Study on Impact of Industrial Structure Upgrading on Energy Efficiency in the Yellow River Basin———Based on the data of 2001—2019

LIU Juan
School of Business Administration, Shandong Women’s University, Jinan, Shandong, China
e-mail: 30015@sdwu.edu.cn

Abstract.The Fifth Plenum of the 19th Central Committee of the Communist Party of China stressed the need to improve the living environment, achieve high-quality economic development, rationally allocate energy resources and improve the energy use efficiency during the 14th Five-Year Plan period. The Yellow River Basin is an important energy base in China, and the energy use efficiency directly affects the ecological protection and high-quality development of the Yellow River Basin. Based on the analysis of the relationship between industrial structure upgrading and energy efficiency, and the panel data of nine provinces in the Yellow River Basin from 2001 to 2019, this paper empirically analyzed the impact of industrial structure upgrading on energy use efficiency in the Yellow River Basin. Results showed that: On the whole, industrial structure upgrading positively promoted the improvement of energy efficiency in the Yellow River Basin; from the view of sequential variation, the overall energy use efficiency in the Yellow River Basin was on the rise; from the view of spatial difference, the energy use efficiency of provisions in the middle and upper reaches of the Yellow River Basin was relatively low, and the energy use efficiency in the lower reaches showed significant advantages.

1.Introduction
The Fifth Plenum of the 19th Central Committee of the Communist Party of China stressed the need to realize the green transformation of production and life style, more reasonable allocation of energy and resources and significantly improved use efficiency, continuing reduction of the total emission of major pollutants and improvement of ecological environment, strengthened ecological security barrier and significantly improved urban and rural living environment during the 14th Five-Year Plan period. The improvement of energy use efficiency is crucial to maintaining economic growth, reducing pollutant emissions and ultimately improving the ecological environment and living environment. At present, most literatures aim to improve energy efficiency based on the perspective of technological innovation (Yue YANG et al., 2018) [1]. However, technological innovation cannot directly improve energy efficiency. Instead, it promotes industrial structure upgrading, thereby contributing to upgrading and structure optimization of energy industry.

The Yellow River Basin is an important birthplace and inheritance and innovation area of Chinese civilization. The building of the Yellow River ecological economic belt is an important starting point to realize the great rejuvenation of Chinese nation. The Party Leadership's Proposals for Formulating the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 clearly proposed to promote the ecological protection
and high-quality development of the Yellow River Basin. The Yellow River Basin also faces the bottleneck of resource constraints while maintaining high-quality economic growth and green development. The Outline of Ecological Protection and High Quality Development Plan for the Yellow River Basin compiled by the National Development and Reform Commission in 2020 pointed out that effective measures should be taken to promote the high-quality development of the Yellow River Basin, accelerate the replacement of old growth drivers with new ones and build a modern industrial system with characteristics and advantages. Resolving the contradiction between economic development and ecological environment in the Yellow River Basin is crucial to the great rejuvenation of Chinese nation and it is of great theoretical and practical significance to explore the methods and paths to improve energy efficiency in the Yellow River Basin through the transformation and upgrading of industrial structure.

2. Literature Review
Extensive studies have been conducted in academia to identify the relationship between industrial structure upgrading and energy efficiency. Binbin YU (2107) analyzed the panel data of 285 prefecture level cities from 2003 to 2013 with the spatial econometric method. The results showed that the upgrading of industrial structure had a significant role in promoting the improvement of energy efficiency [2]. Yingshi LIU (2018) selected the sample data of 260 cities from 2005 to 2014, and analyzed the relationship among industrial structure adjustment, energy efficiency and green total factor production efficiency with the Malmquist index method. The results showed that both industrial structure upgrading and improvement of energy efficiency have a positive role in promoting green total factor production efficiency [3]. In an analysis carried out with a total of 600 sample data of 30 provinces, autonomous regions and municipalities in China from 1997 to 2016 as the research object, Zhaoyang LUO (2019) concluded that the industrial structure adjustment could only have a significant impact on the improvement of energy efficiency after a certain degree of technology upgrading was completed[4].

Scholars commonly believe that industrial structure upgrading can improve energy efficiency. However, most of the current studies were performed based on the nation or different provisions, and few scholars studied the relationship between the industrial structure upgrading and the energy efficiency in the Yellow River Basin. Therefore, this paper will conduct an in-depth analysis of the relationship between the industrial structure upgrading and the energy efficiency in the middle and upper reaches and lower reaches of the Yellow River Basin, and thus provide targeted policy suggestions for achieving the "win-win" situation of energy efficiency improvement and industrial structure upgrading.

3. Study Design

3.1 Index selection
This paper selects the relevant data of nine provinces in the Yellow River Basin from 2005 to 2019. The data comes mainly from China Energy Statistical Yearbook and China Statistical Yearbook, where the indicators involved are energy efficiency and industrial structure upgrading and the control variables include physical capital, human capital, RMB exchange rate and export. The explanation and measurement methods of each variable are as follows:

Energy efficiency (EE): the explained variable in this paper. It is the ratio of total GDP to total energy consumption. The higher the energy efficiency is, the greater the output value per unit of energy consumption is, which means the higher the production efficiency.

Industrial structure upgrading (ISU): the explanatory variable in this paper. Industrial structure upgrading is represented by the ratio of the added value of the tertiary industry to the added value of the secondary industry.

Physical capital (K): Physical capital, human capital, RMB exchange rate and export are defined as the control variables in this paper. The total value of fixed assets is taken as the physical capital stock,
and data processing is performed with 2005 as the base year, in unit of RMB 100 million.

Human capital (L): In the paper, the level of human capital is measured based on the education years per capita in each province. The calculation formula is: primary school×6+ junior high school×9+ senior high school×12+ junior college and above×16, in years.

RMB exchange rate (RMBRATE): The exchange rate between RMB and US dollar is calculated with the direct pricing method in this paper.

EXPORT: The data comes mainly from China Statistical Yearbook, in ten thousand US dollars.

3.2 Data description
The data showed that: As shown in Table 1, the maximum value of the explained variable, i.e. the energy efficiency is 2.323, the minimum value is 0.242, and the standard deviation is 0.499; the maximum value of explanatory variable, i.e. the industrial structure upgrading is 1.695, the minimum value is 0.500, and the standard deviation is 0.258.

Table 1. Descriptive statistics of variables

| Variable | Observations | Mean | Std.Dev. | Max | Min |
|----------|--------------|------|----------|-----|-----|
| EE       | 135          | 0.903| 0.499    | 2.323| 0.242|
| ISU      | 135          | 0.849| 0.258    | 1.695| 0.500|
| K        | 135          | 23370.36| 20380.32| 205622.72| 2035.76|
| L        | 135          | 7.155| 1.056    | 11.146| 5.334|
| RMBRATE  | 135          | 6.852| 5.253    | 8.277| 5.154|
| EXPORT   | 135          | 2240296.714| 3788333| 16144000| 25187.6|

4. Empirical Results and Analysis

4.1 Construction of econometric model
To conduct an in-depth analysis of the impact of industrial structure upgrading on energy efficiency, this paper establishes the following econometric model by reference to the viewpoint of Mingyuan LV et al (2016) [5]:

\[ ee_i = c + aisu_i + b_i \sum u_i + \varepsilon_i \]  

(1)

The meanings of the symbols in the econometric model: the subscript i is the region, t is the year, c is a constant term, u is a series of control variables, and \( \varepsilon \) is a random error term.

4.2 Relationship validation
Through the stationarity test, it is found that: the first-order difference of both energy efficiency and industrial structure upgrading had been verified through the test, while the original variables had not been verified through the test. In a Hausmann test, Chi (2) completed the significance test with value of 34.27 and significance level of 1%. Therefore, the fixed effect model should be selected, and the benchmark regression results are shown in Table 2.

Table 2. Relationship Between Validation

| Variable | (1)         | (2)         | (3)         |
|----------|-------------|-------------|-------------|
| C (Constant) | 0.272* (1.785) | -0.756 (-3.07) | -1.067*** (-4.01) |
| ISU      | 0.921*** (5.75) | 0.183*** (2.53) |         |
| K        | 0.0001*** (9.29) | 0.00002*** (9.32) |         |
As shown in the model (1), without the control variables of physical capital, human capital, RMB exchange rate and export, while the industrial structure upgrading increased by 1 unit, the energy efficiency increased by 0.921 units, showing a significant positive correlation between the industrial structure upgrading and the energy efficiency. Therefore, the tertiary industry may better improve the energy efficiency compared with the secondary industry. Due to poor matching degree of the model (1), R-squared is significantly increased by adding control variables to the econometric model (2) and (3). Model (2) mainly explains the relationship between energy efficiency and control variables such as physical capital, human capital, RMB exchange rate and export. While the physical capital increased by 1 unit, the energy efficiency increased by 0.0001 units; while human capital increased by 1 unit, the energy efficiency increased by 0.2372 units, but the increase was not significant; while RMB exchange rate increased by 1 unit, the energy efficiency decreased by 0.0495 units because increased RMB exchange rate will stimulate imports while excessive dependence on imports may affect the enthusiasm of China's energy technology development; a possible reason of positive coefficient of export is the failure to make good use of imported technology and equipment in energy exploitation and processing due to excessive dependence on exports. In model (3), while the industrial structure upgrading increased by 1 unit, the energy efficiency increased by 0.1834 units, further verifying the conclusion that industrial structure upgrading can promote the improvement of energy efficiency.

To analyze the difference in relationship between industrial structure upgrading and energy efficiency in different locations of the Yellow River Basin, the Yellow River Basin was divided into middle and upper reaches and lower reaches (middle and upper reaches: Qinghai Province, Gansu Province, Ningxia Hui Autonomous Region, Sichuan Province, Inner Mongolia Autonomous Region, Shaanxi Province and Shanxi Province; lower reaches: Henan Province and Shandong Province). From the main measurement results, it was found that while the industrial structure upgrading increased by 1 unit, the energy efficiency increased by 0.215 units in 7 provinces in the middle and upper reaches; and while the industrial structure upgrading increased by 1 unit, the energy efficiency increased by 0.516 units in 2 provinces in the lower reaches, significantly higher than that in middle and upper reaches. It can be seen that high level upgrading of industrial structure in lower reaches has significantly promoted the improvement of energy efficiency. Possible reasons of higher energy efficiency may be that developed economy in Shandong and Henan provinces, advantages in geographical locations, advanced technologies due to the inflow of foreign investment, and technology spillover effect on Chinese enterprises caused by competitive effect, demonstration effect, personnel training and turnover effects and backward and forward correlation effect. The energy efficiency of such regions can be further improved by promoting the upgrading of industrial structure.

5. Conclusions

5.1 Conclusions of study

Based on the panel data of nine provinces in the Yellow River Basin from 2005 to 2019, this paper empirically analyzed the relationship between industrial structure upgrading and energy efficiency.
The results showed that: (1) High level upgrading of industrial structure has a significant positive impact on the improvement of energy efficiency in the Yellow River Basin. Human capital and technology can promote the improvement of energy efficiency, while RMB exchange rate and export have a negative effect on energy efficiency; (2) the promotion of industrial structure upgrading on energy efficiency in the middle and upper reaches of the Yellow River Basin is significantly lower than that in the lower reaches.

5.2 Countermeasures and suggestions

(1) It is suggested to actively explore the influencing mechanism of industrial structure upgrading on energy use efficiency, promote the benign interaction between industrial structure adjustment and energy industry, give full play to the role of the market, break the division of administrative divisions, and strengthen the flow of factors among different regions. (2) The provinces and regions in the Yellow River Basin should make clear the characteristics of resource endowment and economic development of each region, and formulate specific paths for industrial structure adjustment. Regions in the lower reaches should rely on their own advantages, vigorously develop high-tech industries and high-end manufacturing industries, and improve the quality and level of the tertiary industry. Regions in the middle and upper reaches should gradually reduce high energy consumption enterprises and introduce advanced technology, capital and human capital to realize economic transformation as soon as possible. (3) All provinces and regions should increase investment in scientific and technological research and development, speed up the development of new energy, vigorously develop the clean energy industry, and optimize the energy consumption structure. (4) On the basis of protecting the ecological environment, it is suggested to expand the economic aggregate of the Yellow River Basin, promote the upgrading and transformation of industrial structure through the effect of scale economy, and gradually improve the energy use efficiency in the Yellow River Basin through industrial structure upgrading, thereby promoting the green and high-quality development of the Yellow River Basin.

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