Research on the Transmission Effect of Energy Price Fluctuations in High Energy-Consuming Industries

Weiwei Zhang(✉), Kan Yang, Qiujie Sun, and Junjie Li

Economic and Technological Research Institute of State Grid Zhejiang Electric Power Co., Ltd., Hangzhou 310000, Zhejiang, China
562715987@qq.com

Abstract. High energy-consuming industries are an important part of China's industrial structure, and are of great significance for China to promote "steady growth" and "carbon peaking and carbon neutrality". Energy is a key raw material in the production process of energy-intensive industries. Therefore, energy prices and the prosperity of energy-intensive industries often affect each other. In order to clarify the specific situation of the transmission of energy price fluctuations in high energy-consuming industries, this paper conducts research from two aspects: mechanism discussion and empirical analysis. Specifically, this paper firstly describes the structural impact of energy price fluctuations on high energy-consuming industries from the perspective of the internal characteristics of high-energy-consuming industries, and summarizes the mechanism by which high-energy-consuming industries are affected by energy price fluctuations. Subsequently, the VAR model is used to quantitatively study the transmission mechanism of energy prices in high-energy-consuming industries, and the impact of energy price fluctuations on production costs, product prices, and prosperity of high-energy-consuming industries is calculated.

Keywords: Energy price fluctuations · high energy-consuming industries · Inflation effect

1 Introduction

As a key sector of the Chinese economy, the efficient and sustainable development of energy-intensive industries is an inevitable requirement for China's economic "stimulate long-run economic growth" [1–3]. Since high-energy-consuming industries are generally in the upstream of the industrial chain, their products often become the input factors of downstream light industry, service industry and other industries. Facing this background, ensuring the stable supply and price control of products in high-energy-consuming industries is important for the development of the industry itself and downstream industries. The core input element of high-energy-consuming industries is energy, so energy price fluctuations are crucial to the cost-benefit situation of high-energy-consuming industries, and can ultimately affect the product supply of high-energy-consuming industries.

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Moreover, China is currently in a critical period of reform, and the goal of "carbon peaking and carbon neutrality" proposed in 2020 further puts forward new requirements for China's energy system reform [4–6].

In view of the above actual conditions, traditional fossil energy will inevitably be gradually transformed into renewable energy, and this process will inevitably bring new uncertainty to energy prices. Since most of China's energy consumption is concentrated in the industrial sector, meanwhile, high energy-consuming industries are the core energy consumption sectors, the risk of energy price uncertainty caused by the process of realizing the dual carbon goals will inevitably impact high energy-consuming industries. Correspondingly, changes in demand in high-energy-consuming industries will also adversely affect energy price levels.

It can be seen that understanding and judging the transmission effect of energy price fluctuations in energy-intensive industries is of great practical significance, whether from the perspective of promoting economic growth of China or from the perspective of "carbon peaking and carbon neutrality". However, the current researches have not conducted on this issue well. Although there are many papers focused on the impact of energy prices on industrial production, other commodity prices, and environmental performance [7–10], few targeted investigations have been done in the field of the transmission effect in high energy-consuming industries, particularly, concentrating on the Chinese status.

Therefore, this paper aims to provide insights into the issue of energy price transmission effects in energy-intensive industries through both theoretical and empirical analysis. Specifically, based on the industrial chain position of high-energy-consuming industries, this paper clarifies the theoretical transmission path and sequence of the impact of energy prices after energy price fluctuations. The impact characteristics and impact scale of product prices and economic conditions in high-energy-consuming industries are estimated based on the vector autoregression model (VAR) model, and Granger causality test are conducted to further understand the response of high-energy-consuming industries to energy price fluctuations.

2 Energy Price Transmission Mechanism for High Energy-Consuming Industries

The core input factor of energy-intensive industries is energy. Therefore, rising primary energy prices and electricity prices will have an impact on investment, production, and sales in energy-intensive industries.

Since the price of primary energy is mainly affected by market supply and demand conditions, while the price of electricity is more affected by policy adjustment, the internal transmission mechanism of energy prices in high-energy-consuming industries should also be discussed in two ways.

First of all, when energy prices or electricity prices change, the direct impact on energy-intensive industries is to increase their cost of energy utilization and electricity utilization [11]. In response to changes in the cost environment, the energy-intensive industries themselves will take the lead in making adjustments [12]. For the change of primary energy cost, enterprises can realize the relative adjustment of their own energy costs by means of energy substitution, and can also reduce the level of dependence on energy in the production process by improving the technical level and production efficiency [13–15]. Changes, although companies are also facing cost pressures, but due to the lack of alternative energy sources for electricity, after the price of electricity rises, companies may take the main response to efficiency upgrades. However, no matter whether an enterprise adopts energy substitution or efficiency upgrade to respond to changes in energy prices, because the energy demand in the production process of enterprises has certain rigid characteristics, and there is also a certain cost increase in the response process, changes in energy prices will eventually be transmitted backwards. And affect the cost changes in the entire production process of the enterprise. The products of high-energy-consuming industries are generally the production factors of downstream industries, so they have stronger seller's market power. In the face of changes in production costs (especially rising production costs), energy-intensive companies will also provide products to downstream industries at higher prices, thereby reducing their own cost pressures.

3 The Impact of Energy Price Fluctuations on Product Prices in High Energy-Consuming Industries

3.1 Model and Data

This part focuses on the changes in product prices in energy-intensive industries caused by energy price fluctuations. Specifically, this part selects the ex-factory price indices of non-ferrous metal manufacturing and ferrous metal manufacturing industries as the representative of product prices in high energy-consuming industries. This choice mainly takes into account that among the six high-energy-consuming industries released by the National Development and Reform Commission of China, most of the other industries are involved in energy extraction or energy processing, while the non-ferrous and ferrous metal manufacturing industries mainly use energy as a form of power supply. in the production process. On the other hand, the use of China's coal price index as a substitute variable for energy price fluctuations is mainly due to the fact that coal consumption accounts for more than half of China's primary energy consumption and is China's main energy source. Therefore, based on the above theoretical mechanism, it can be inferred that when the coal price fluctuates significantly, the energy price transmission within the high energy-consuming industry will eventually lead to the same direction fluctuation of the product price of the high-energy-consuming industry.

Based on data availability, this section selects price data from October 2014 to July 2022 for empirical analysis. Since coal prices, non-ferrous metal manufacturing products and ex-factory price indices of ferrous metal manufacturing products are all time series data, in order to avoid pseudo-regression in regression analysis, it is necessary to build a vector autoregression model (vector autoregression) to construct the data. Mold. The vector autoregressive model constructs a model by taking each endogenous variable in the system as a function of the lagged values of all endogenous variables in the system, thereby extending the univariate autoregressive model to a "vector" autoregressive model composed of multivariate time series variables. Therefore, the vector autoregression analysis of coal price index, non-ferrous metal manufacturing ex-factory price index, and ferrous metal manufacturing ex-factory price index can effectively show the impact of coal price changes on product prices in high energy-consuming industries.

3.2 VAR Model Estimation

The calculation results based on the vector autoregressive model are shown in Table 1. Table 1 is divided into two parts, which respectively show the impact of other price index changes on the ex-factory price index of non-ferrous metal manufacturing and the ex-factory price index of ferrous metal manufacturing.

First of all, for the non-ferrous metal manufacturing industry, the factors that can affect the current ex-factory price of products are mainly its own price in the previous period and the price of coal in the previous period. This shows that coal price fluctuations can have a significant impact on non-ferrous metal manufacturing products, and this impact does not occur at the same time, but lags behind, reflecting the transmission characteristics of energy price fluctuations to high energy-consuming industries.

Secondly, for the ferrous metal manufacturing industry, the variables that can affect the ex-factory price index of its products are also the one-stage lag level of its own price and the one-stage lag coal price level. This reflects that coal prices also have a significant transmission effect of price fluctuations on ferrous metal manufacturing. For the two high-energy-consuming industries considered in this paper, the ex-factory price levels of their products can be affected by the lagging effect of coal prices, but the price impact between different high-energy-consuming industries is not significant, indicating the impact of coal prices on the prices of high-energy-consuming industries It far exceeds the price spillover effect between different energy-intensive industries.

3.3 Granger Causality Test

In order to further clarify the impact of coal price on the ex-factory price level of non-ferrous metal manufacturing and ferrous metal manufacturing products, based on the vector autoregression model, this part further uses the Granger causality test to examine the predictive causal impact of coal price. The results are shown in Table 2.

It can be seen that the coal price can always become the Granger factor of the ex-factory price index of non-ferrous metal manufacturing and ferrous metal manufacturing products at a significance level of at least 5%. In other words, the lagging item of coal price has a certain ability to predict the price of non-ferrous metal manufacturing and ferrous metal manufacturing ex-factory products. This result further verifies the calculation results of the vector autoregressive model, and the transmission effect of coal price fluctuations on high energy-consuming industries is significant.

Table 1. VAR model estimation results

Non-ferrous metal manufacturing	Variables	coefficients	S.E.	Z-value	P-value
	Non-ferrous metal manufacturing				
	L1.	1.177	0.333	3.54	0.000
	L2.	0.242	0.530	0.46	0.648
	L3.	-0.683	0.348	-1.97	0.049
	Ferrous metal manufacturing				
	L1.	-0.055	0.178	-0.31	0.760
	L2.	-0.168	0.281	-0.6	0.550
	L3.	0.307	0.187	1.64	0.100
	Coal price				
	L1.	0.005	0.003	2.06	0.040
	L2.	0.000	0.003	0.07	0.947
	L3.	0.000	0.003	-0.11	0.910
	Constant	-1.881	0.931	-2.02	0.043
Ferrous metal manufacturing	Non-ferrous metal manufacturing				
	L1.	0.050	0.614	0.08	0.935
	L2.	0.502	0.978	0.51	0.607
	L3.	-0.879	0.642	-1.37	0.171
	Ferrous metal manufacturing				
	L1.	1.025	0.329	3.12	0.002
	L2.	-0.317	0.518	-0.61	0.541
	L3.	0.364	0.345	1.06	0.291
	Coal price				
	L1.	0.010	0.005	2.23	0.026
	L2.	0.002	0.006	0.43	0.667
	L3.	-0.007	0.005	-1.47	0.141
	Constant	-2.172	1.717	-1.27	0.206

Note: L1., L2., L3. Represent the lag period 1–3 of the variable respectively, and the selection of the variable lag period is based on the AIC criterion

Table 2. Granger causality test estimation results

Equation	Excluded	chi2	P-value
Non-ferrous metal manufacturing	Coal price	8.013**	0.046
Ferrous metal manufacturing	Coal price	9.216**	0.027

4 Conclusion

Currently, exploring the low-carbon green transformation and development of energy-intensive industries is becoming more and more important in facing of the carbon neutrality target of China [15–18].

To clarify how the energy price potentially affect the green transformation of energy-intensive industries this paper analyzes the transmission effect of energy price fluctuations in high energy-consuming industries from two aspects: theoretical mechanism and empirical analysis. From this research, the internal transmission mechanism of energy prices in high energy-consuming industries mainly includes two paths: fossil energy price transmission and electricity price transmission. When energy prices fluctuate, energy-intensive industries may mitigate the impact of energy price fluctuations through energy substitution or efficiency upgrades, but will ultimately lead to changes in industrial product prices in energy-intensive industries through transmission. Based on the VAR model estimation, this paper further combs the impact of energy price changes represented by coal prices on products in high-energy-consuming industries. After the shock of coal price rise, through the price transmission mechanism, the products of high energy-consuming industries will also change in the same direction. However, due to differences in production processes between industries, different high-energy-consuming industries have different characteristics in their response to changes in energy prices. Generally speaking, industries with less elastic demand for energy products tend to be more affected by shocks, and the ex-factory prices of their products are often subject to drastic changes in a short period of time.

Based on the research conclusions of this paper, we can summarize some targeted policy recommendations. On the one hand, energy-intensive industries are still an important pillar industry of China's industrial economy in a short period of time. To promote the "steady growth" of China's economy, it is necessary to effectively guarantee the reasonable development space of energy-intensive industries. Thus, relevant decision-making departments should fully design the development plan of China's high-energy-consuming industries, and avoid high-quality production shutdowns caused by energy supply shortages. On the other hand, promoting the high-quality development of energy-intensive industries is of great significance to China's "carbon peaking, carbon neutrality" process. Thus, relevant departments should scientifically plan the transformation path of high-energy-consuming industries, and adopt energy price regulations for high-energy-consuming industries, thereby outdating the production capacity. At last, it is also necessary to clarify the heterogeneous characteristics of high energy-consuming industries, adopt differentiated energy price policies to implement macroeconomic adjustments.

As energy-intensive industries will continue to contribute to China's economy, future research should focus on judging and examining the impact of energy price policies (such as electricity price policies) on the industry, and indicating the direction of policy adjustment.

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