

# Empirical Analysis of Henan Industrial Structure Evolution Based on Energy Big Data

Shuo Yin<sup>1</sup>, Xing Chen<sup>1</sup>, Zhe Chai<sup>1</sup>, Xingwu Guo<sup>1</sup>, Man Jin<sup>1</sup>, Yao Lu<sup>1</sup> and  
Jiabin Feng<sup>2</sup>

<sup>1</sup>State Grid Henan Electric Power Company Economic and Technical Research Institute,  
Zhengzhou, China

<sup>2</sup>School of Electrical Engineering, Zhengzhou University, Zhengzhou, China.

**Abstract.** In order to analyze the interaction between the optimization of industrial structure and energy consumption in Henan Province and its internal laws, we collect data on economic development and energy consumption from 1995 to 2019, and use the VAR model for empirical analysis. The research results show that the relationship between industrial structure optimization and energy consumption is not a simple one-way causal relationship. Optimization has a negative impact, which can then promote the optimization of the industrial structure for a certain period of time. However, in the long run, there is no significant causal relationship between energy efficiency and industrial structure optimization.

**Keywords:** industrial structure; energy consumption; VAR model; co-integration theory.

## 1. Preface

Energy is an important material basis for the survival and development of human society, and a strategic support for the national economy of a country or region. From the perspective of China's economic development process, since entering the 21st century, most of the provinces and regions in the country have experienced rapid and stable long-term economic development, and the industrial structure has also been continuously improved in the process. The long-term large demand has caused contradictions in the supply and demand of energy resources, and they are becoming more and more obvious.

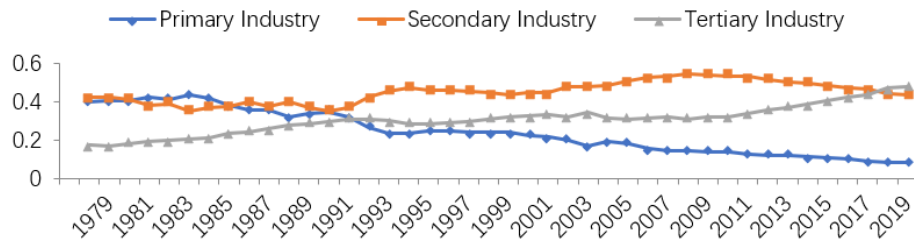
In recent years, Henan Province has been committed to adjusting the economic structure and striving to achieve healthy economic development. As an important part of economic restructuring, changes in industrial structure affect the direction of changes in energy consumption. In the context of global low-carbon development and green economy, it has become the consensus of all countries to effectively optimize the industrial structure to improve the energy efficiency at the input end of the entire economic system, and at the same time reduce the emission of pollutants at the output end of the economic system.

## 2. The status quo of industrial development in Henan

Henan, as a major food province located in the Central Plains, has achieved rapid economic development by virtue of low-cost factor supply, huge market demand and accumulated technical capabilities. Especially in recent years, Henan has relied on the innovation-driven development strategy, adhered to the supply-side structural reform as the main line, and vigorously promoted high-quality economic development on the premise of well-established "six stability" foundation and guaranteed agricultural security, and optimized and upgraded the industrial structure.

Regarding the industrial structure, since the reform and opening up, Henan has been making efforts in the development of the secondary and tertiary industries, constantly adjusting its thinking, seizing opportunities for the transfer of international, especially domestic coastal industries, actively undertaking industrial transfers, and rapidly adjusting the industrial structure relying on economic levers. Henan's GDP was 5,425.920 billion yuan in 2019, an increase of 7.0% over the previous year. Among them, the added value of the primary industry was 463.54 billion yuan, an increase of 2.3%;

the added value of the secondary industry was 2,360,579 billion yuan, an increase of 7.5%; the added value of the tertiary industry was 2601.801 billion yuan, an increase of 7.4%. The ratio of the primary, secondary and tertiary industries is 8.5:43.5:48.0, and the ratio of the added value of the tertiary industry to the GDP has increased by 0.7 percentage points over the previous year, and gratifying results have been achieved.



**Figure 1.** Trends in the industrial structure of Henan Province over the years

It is worth noting that although under the guidance of the reform and opening up policy and the rise of central China, the economy of Henan has been booming, and the output value ranking of the tertiary industry has achieved a good development situation, but the proportion of the tertiary industry is relatively inadequate, the proportion of primary and secondary industries is still relatively large. There is a clear gap between Henan's industrial structure and the developed regions, and it faces a lot of deep-level adjustment pressures, and there is a lot of room for adjustment and optimization.

This article mainly studies the relationship and internal laws between industrial structure optimization and energy consumption, involving multiple variables and dynamic interactions. The VAR model can be used to analyze the dynamic relationship between variables, while avoiding problems such as errors caused by endogeneity.

### 3. Variable selection and data sources

Energy consumption can be measured by total energy consumption and energy efficiency. Among them, the total energy consumption reflects the scale of regional energy consumption, which is related to the speed of economic development and economic development mode, and is expressed by EIR; from the perspective of consumption, energy efficiency refers to the energy services provided to final users.

The definitions of related variables and descriptive statistics are shown in Table 1.

**Table 1.** Variable names and definitions

	Name	Symbol	Definition	Average Value	Standard Deviation	Minimum	Maxmum
Explained variable	Degree of industrial structure optimization	lnISR	The proportion of the total GDP of the secondary industry and the tertiary industry	0.7576	0.1113	0.5625	0.9146
explain variable	Total energy consumption	lnEIR	The sum of various energy consumed by various sectors	4.6648	5.3190	0.4110	20.5807
	energy efficiency	lnEEA	Energy processing conversion efficiency	0.66736	0.0567	0.5834	0.7503
control variable	GDP per capita	lnDP	Total GDP / permanent population	1.2826	1.6155	0.0232	5.6388
	Urbanization level	lnUP	The proportion of urban population in total population	0.2657	0.1283	0.1360	0.5321
	Investment in fixed assets	lnI	Fixed asset investment	0.2221	0.1398	-0.073	0.58
	Energy endowment	lnER	Proportion of total primary energy production in the country	0.0531	0.0158	0.0257	0.0777

## 4. Empirical analysis

### 4.1 Unit root test

If the time series is non-stationary, false regression may occur. Therefore, it is necessary to test the stability of the related series variables to ensure the validity of the regression results. This paper uses the unit root test (ADF) method to verify the stability of the data. Table 2 shows the unit root test results of each variable.

**Table 2.** Unit root test results

Variable	ADF Value	1% Level	5% Level	10% Level	Stationary Analysis
lnISR	-4.519	-4.343	-3.584	-3.230	stable
lnEIR	-2.173	-4.343	-3.584	-3.230	unstable
ΔlnEIR	-6.739	-3.736	-2.994	-2.628	stable
lnEEA	-1.491	-4.380	-3.600	-3.240	unstable
ΔlnEEA	-4.310	-3.750	-3.000	-2.630	stable
lnDP	-1.145	-4.343	-3.584	-3.230	unstable
ΔlnDP	-4.785	-3.736	-2.994	-2.628	stable
lnUP	-0.682	-4.343	-3.584	-3.230	unstable
ΔlnUP	-5.186	-3.736	-2.994	-2.628	stable
lnI	-1.823	-4.343	-3.584	-3.230	unstable
ΔlnI	-4.742	-3.730	-2.992	-2.626	stable
lnER	-1.227	-4.343	-3.584	-3.230	unstable
ΔlnER	-3.925	-3.730	-2.992	-2.626	stable

The unit root test results show that the lnEIR and lnEEA series in Henan Province from 1990 to 2019 were not stable, and the first-order difference must be passed to achieve a stationarity above 99% of the significance level. Therefore, it can be determined that the lnEIR and lnEEA sequences in Henan Province from 1990 to 2019 are first-order single integers. The absolute value of the ADF of the lnISR sequence is 4.519, which is greater than the critical absolute value at the 5% level and can be considered as a zero-order single integer.

### 4.2 Johansen Cointegration Test

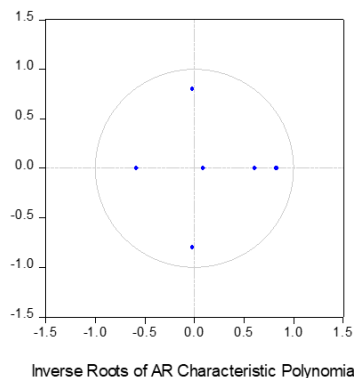
Before the cointegration test, the optimal lag order needs to be determined first. According to the minimum principle of AIC and SC, the optimal lag order of the VAR model is determined to be 2. In this paper, the current more general Johansen test method is used to test the co-integration relationship. The specific co-integration test results are shown in Table 3.

**Table 3.** Johansen-Juselius Cointegration Test Results  
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.649373	41.93602	29.79707	0.0013
At most 1 *	0.473567	18.87930	15.49471	0.0148
At most 2 *	0.194683	4.763416	3.841466	0.0291

**Table 4.** VAR(2) model estimation results

	LnISR	LnEIR	LnEEA
R-squared	0.996987	0.998217	0.982260
Adj. R-squared	0.984936	0.991083	0.911302
Sum sq. resids	0.000184	0.007715	0.002741
S.E. equation	0.006789	0.043918	0.026176
F-statistic	82.72740	139.9387	13.84273
Log likelihood	92.45423	53.24768	64.11512
Akaike AIC	-7.186117	-3.452160	-4.487155
Schwarz SC	-6.340551	-2.606595	-3.641589
Mean dependent	-0.161850	-0.069281	-0.396324
S.D. dependent	0.055316	0.465099	0.087890



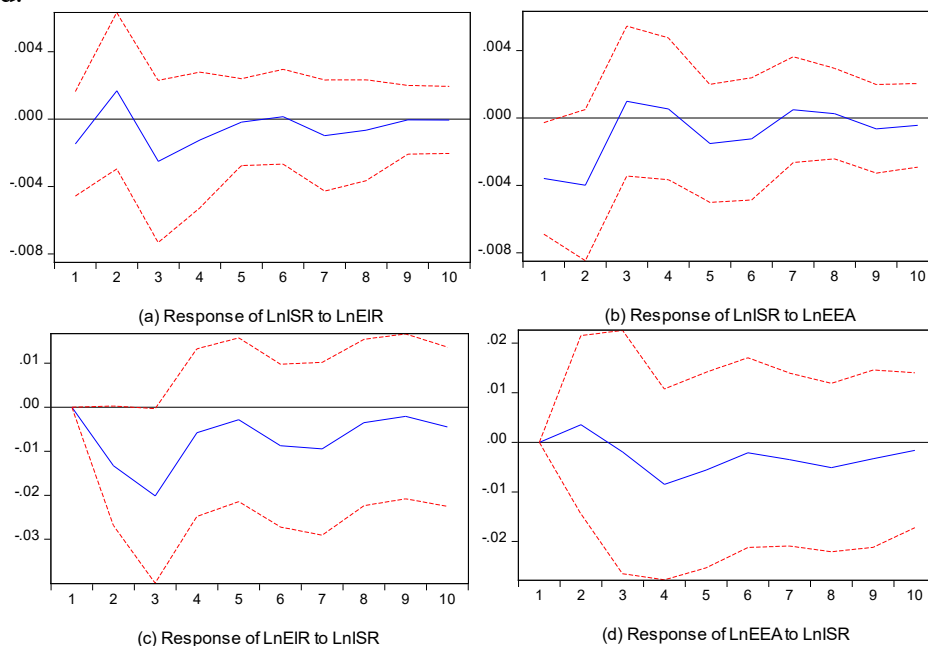
**Figure 2.** Inverse Roots of AR Characteristic Polynomial

It can be seen from the results in Table 3 that the results of the cointegration test evaluated by the maximum characteristic root trace statistic, at the 5% significance level, there are two critical values at the significance level where the trace statistic is greater than 5%, That is to say, at the 5% level, the variables LnISR, LnEIR and LnEEA have a co-integration relationship, and then the VAR model can be constructed. It can be seen from Table 4 that the adjusted R2 values of the three equations of LnISR, LnEIR, and LnEEA in the VAR model are 0.997, 0.998, and 0.982, respectively, indicating that the constructed VAR model fits well. The F test passes, indicating that the model is theoretically established.

Before proceeding to the next step of research and analysis, the VAR model needs to be tested for characteristic roots. The result of the characteristic root test of the VAR model is shown in Figure 2.

### 4.3 Impulse response analysis

In order to see the dynamic relationship between D (LnISR), D (LnEIR), and D (LnEEA), the result of plotting the impulse response function distribution of the VAR model is shown in Figure 3. In the figure, the horizontal axis represents the number of response periods (years) of the impact action, and the vertical axis represents the degree of change of each variable. The thick solid line in the middle is the impulse response line, which represents the response of the variable to the impact in each period.



**Figure 3.** Impulse response function

From the impulse response function distribution in Figure 3(a) and (b), it can be seen that after a positive impact on the scale of energy consumption and energy use efficiency in the current period, both have produced significant feedback on the optimization of the industrial structure. Among them,

the scale of energy consumption first had a negative impact on the optimization of industrial structure in the first phase, and then turned into a positive impact in the second phase, and then turned into a negative impact, and gradually converged after the eighth period. The above results show that in the short term, energy consumption in Henan has an obstructive effect on the optimization of the industrial structure. The reason is that the energy consumption structure of Henan, which is dominated by coal consumption, cannot be changed in the short term.

From the distribution of impulse response functions in Figure 3(c) and (d), it can be seen that the optimization of industrial structure has a negative impact on the scale of energy consumption and fluctuates continuously; the optimization of industrial structure has a positive impact on energy efficiency in the first two periods and then turned into a negative influence, and gradually converged. On the whole, the optimization of the industrial structure in Henan Province has a relatively obvious inhibitory effect on the scale of energy consumption, that is, the optimization of the industrial structure can effectively reduce the scale of energy consumption in Henan Province. At the same time, optimization of the industrial structure can also improve energy efficiency in the short term.

## 5. Conclusions and recommendations

According to the empirical analysis of the industrial structure and energy consumption data of Henan Province from 1990 to 2019, the following conclusions can be drawn: There is a significant interactive relationship between the province's energy consumption and industrial structure optimization. In the long run, the causal relationship between energy use efficiency and industrial structure optimization is not Significant.

According to the research conclusions of this article, Henan can take actions from the following aspects in the future: First, unswervingly continue to promote the optimization of the industrial structure. While paying attention to the high-quality development of the primary and secondary industries, vigorously developing the tertiary industry is of great significance for energy conservation and improvement of energy utilization efficiency, and it is also conducive to alleviating Henan's environmental pressure. Second, strengthen the implementation of the dual control system for energy consumption, refine the energy consumption reduction action plan, optimize the allocation of energy resources, and improve energy utilization efficiency. The use of a sound energy system to force the optimization and upgrading of the industrial structure has been tested in practice. Third, increase investment in science and technology, and use technology to improve energy efficiency. As a major emerging industrial province, the lack of technological innovation capabilities not only restricts the improvement of energy utilization efficiency, but also restricts the optimization and upgrading of the industrial structure.

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