 , PE_l , GDP , and POP represent CO_2 emissions, total primary energy consumption, gross domestic product, and total domestic population, respectively. Kaya's identity is simple and easy to operate, and has been widely used in energy and environmental economics. However, because of the limited number of variables examined, the results obtained are basically limited to the macroscopic quantitative relationship between CO_2 emissions and energy, economy and population. Based on the original Kaya identities, the driving factors that may affect China's agricultural carbon emissions are further broken down as follows:

$$\begin{aligned} CO_2^R &= \frac{CO_2^R}{PE_l^R} \cdot \frac{PE_l^R}{GDP^R} \cdot \frac{GDP^R}{POP^R} \cdot \frac{POP^R}{POP} \cdot POP \\ &= CPE \cdot PEG \cdot GDP \cdot IUR \cdot POP \end{aligned} \quad (3)$$

Where CO_2^R represents the total amount of carbon emissions from the agricultural production sector due to energy consumption; PE_l^R represents the total agricultural energy consumption; GDP^R represents the GDP contributed by the agricultural sector in GDP, agricultural GDP; POP^R and POP respectively rural population and total population. $CPE = \frac{CO_2^R}{PE_l^R}$ indicates the intensity of

agricultural carbon emissions, that is, the carbon emissions generated by each unit of energy consumption, reflecting the impact of general technical factors in agricultural production;

$PEG = \frac{PE_t^R}{GDP^R}$ indicates the energy efficiency of agricultural use, that is, the energy intensity of unit agricultural GDP, reflecting the low-carbon technical factors of agriculture. The impact of $GDP = \frac{GDP^R}{POP^R}$; the living standard, that is, rural per capita agricultural GDP, reflects the agricultural

economic growth results enjoyed by the rural population per capita; $IUR = \frac{POP^R}{POP}$ indicates that the

rural population accounts for the proportion of the total population, indirectly reflecting the level of urbanization. Generally speaking, the proportion of urban population to the total population is used to indicate the level of urbanization. The larger the proportion of urban population, the higher the level of urbanization. The indirect indicator is used here, that is, the proportion of rural population to the total population, and the lower the proportion, the urbanization. The higher the level [2]. POP represents the total population, that is, the population size effect, reflecting the impact of population changes on agricultural carbon emissions.

2.3. LMDI decomposition method

According to the LMDI method, the decomposition results of each factor are as follows:

$$\Delta CO_2^{CPE} = \left[\frac{(CO_2^R)^t - (CO_2^R)^0}{\ln(CO_2^R)^t - \ln(CO_2^R)^0} \times \ln \frac{CPE^t}{CPE^0} \right] \quad (4)$$

$$\Delta CO_2^{PEG} = \left[\frac{(CO_2^R)^t - (CO_2^R)^0}{\ln(CO_2^R)^t - \ln(CO_2^R)^0} \times \ln \frac{PEG^t}{PEG^0} \right] \quad (5)$$

$$\Delta CO_2^{GDP} = \left[\frac{(CO_2^R)^t - (CO_2^R)^0}{\ln(CO_2^R)^t - \ln(CO_2^R)^0} \times \ln \frac{GDP^t}{GDP^0} \right] \quad (6)$$

$$\Delta CO_2^{IUR} = \left[\frac{(CO_2^R)^t - (CO_2^R)^0}{\ln(CO_2^R)^t - \ln(CO_2^R)^0} \times \ln \frac{IUR^t}{IUR^0} \right] \quad (7)$$

$$\Delta CO_2^{POP} = \left[\frac{(CO_2^R)^t - (CO_2^R)^0}{\ln(CO_2^R)^t - \ln(CO_2^R)^0} \times \ln \frac{POP^t}{POP^0} \right] \quad (8)$$

3. Data sources and processing

According to the China Statistical Yearbook, agricultural energy consumption includes coal, coke, gasoline, kerosene, diesel, fuel oil and electricity. The fossil energy consumption data used in this paper is derived from the energy consumption scale of the sub-sectors in the China Statistical Yearbook. The population figures and agricultural output data of the past years are derived from the

China Statistical Yearbook, and the carbon emissions of various energy sources in the calculation of carbon emissions [3]. The coefficient adopts the carbon emission coefficient adopted by the Energy Research Institute of the National Development and Reform Commission. The specific values of the standard coal conversion coefficient and carbon emission coefficient are shown in Table 1.

Table 1. Standard coal conversion coefficient and carbon emission coefficient.

Energy type	Conversion factor / carbon displacement coefficient	Energy type	Conversion factor / carbon displacement coefficient
coal	0.714/0.756	Diesel	1.457/0.592
Coke	0.971/0.856	Fuel oil	1.429/0.619
gasoline	1.471/0.554	electric power	1.429/0.619
kerosene	1.457/0.571		

4. Results analysis

From formula (1) and previous data, the carbon emissions from the national and agricultural sectors due to direct energy consumption in 2007-2017 can be calculated. It can be more clearly seen from Figure 1 that the absolute quantity of primary energy consumption in China varies with time. It shows an upward trend of volatility, and its proportion in the total energy consumption of the three industries is declining year by year. This can be explained by the fact that as agriculture changes to modernization, changes in production methods and business models will cause energy consumption in agriculture. The absolute number has risen. However, relatively speaking, as the proportion of GDP in the national economy in the national economy continues to shrink with the increase in the level of urbanization and industrialization, its relative proportion shows a downward trend [4].

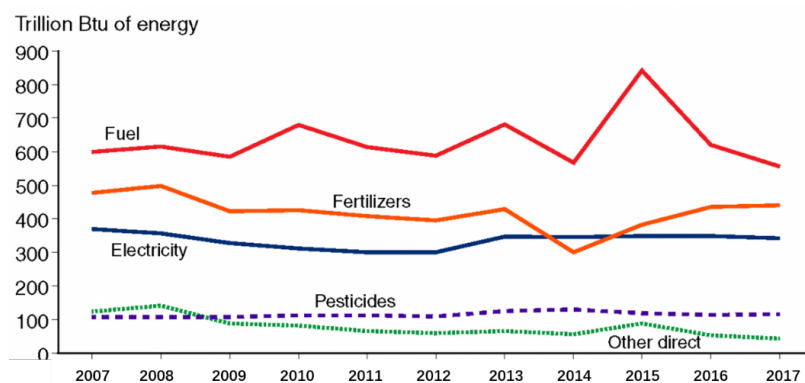


Figure 1. Distribution of various types of agricultural energy consumption in China from 2007 to 2017.

It can be seen from Figure 2 that from 2007 to 2017, the intensity of agricultural carbon emission showed a gradual downward trend, and there was a large fluctuation between 2014 and 2016. The intensity of agricultural energy was not only reflected in 2014-2016, but also during the inspection period. The slow decline trend; the rural living standard showed a substantial improvement during the inspection period, which was mainly related to the overall economic environment; the total population showed a slow upward trend during the inspection period, in line with the general law of population growth; The level of urbanization shows a relatively gradual downward trend, that is, the level of urbanization is rising. In fact, the indirect urbanization rate is symmetric with the general population urbanization rate of 0.5, as shown in Figure 3.

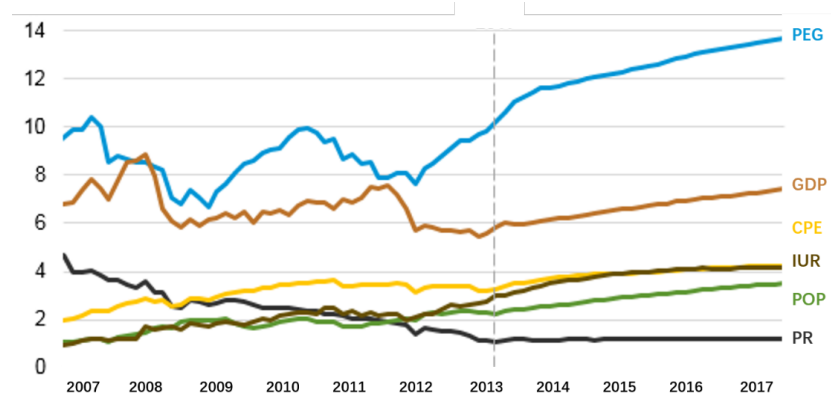


Figure 2. Curve of agricultural carbon intensity, energy intensity, rural living level, indirect urbanization level, rural population and total population size in 2007-2017.

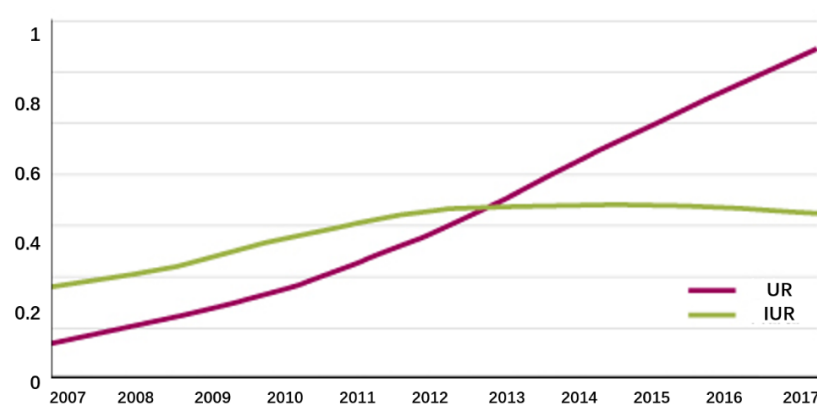


Figure 3. China's urbanization rate (UR) and indirect urbanization rate (IUR) from 2007 to 2017.

The data obtained by LMDI multiplication decomposition shows that agricultural carbon emissions have increased by about 1 time in 2007-2017, but this value is obviously underestimated due to the use of indirect urbanization indicators. Among them, the change of general technical effect caused the agricultural carbon emission change to be 0.7271 times of the base period, and the agricultural low-carbon technology effect caused the agricultural carbon emission change to be 0.1284 times of the base period, which showed a significant negative driving force, but from the segmented interval year Investigating its drive shows a wave dynamic potential. On the contrary, changes in rural living standards have caused agricultural carbon emissions to change to a base period of 15.1713 times, showing a strong positive driving force, and from each segment of the annual interval, it has also maintained more than one-fold change. The total population change also caused a positive change in agricultural carbon emissions [5]. This change was 1.1901 times relative to the base period, and it also showed a consistent positive drive during each sub-segment observation period. More specifically, due to the indirect urbanization and the indicators of urbanization are mutually inverse indicators, in the process of decomposition, the negative impact on agricultural carbon emissions is used. The same algorithm is used to measure the impact of general urbanization rate on carbon emissions. It caused an increase of 1.0111 times in agricultural carbon emissions throughout the inspection interval, showing a weak positive drive.

5. Conclusion

Through the optimization of technology research and production management methods, continuously improve fuel carbon emission efficiency and reduce energy consumption per unit of output, thereby

reducing carbon emission intensity and energy intensity, and reducing carbon emissions from agricultural energy consumption. Through the development and promotion of the use of biomass energy, solar energy and other clean energy to improve rural energy structure, with agricultural waste recycling and innovative agricultural management model, reduce carbon emissions in agricultural production and management, and take sustainable agricultural development with low carbonization the way. In the case of a general improvement in the living standards of the rural population, we maintain a good atmosphere of diligence and thrift, make the best use of modern facilities, and save on the use of living and production energy. While improving the living standards of the rural population, we will cultivate a low-carbon life and low-carbon production awareness of the rural population from the perspective of social responsibility, and promote energy conservation and emission reduction in the life and production process. Promote urbanization construction in a rational and orderly manner, integrate low-carbon agricultural development into urban-rural integration and urban-rural integration development, appropriately control the speed of urban scale expansion, change urban and rural lifestyles, cultivate low-carbon life concepts, and use new clean energy. In terms of promotion, the investment in people's property and materials will be increased to ensure that farmers will effectively and efficiently change to the citizens during the urbanization process.

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References

- [1] Sun Meng. Empirical Study on the Influencing Factors of China's Energy Consumption Carbon Emissions Change. Jilin University, Vol.1 (2010) No.28, p. 117-119.
- [2] Li Huifeng. An Empirical Study on the Decomposition of Carbon Emission Factors in Primary Energy Consumption in Beijing. Journal of Frontiers, Vol. 9 (2011) No.12, p. 103-109.
- [3] Guo Yongqi. Factor Decomposition and Empirical Study of Carbon Emissions in China's Energy Consumption. Nandu Academy: Journal of Humanities and Social Sciences, Nanyang Normal University, Vol. 4 (2013) No33, p. 117-118.
- [4] Geng Chengxiang, Lin Yong. Empirical Study on the Factor Decomposition of Energy Consumption Carbon Emission in Gansu Province. Industrial Technology & Economy, Vol.1 (2012) No.14, p. 37-43.
- [5] LI Guozhi, LI Zongzhi, ZHOU Ming. Empirical Analysis of the Relationship between Carbon Emissions and Agricultural Economic Growth. Agricultural Economics and Management, Vol.3 (2011) No.4, p. 32-39.