Research on the Impact of upgrading of consumption structure on energy intensity under the background of urban and rural dual economy

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Abstract: Based on the current situation of dual economic structure of urban and rural areas in China, this paper takes urban and rural areas as two independent research objects, and constructs the panel threshold regression model of consumption structure upgrading on energy consumption intensity. The results show that the upgrading of regional urban residents' consumption structure has double threshold effect on energy intensity, and the upgrading of urban residents' consumption structure has a restraining effect on energy intensity. With the upgrading of per capita income, it first decreases and then increases; the upgrading of rural residents' consumption structure has a double threshold effect on energy intensity, the upgrading of rural residents' consumption structure will significantly inhibit the energy intensity when the per capita income of residents is in the maximum range. In addition, under the threshold of per capita income, compared with rural areas, the upgrading of consumption structure of urban residents has a more prominent effect on the inhibition of energy intensity.

1. Introduction

Energy is not only the material basis of social production and people's life, but also the power source of economic development. With the development of economy, more and more energy needs will be generated, and the sustainable use of non-renewable resources such as fossil resources will make energy shortage a common problem facing the international community. The extensive economic growth mode which depends on resource consumption aggravates the severity of energy shortage in China. China's energy consumption ranks first in the world, its energy intensity is higher than that of developed countries, and its energy efficiency needs to be further improved. In the critical period of economic development transformation and upgrading, it is of great significance to solve the contradiction between the limitation of energy resources and the sustainability of economic growth. Not only that, coal based energy consumption structure has produced a large number of greenhouse gases, and now China's carbon dioxide emissions have ranked second in the world. In order to solve these problems, general secretary Xi Jinping put forward the energy security strategy of "four revolutions and one cooperation" in 2014. He explicitly demanded that we must firmly control the total energy consumption, reduce the intensity of energy use, and put energy conservation in the whole process of economic and social development and various fields. However, to solve the energy problem, we should not only rely on the energy industry itself, but also combine the whole economic development mode and the structure of production and consumption.

The consumption of residents has become the main factor causing the increase of energy consumption[1][2]. The existing research focuses on the relationship between the consumption level of...
residents and the total energy consumption and CO$_2$ emissions. Wei Y M say that the carbon emissions caused by the daily consumption of Chinese residents accounted for 30% of the total carbon emissions in China every year$^{[3]}$. The energy consumption caused by residents' daily consumption accounts for 45% - 50% of the total energy consumption$^{[4]}$. Moreover, the impact of residents' consumption on energy consumption is not a simple linear relationship, and there are obvious regional differences$^{[5]}$. Chen X H found that the expansion of urban-rural income gap is bad to the improvement of social energy efficiency$^{[6]}$. At present, the consumption expenditure scale of residents is increasing year by year, and the demand for consumption is becoming more and more diverse. There are few studies on the energy consumption intensity notice the changes in the consumption structure of urban and rural residents. Based on the background of the dual development of urban and rural areas in China, To discusses the relationship between the upgrading of consumption structure of urban and rural residents and the intensity of energy consumption respectively, providing a new idea for the correct understanding of China's energy problem.

2. research design

2.1 Variable selection and data source

Energy consumption intensity is interpreted variable, which is measured by the ratio of consumption data of ten thousand tons of standard coal and GDP at the end of each year. GDP is converted based on 1978. The upgrading index of consumption structure of urban residents and that of rural residents are selected as the main explanatory variables. Draw lessons from the existing research of domestic scholars$^{[7]}$. The upgrading index of consumption structure of urban residents is determined by the proportion of the sum of the consumption of health care, education, culture, transportation and communication of urban residents in each region to the total consumption of urban residents in each province. The upgrading index of consumption structure of rural residents is calculated by the same method.

The per capita income of urban residents and rural residents is the threshold variable of this paper. In order to eliminate the influence of price factors, the data are translated on the basis of 1978. With reference to the existing research, technological progress, population scale and industrial structure are included in the control variables. The percentage of regional invention patent authorization in the total number of patent authorization is used to measure the level of regional technological progress; the population at the end of each year is used to measure the population scale of each region, which is also treated logarithmically; the ratio of the output value of the secondary industry to the output value of the tertiary industry in each region is used to measure the industrial structure of the region.

Due to the lack of some data, in order to ensure the integrity of the research data and the accuracy of empirical analysis, this paper selects panel data from 29 provinces and municipalities in China, excluding Tibet and Xinjiang. The time span is from 2007 to 2017. The relevant data are from China energy statistical yearbook and China Statistical yearbook.

2.2 Model settings

Threshold model can be divided into single threshold regression model and multi threshold regression model. Multi threshold regression model is the extension of single threshold regression model. Single threshold regression model provides the basis for parameter estimation and hypothesis test of multi threshold regression model.

First, the regression equations of single threshold and double threshold are set as follows:

$$y_{it} = \beta_0 + \beta_1 Z_{it} + \theta_1 X_{iq} (q_i \leq r) + \theta_2 X_{ir} (q_i > r) + u_{it} + \varepsilon_{it}$$ (1)

$$y_{it} = \beta_0 + \beta_1 Z_{it} + \theta_1 X_{iq} (q_i \leq r) + \theta_2 X_{ir} (q_i > r) + \theta_3 X_{it} (r_1 < q_i \leq r_2) + \theta_4 X_{it} (q_i > r_2) + u_{it} + \varepsilon_{it}$$ (2)

In the above formula $y$ is the energy consumption intensity, $Z$ is the set of control variables, and $X$ is the upgrading index of consumption structure of urban and rural residents. $q$ is the threshold variable expressed by the per capita income of urban and rural residents. $\beta_0, \beta_1, \theta_1, \theta_2$ are the output

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elasticity coefficients of each variable, \( u_t \) are regional fixed effects and \( \varepsilon_t \) is the random interference term. \( r \) is the threshold value to be estimated, \( i \) and \( t \) represent provinces and years respectively. \( I (\bullet) \) is an explicit function. When the condition of the function is satisfied, the value is 1. Otherwise, the value is 0.

3 Empirical analysis

3.1 The threshold effect of the upgrading of consumption structure on energy intensity in rural areas

Using Stata14.0 software, taking the per capita income of rural residents in each region as the threshold variable, bootstrap (BS) method was used to conduct 500 self sampling, and then tested the hypothesis of single threshold, double threshold and triple threshold successively. It can be seen from Table 1 that the upgrading index of rural residents’ consumption structure has a threshold effect on energy intensity. The p-values of single threshold model and double threshold model are 0.000 and 0.036, respectively, indicating that single threshold and double threshold exist at the significance level of 1% and 5%, while the test results of triple threshold model are not significant, so this paper adopts the double threshold model for analysis. The two thresholds and their confidence intervals are further estimated. The results are shown in Table 2. The first threshold is 6.541 and the second threshold is 7.432. The LR figure is shown in Figure 1. X-axis represents threshold parameter, Y-axis represents LR value. The horizontal dotted line in Figure 1 represents the LR critical value of the likelihood ratio statistic at 95% confidence level. The interval between the two points where the horizontal dotted line intersects the LR test curve is the confidence interval of the threshold value. When the threshold value falls in this interval, the likelihood ratio statistic is less than the critical value, which means that the threshold value is valid.

| Threshold number test | number of self sampling | F   | P    | critical value       |
|-----------------------|-------------------------|-----|------|----------------------|
|                       |                         |     |      | 1%                  | 5%       | 10%       |
| Single threshold test | 500                     | 47.142 | 0.000 | 33.654               | 20.534   | 13.501     |
| Double threshold test | 500                     | 15.825 | 0.036 | 23.061               | 13.363   | 9.462      |
| Three threshold test  | 500                     | 5.795  | 0.196 | 24.899               | 13.650   | 9.224      |

Table 2 Estimated threshold of rural area and its confidence interval

| The threshold effect of the upgrading of consumption structure on energy intensity in rural areas | 7.432 | [7.112, 7.945] |
|---------------------------------------------------------------------------------------------|------|----------------|
| 3.2 The threshold effect of the upgrading of consumption structure on energy intensity in urban areas |

Referring to the above methods, taking the per capita income of urban residents in each region as the threshold variable, this part tests the threshold effect of upgrading the consumption structure of urban residents. Just as Table 3 says, The upgrading index of consumption structure of urban residents has a threshold effect on per capita energy intensity. The p-values of single threshold and double threshold
are 0.008 and 0.029, respectively, indicating that the single threshold and double threshold pass the test at the significance level of 1% and 5%, although the triple threshold model is also significant at the level of 1%, but because the third threshold is within the range of the first two thresholds, referring to the research of domestic scholars, it is decided to use the double threshold model for analysis, so as to reduce freedom. Table 4 shows the two thresholds and their corresponding confidence intervals under the double threshold model. The first threshold is 9.569 and the second threshold is 10.701. Similarly, LR charts show that threshold estimates are valid.

Table 3 Results of the number of thresholds in Urban area

| Threshold number test | model           | number of self-sampling | F     | P      | critical value |
|-----------------------|-----------------|-------------------------|-------|--------|----------------|
|                       |                 |                         |       |        | 1%     | 5%     | 10%    |
| Single threshold test |                 |                         | 500   | 28.371 | 0.008  |         |        |
| Double threshold test |                 |                         | 500   | 18.414 | 0.029  |         |        |
| Three threshold test  |                 |                         | 500   | 15.659 | 0.004  |         |        |

Table 4 Estimated threshold of Urban area and its confidence interval

| The threshold effect of the upgrading of consumption structure on energy intensity in urban areas | critical value | 95% confidence interval |
|------------------------------------------------------------------------------------------------|----------------|-------------------------|
| 9.569                                                                                           |                | [9.123, 9.998]          |
| 10.701                                                                                          |                | [9.253, 10.778]         |
| 9.188                                                                                          |                | [9.188, 10.288]         |

Figure 1 Two-threshold likelihood ratio test of per capita income of rural residents
3.3 Regression results of threshold model

The threshold values obtained from the two tests are respectively substituted into formula 2, and the regression results are shown in Table 6. We can see the relationship between the upgrading of consumption structure and energy intensity of urban residents has different effects with the change of per capita income level of urban residents. In general, the upgrading of consumption structure of urban residents can significantly reduce the regional energy intensity. When the per capita income of urban residents is at the lowest level, the regression result of the upgrading of the consumption structure of urban residents to the energy intensity is -0.497 at the significance level of 5%. If the per capita income of urban residents increases to the middle range, the inhibition decreases to -0.251, which is because with the improvement of the income level, the housing, vehicles, and communication consumption have stimulated the development of high energy consuming industries such as urban industry and manufacturing industry. When the income of urban residents exceeds the maximum threshold, urban residents will tend to choose new energy-saving and environmental protection products with higher quality of life, and the consumption will turn to service industry and knowledge technology intensive industry with higher price level, which has high price and low energy consumption coefficient. In this range, the upgrading of consumption structure of urban residents shows the greatest inhibition on energy intensity, with a correlation coefficient of -0.824, which is significant at the level of 1%.

The threshold regression results of upgrading the consumption structure of rural residents in the region are shown in column 2 of table 6. When the per capita income of rural residents is at the lowest level, the regression result of upgrading index of consumption structure of rural residents to energy intensity is not significant. This may be because the consumption of rural residents in the lowest income range is still at the level of basic necessities such as food, clothing and housing due to the limitation of economic development level. When the income of rural residents increases to the middle range, the upgrading of the consumption structure of rural residents promotes the energy consumption intensity, and the correlation coefficient is 0.007 at the significance level of 10%. because the consumption of automobiles and household appliances of rural residents increases and the energy consumption increases, but limited by the constraints of economic development, the energy intensity is reversed increase. When the per capita income of rural residents crosses the highest threshold, the consumption structure is further improved, and the inhibition coefficient is -0.003, which is significant at the level of 10%. From table 6, we can also see that the upgrading of consumption structure of urban residents has a more prominent effect on the inhibition of energy intensity. Therefore, to solve the energy problem at this stage, we should not only adjust the consumption structure of urban residents, but also further stimulate the potential of rural residents in energy conservation and emission reduction.
ural areas, the intensity. Under the two regression models, technological progress has different effects on energy intensity. Because a restraining effect on energy intensity. With the structure of urban residents in the increase regional R&D investment and cultivate innovative technical talents, high pollution and emission to the technology intensive low industrial structure, guide cooperate with the deepening implementation of the "coal to electricity" policy. (3) Adjust the industrial structure, guide the transformation and upgrading of the resource intensive industries with high pollution and emission to the technology intensive low-carbon industries as soon as possible. To increase regional R&D investment and cultivate innovative technical talents, promote the accelerated utilization of "energy saving and emission reduction" technologies.

### Table 5 Threshold regression results

| Threshold value | The threshold effect of the upgrading of consumption structure on energy intensity in urban areas | The threshold effect of the upgrading of consumption structure on energy intensity in rural areas |
|----------------|-------------------------------------------------|-------------------------------------------------|
| r≥9.569        | -0.497⁷  (-2.540)                               | -0.524⁷  (-2.880)                               |
| 9.569<r≤10.701 | 0.251⁷  (1.750)                                 | 0.077²  (0.95)                                 |
| r>10.701       | -0.924³  (-3.954)                               | -0.176  (-1.844)                               |
| r≤6.541        | 0.007⁷  (0.95)                                  | 0.003⁷  (0.16)                                 |
| 6.541<r≤7.432  |                                                 |                                                 |
| r>7.432        |                                                 |                                                 |

Note: * * * means significant at 1%, * * means significant at 5%, and * means significant at 10%.

The analysis results of the control variables are the same as those of the existing research. The rapid development of secondary industry and population scale also has a significant positive role in promoting energy intensity. Under the two regression models, technological progress has different effects on energy intensity. Because technological progress makes high energy consuming enterprises improve equipment and technology, the increase of enterprise productivity reduces energy intensity, but on the other hand, the increase of enterprise output will also lead to consumption growth.

### 4. Conclusions and suggestions

This paper draws the following conclusions: (1) the upgrading of consumption structure of urban and rural residents in each province has a double threshold effect on energy intensity. (2) the upgrading of consumption structure of urban residents has a restraining effect on energy intensity. With the improvement of per capita income, the upgrading of consumption structure of urban residents in the region will reduce the energy intensity of the region. (3) The upgrading of the consumption structure of rural residents improves the energy intensity when per capita income is distributed in the lowest range. But it turn to inhibit the energy intensity when per capita income is distributed in the largest range. (4) compared with the rural areas, the upgrading of the consumption structure of urban residents has an effect on the energy intensity. The inhibition was more prominent.

In this regard, this paper puts forward the following suggestions: (1) It is necessary to increase the publicity of low-carbon consumption concept, enhance the awareness of energy conservation of urban residents, especially promote the transformation of their residential consumption and transportation to a low-carbon lifestyle. We should give appropriate policy preference, encourage urban residents to transform into knowledge intensive industries and service industries, and then control energy intensity. (2) the energy consumption of rural residents is more to meet the basic living needs. We should give corresponding subsidies to eliminate high energy consumption household equipment in rural areas and promote energy-saving household appliances at low cost. In addition, we should popularize the knowledge of energy conservation and environmental protection to rural areas, encourage them to cooperate with the deepening implementation of the "coal to electricity" policy. (3) Adjust the industrial structure, guide the transformation and upgrading of the resource intensive industries with high pollution and emission to the technology intensive low-carbon industries as soon as possible. To increase regional R&D investment and cultivate innovative technical talents, promote the accelerated utilization of "energy saving and emission reduction" technologies.

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