Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 9, No. 1, 2023

Research on the Influence of Financial Factors on Coal Price at Different Stages

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Abstract: Coal is the main source of energy consumption in China and its prices have long been emphasized by various industries. This paper constructs a VAR model to study the impact of futures market factors and economic environment factors on coal prices in two time intervals, which are 2016 to 2020 and 2021 to 2022 respectively, under the background of a huge increase in steam coal prices in Qinhuangdao, China, in 2021 as well as to compare and analyze the results. It is found that some of the financial factors will have impact on the steam coal market price, but the overall impact is not significant. However, after 2021, the impact of financial factors on the steam coal market price deepens. Based on the empirical results, this paper suggests that coal market participants should mainly focus on non-financial factors, but should also take into account the fact that the importance of financial factors will increase under some unexpected circumstances.

Keywords: Coal prices, Commodity financialization, Price volatility, VAR model.

1. Introduction

1.1. Research Background

As one of the most abundant and well-known fossil fuels on earth, coal plays a vital role in people's lives. China is a country with abundant coal resource and has a large coal trading market. For the market participants, how to catch the coal price trend is an issue that must be taken into account. At the same time, as a basic commodity, the price trend of coal can be a response to national macroeconomic situation. As the overall financialization level of the global commodity market continues to rise, coal is inevitably affected and its price starts to be linked to financial factors, which receives attention from all sectors of society.

Chengsi et al. [1] define the financialization of commodities as an irreversible and increasing trend of the participation of financial attributes in the trading process. Henderson et al. [2] find through their study that the involvement of financial investors in this process affect commodity prices and confirm the judgment made by Michael and Wei [3] that information frictions interfere with the choices of commodity market participants and that this interference will be further transitioned to the commodity market. Conghui et al. [4] find an important role of liquidity shocks in the context of financialization when commodity markets are previously linked to stock markets. In the Chinese market, Zunxin et al. [5] argue that there is a significant correlation between some commodity prices and some macro financial factors. As a branch of general commodities, major commodities are more susceptible to financialization risks due to their own qualities. Many scholars have also conducted studies on the financialization of major commodities in recent years. Chunyi and Bingyi [6] suggest that the price fluctuations of these commodities, which are homogeneous, tradable, and widely used as basic industrial raw materials, are closely linked to the prices of related financial assets. At the specific commodity level, Yinglin et al. [7] argue that agricultural commodities like corn and soybeans are less financialized and less influenced by financial factors, while for industrial and metal products, events in financial markets, such as financial crises and stock market crashes, can have a strong impact on their correlation with stock indices. Regarding the counteraction of financialized major commodities on macroeconomic factors, Xiang et al. [8] conduct a further study and conclude that the counteraction is significant and can even exceed the shocks brought by monetary and fiscal policies as well as highlight the effect of financial crises on the transmission mechanism of this counteraction.

Coal, which is traded in a non-retail manner and widely used in industry, is a prime example of a major commodity and scholars have conducted a series of studies on this topic. At the coal price level, through the study of Yanbing and Tenghua [9], it can be concluded that commodities in the energy market interact with each other, with natural gas prices having a weak negative impact on coal prices over a longer time horizon, and oil prices causing a larger positive impact. In addition to this, Jingye et al. [10] also find that in the steam coal area, international coal prices have a comparatively significant effect on domestic coal prices. Chang and Xuran [11] attempt to link coal price volatility to policy, their findings show the joint effect of many factors such as coal supply, economic demand and inventory demand on coal prices and that policy can also have a substantial impact on coal prices. Dai et al. [12] use exponential smoothing and multiple linear regression to attempt to make forecasts for Qinhuangdao steam coal prices, while Yin et al. [13] use an ARIMA-SVM model to investigate similar topics. Guo et al. [14] use a VAR model to explore various factors that are drivers of coal prices, including the amount of coal price growth and economic growth. At a more macro level of the coal market, a study by Qing and Le [15] focuses on the supply curve of coal and finds that the Chinese provincial coal industry has entered the market economy, while the national coal price index plays a huge role in the steam coal market. Li and An [16] conduct a series of studies based on a co-movement matrix that can show the co-movement between indicators, confirming that the carbon market and coal stock market have an impact on the coal futures market. Indeed, Yan

et al. [17] also find a long-run equilibrium relationship between carbon emission prices and steam coal futures prices, with the latter exerting a more pronounced influence on the former.

In summary, the existing literature has explored the topics of the major commodity financialization and coal prices from multiple perspectives. Researches on the financialization of major commodities have mainly focused on the impact of this phenomenon on commodity prices, while researches on coal prices are more diverse, with experts and scholars exploring the linkages between coal prices and various possible external factors from different dimensions, including financial factors. However, there are few current studies that examine the extent to which financial factors affect coal prices at different time periods.

1.2. Research Overview

In recent years, the coal market has not been "peaceful". In 2021, as the world economy was gradually recovering from the blow of the COVID-19 epidemic, a global energy crisis was set off, with crude oil prices and natural gas prices both showing significant increases, while the coal market also suffered. In China, in addition to the disruption of the energy crisis, the coal market was also hit by the mismatch between electricity supply and demand, the reduction of domestic coal output and imported coal. These effects indirectly raised the national coal demand and cut coal supply, making its price suddenly high and oscillating. In this unusual situation, studying the magnitude of the impact of each factor on coal prices can both inform investors' decision making and reveal the feedback made by a country's coal market in the face of shocks.

This paper focuses on the magnitude of financial factors affecting coal prices at different stages (i.e., pre- and post-shock). On the theoretical side, this paper makes the first attempt to model various financial factors affecting coal prices in China as well as to compare the differences in the impact of these factors on coal prices over time. On the practical side, this paper shows the strength of financial factors' impact on coal prices at different stages for market participants to refer to, so that investors and practitioners in different environments can make more accurate forecasts on coal market conditions.

2. Theoretical Analysis

2.1. Analysis of RJ/CRB and Coal Price Trend

RJ/CRB index, which is the Reuters/Jefferies Commodity Research Bureau Futures Price index, measures a weighted aggregate of 19 types of commodity price indices, including crude oil, wheat, gold, etc., and has a strong ability to reflect the overall price changes of the commodity market. Qinhuangdao port is an important part of China's coastal coal transportation system, this paper selects the market price of Q5500 Shanxi-produced steam coal in Qinhuangdao, which reflects the change of China's coal price to a certain extent. Figure 1 depicts the change trend of RJ/CRB index and steam coal price from July 2, 2007 to March 11, 2022. It can be seen that both indices show an upward trend during 07-08, followed by a relatively stable trend with smaller oscillations for a longer period of time, in general, the trend of the RJ/CRB index and steam coal price over time is consistent. From 2021 onward, steam coal price skyrocketed, rapidly rising to nearly four times its previous average level, since then, the consistency of the trend between steam coal price and the RJ/CRB index no longer holds. The above analysis leads to the hypothesis that the factors that play an important role in macro commodity market pricing may also have a similar effect on coal prices.

Figure 1. Comparison between the Trend of Qinhuangdao Q5500 Steam Coal Price and RJ/CRB Price Index

2.2. Variable Selection and Data Processing

This paper selects Qinhuangdao Q5500 Shanxi-produced steam coal price as the explained variable, classifies financial factors that have the potential ability to influence coal price change into two categories: futures market factors and economic environment factors, selects representative factors in each of these two categories for examination. This paper uses the conjectures presented above to select a portion of those factors that have been proven to have an impact on commodity prices.

2.2.1. Futures Market Factors

The futures market, as a typical example of financial market, cannot operate without the spot goods market, it also has an interaction with the spot goods market at the commodity price level. In China, the Nanhua Commodity Index is a kind of index similar to the RJ/CRB index, which has the ability to reflect commodity prices and has a more significant connection with national commodities than other indices, so it is assumed that the Nanhua Commodity Index has a certain degree of influence on coal prices. This paper chooses the Nanhua Composite Index (nhall), Nanhua Steam Coal Index (nhcoal) to study. Besides, Nanhua Industrial Products Index (nhindustry) will be taken into account, given that coal is often a necessity in industrial production. In addition to this, the Futures Closing Price of Steam Coal (coalfu) will also be included in the model measurement.

2.2.2. Economic Environment Factors

Currency-related macroeconomic factors can influence the state of supply and demand in traditional markets and indirectly affect commodity prices. Based on Zunxin et al. [5], there is a significant negative correlation between commodity prices and the U.S. dollar index during the financialization of commodities, and the dollar effect can explain the changes in the Chinese commodity market to some extent, so the U.S. dollar index (dindex) is selected in this paper. Secondly, Xin and Xuejun [18] argue that the RMB exchange rate

contributes to commodity price change and the spot exchange rate of USD to CNY (exrate) is selected in this paper based on this conclusion. The data are all obtained from Wind database.

2.2.3. Data Processing

To avoid problems like collinearity and heteroscedasticity and to make it easier to study, the collected data are logarithmized. In addition to this, to remove the influence of individual extreme values on the data as a whole, this paper does winsorization for data that are not included in the size range of 1% to 99%.

2.3. Data Analysis and Data Partitioning

To enhance the timeliness and practicality of this paper's research, data from recent years are used as the main research object. The coal price data from November 1, 2016 to March 11, 2022 are analyzed and it can be seen in Figure 2 that the change curve of coal prices shifts from relatively smooth trend to rapid and violent fluctuations with 2021 as the cut-off point. Xinxiang et al. [19] investigate the macro volatility pattern of coal prices and the study introduces the concept of the Kondratiev Wave, which is considered to play a crucial role in major commodity price fluctuations. After analyzing this theory, it is possible to classify the market condition of coal prices as 10-year cycles, where the prices from 2010 to 2020 belong to the same cycle and the data from 2020 to 2030 are predicted to belong to another one, which is also well evidenced in Figure 2. Yan's [20] study takes coking coal as the object of analysis, which can explain the price trend of Chinese steam coal to a certain extent. In this study, it is shown that factors which affect the price of coking coal in 2021 include China's coking coal importer problem, the COVID-19 epidemic problem and so on, thus the price of coking coal rises driven by global influencing factors. According to Xianping and Wen [21], coal prices have shifted significantly due to the impact of unexpected external events and no longer maintain their original stable pattern.

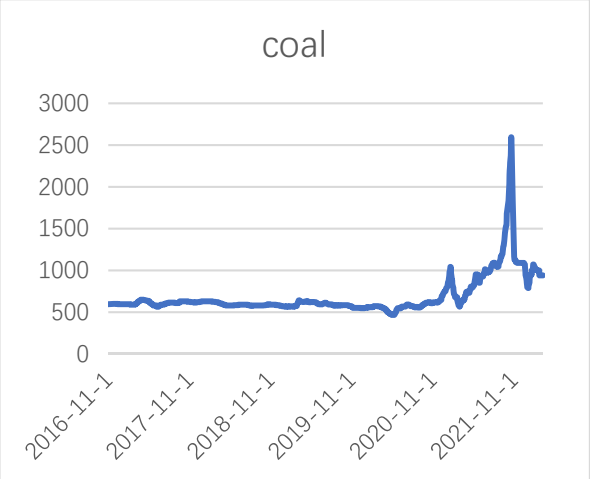

Figure 2. Trend of Qinhuangdao Q5500 Steam Coal Price from 2016 to 2022

Combining the above information, the total study interval can be divided into two periods, which are from November 1, 2016 to December 31, 2020 and from January 1, 2021 to March 11, 2022. This paper will study the involvement of financial factors in coal price volatility and compare the results obtained.

3. Empirical Analysis

In this paper, a VAR (vector autoregressive) model is selected to simulate the interaction of a total of seven elements mentioned above and to analyze the impact of financial factors on steam coal prices accordingly.

Model expression is $Y_t=A_1Y_{t-1}+A_2Y_{t-2}+\ldots+A_nY_{t-n}+u_t$, where variable $Y_{t-i}=[Coal_{t-i}, NHCoal_{t-i}, NHIndustry_{t-i}, NHAll_{t-i}, CoalFu_{t-i}, ExRate_{t-I}, DIndex_{t-i}]$.

Also, $A_i=[A_{1i},A_{2i},\ldots,A_{7i}]$, $u_t=[u_{1t},u_{2t},\ldots,u_{7t}]$, elements in Y_{t-i}have been processed to the point where they can be used in the model, i=1,2,...,n, n is the maximum lag order.

3.1. Data Stationarity Test

The unit root test is often used to conduct the study of the stationarity of the data. Tables 1 and 2 show that the data for 2016 to 2020 and 2021 to 2022, after the test, both have P-values greater than 0.05 and cannot reject the original hypothesis, thus both are non-stationary series. After first-order differencing the original data, the tests show that the P-values are less than the significance level, which means that all variables in both sets of tests are consistent with the original hypothesis and the data are stationary and can be used in the VAR model. The differenced variables are named as: dlncoal, dlnnhcoal, dlnnhindustry, dlnnhall, dlncoalfu, dlnexrate, dlndindex.

Table 1. ADF unit root test for data from 2016 to 2020

Variable	t	P	Critical value		
			1%	5%	10%
lncoal	-1.954	0.307	-3.437	-2.865	-2.568
lnnhcoal	-1.134	0.701	-3.437	-2.865	-2.568
lnnhindustry	-2.32	0.166	-3.437	-2.865	-2.568
lnnhall	-2.59	0.095	-3.437	-2.865	-2.568
lncoalfu	-2.78	0.061	-3.437	-2.865	-2.568
lnexrate	-1.032	0.741	-3.437	-2.865	-2.568
lndindex	-1.352	0.605	-3.437	-2.865	-2.568

Table 2. ADF unit root test for data from 2021 to 2022

Variable	t	P	Critical value		
			1%	5%	10%
lncoal	-2.023	0.276	-3.455	-2.872	-2.572
lnnhcoal	-1.283	0.637	-3.455	-2.872	-2.572
lnnhindustry	-1.481	0.543	-3.455	-2.872	-2.572
lnnhall	-1.388	0.588	-3.455	-2.872	-2.572
lncoalfu	-1.913	0.326	-3.455	-2.872	-2.572
lnexrate	-0.924	0.780	-3.455	-2.872	-2.573
lndindex	-0.194	0.939	-3.455	-2.872	-2.572

3.2. Cointegration Test

A cointegration relationship describes the long-run equilibrium relationship that exists between the variables. Given that all of the above variables satisfy integration of order one, it is conjectured that there is a cointegration relationship between them. In this paper, Johansen cointegration test is used to analyze the two sets of original variables without differential treatment.

As shown in Tables 3 and 4, according to the trace statistics, a cointegrating relationship exists between all nine variables for both intervals, 2016 to 2020 and 2021 to 2022.

Table 3. Johansen cointegration test for data from 2016 to 2020

Maximum rank	Params	LL	Eigen-value	Trace statistic	Critical value 5%
0	56	26282.971	.	183.328	124.24
1	69	26328.854	0.09071	91.562*	94.15
2	80	26347.027	0.03696	55.2159	68.52
3	89	26359.432	0.02538	30.4074	47.21
4	96	26365.996	0.01351	17.2779	29.68
5	101	26371.905	0.01217	5.4603	15.41
6	104	26374.622	0.00561	0.0274	3.76
7	105	26374.635	0.00003		

Table 4. Johansen cointegration test for data from 2021 to 2022

Maximum rank	Params	LL	Eigen-value	Trace statistic	Critical value 5%
0	56	6511.5091	.	127.5411	124.24
1	69	6532.2189	0.14125	86.1215*	94.15
2	80	6552.6251	0.13933	45.3091	68.52
3	89	6561.045	0.06003	28.4693	47.21
4	96	6567.2602	0.04467	16.0389	29.68
5	101	6572.2656	0.03614	6.0281	15.41
6	104	6574.9495	0.01954	0.6603	3.76
7	105	6575.2796	0.00242		

3.3. Model Lag Order Selection

In this paper, based on the HQIC criterion, the lag order of both models is selected as 1, and the VAR model is built on this basis.

Table 5. Model lag order selection for 2016 to 2020

	LR	df	p	FPE	AIC	HQIC	SBIC
0				6.8e-33	-54.2003	-54.1868	-54.1649*
1	247.49	49	0	5.7e-33	-54.3837	-54.2758*	-54.1003
2	110.34	49	0	5.6e-33*	-54.3966*	-54.1942	-53.8651
3	88.302	49	0	5.7e-33	-54.3865	-54.0897	-53.607
4	96.559*	49	0	5.7e-33	-54.385	-53.9938	-53.3575

Table 6. Model lag order selection for 2021 to 2022

	LR	df	p	FPE	AIC	HQIC	SBIC
0				1.0e-29	-46.8804	-46.8428	-46.7869*
1	241.51	49	0	6.0e-30*	-47.4139*	-47.1134*	-46.6656
2	85.294*	49	0.001	6.3e-30	-47.3667	-46.8032	-45.9635
3	56.787	49	0.208	7.4e-30	-47.2135	-46.387	-45.1555
4	37.968	49	0.873	9.3e-30	-46.9903	-45.9009	-44.2776

3.4. VAR Model Stationary Test

After building the model, it is often necessary to use the unit root test to assess the stationarity of the model parameters, i.e., to show there does not exist unit roots in order to avoid spurious regression. Figures 3 and 4 show that all eigenvalues fall within the unit circle and the model meets the stationary requirement.

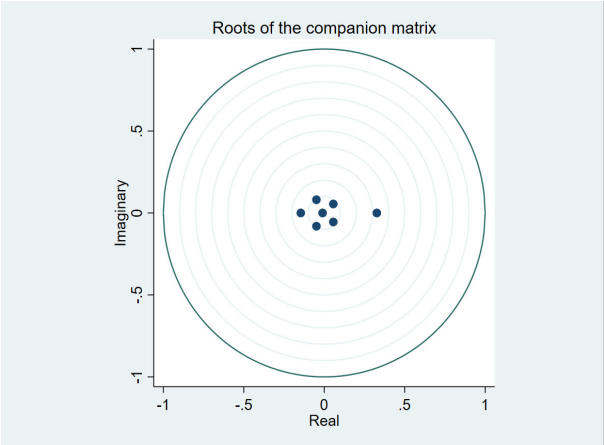

Figure 3. Unit root test of the model for 2016 to 2020

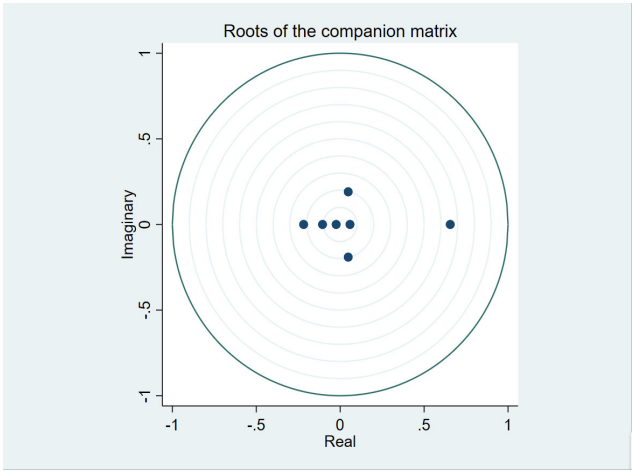

Figure 4. Unit root test of the model for 2021 to 2022

3.5. Granger Causality Test

Granger causality tests are often used to test whether one variable is the cause of a change in another variable. It should be noted that the "causality" referred to in Granger causality tests only stays in the statistical level, not necessarily the factual causality. Moreover, the test's result is sensitive to the lag order and cannot be used as the only tool to assess the interaction between factors.

Tables 7 and 8 show that most of the variables are not the Granger causes of dlncoal (coal price change), but the remaining six variables as a whole is a one-way Granger causality for dlncoal. In addition to this, for the variables from 2016 to 2020, dlnnhcoal (change in Nanhua Steam Coal Index) is the Granger cause of dlncoal, while in 2021 to 2022, this relationship does not exist. In general, the sum of all variables is the Granger causality of dlncoal, so this paper will continue to explore the relationship between each variable and dlncoal.

Table 7. Granger causality test results for each variable on dlncoal from 2016 to 2020

Equation	Excluded	chi2	df	Prob>chi2
dlncoal	dlnnhcoal	7.8076	1	0.005
dlncoal	dln-nhindustry	0.93965	1	0.332
dlncoal	dlnnhall	1.5354	1	0.215
dlncoal	dlncoalfu	1.6997	1	0.192
dlncoal	dlnexrate	0.68005	1	0.41
dlncoal	dlndindex	0.10894	1	0.741
dlncoal	ALL	13.523	6	0.035

Table 8. Granger causality test results for each variable on dlncoal from 2021 to 2022

Equation	Excluded	chi2	df	Prob>chi2
dlncoal	dlnnhcoal	2.9962	1	0.083
dlncoal	dln-nhindustry	0.08082	1	0.776
dlncoal	dlnnhall	0.62799	1	0.428
dlncoal	dlncoalfu	0.35417	1	0.552
dlncoal	dlnexrate	0.31594	1	0.574
dlncoal	dlndindex	0.85095	1	0.356
dlncoal	ALL	26.226	6	0

3.6. Mean Spillover Effect Analysis

Both mean spillover and volatility spillover are part of the information transmission mechanism in financial markets, with the former indicating the impact of changes in one factor on other factors. This section will focus on the analysis of the mean spillover of each variable on dlncoal. The results in Table 9 and Table 10 show that dlncoal(-1) (the lag one coal price change) and dlnnhcoal(-1) (the lag one Nanhua Steam Coal Index change) have one-way mean spillover effects on dlncoal in both time intervals from 2016 to 2020 and from 2021 to 2022, which is consistent with the Granger causality test results. In addition to this, the study by Lin and Wenjing [22] also shows that there is a one-way mean spillover of steam coal futures prices to its spot prices between 2013 and 2015, i.e., the futures market has a certain price discovery function. In general, for coal price changes, there is a mean spillover effect on it from its lag one version and lag one Nanhua Steam Coal Index in the futures market, this effect is relatively stable and does not change due to the factors that cause large fluctuations in coal prices in 2021.

Table 9. Mean equation of dlncoal from 2016 to 2020

	coefficient	standard deviation	t
dlncoal(-1)	0.325	0.031	10.619
dlnnhcoal(-1)	0.065	0.023	2.783
dlnnhindustry(-1)	0.075	0.078	0.965
dlnnhall(-1)	-0.111	0.09	-1.234
dlncoalfu(-1)	-0.025	0.019	-1.298
dlnexrate(-1)	-0.05	0.06	-0.821
lndindex(-1)	0.013	0.041	0.329
constant	0	0	0.946

Table 10. Mean equation of dlncoal from 2021 to 2022

	coefficient	standard deviation	t
dlncoal(-1)	0.608	0.046	13.185
dlnnhcoal(-1)	0.145	0.085	1.705
dlnnhindustry(-1)	0.074	0.266	0.28
dlnnhall(-1)	-0.228	0.292	-0.781
dlncoalfu(-1)	0.043	0.073	0.586
dlnexrate(-1)	-0.384	0.693	-0.554
lndindex(-1)	-0.298	0.327	-0.909
constant	0	0.001	0.029

3.7. Impulse Response Analysis

Impulse responses are often used to show the response of other variables of the model in different periods when one variable is subjected to a shock. To discuss the long-run and short-run effects, the horizontal axis range is set from 0 to 8 periods; to facilitate the comparison of the two data results, the vertical axis scale range is set uniformly from -0.4 to 0.2. In Figures 5 and 6, the second element within the title of each sub-picture is the shocked variable and the third element is the affected variable.

According to Figure 5, it can be seen that during the time period from 2016 to 2020, from the futures market perspective, the change in the closing price of steam coal futures has a weak short-term negative impact on the change in power coal prices after the shock, which has reached the maximum in the first period and tends to 0 since the second period, the change in the Nanhua Steam Coal Index and the change in the Nanhua Industrial Products Index cause a similar impact trend, both having a short-term positive impact. In contrast, the impact of the change in the Nanhua Composite Index is the largest and has a short-term negative impact. In terms of the economic environment, changes in the US dollar index have a weak, short, and positive impact. In contrast, changes in the exchange rate have a larger negative impact, with a slight increase in both magnitude and duration, before leveling off after the second period. Briefly, during this period, the impact of financial factor changes on the change of steam coal price is mostly short-term and shallow. The factors that cause a positive impact include: the change of US dollar index, the change of Nanhua Steam Coal Index, the change of Nanhua Industrial Products Index. The factors that cause a negative impact include: the change of steam coal futures closing price, the change of exchange rate, the change of Nanhua Composite Index.

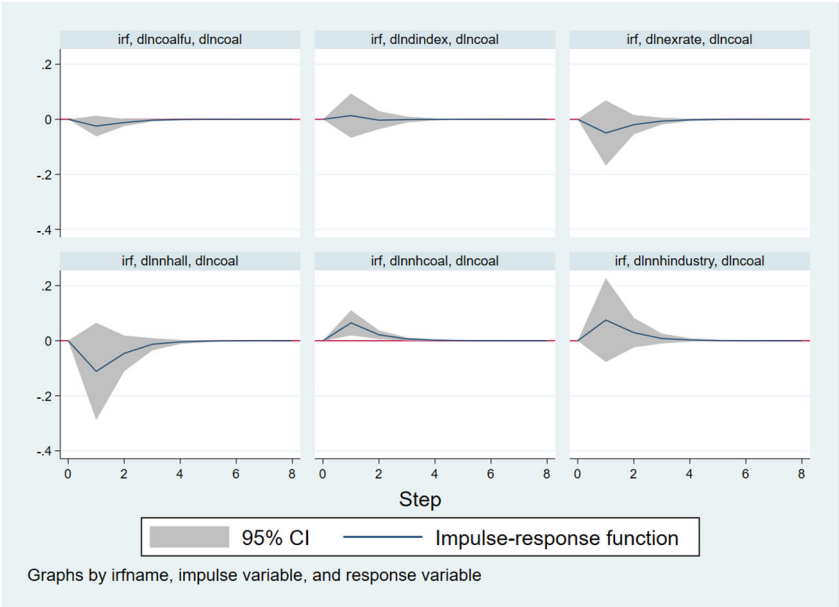

Figure 5. Impulse response plot of each factor on dlncoal from 2016 to 2020

According to Figure 6, it can be seen that in the time period from 2021 to 2022, from the futures market perspective, the change in the closing price of steam coal futures has a weak positive impact on the change in steam coal prices, which fades away after the second period. The change in the Nanhua Composite Index will have a greater impact, which is a negative one and it lasts longer and starts to converge to zero after the sixth period. Both change of Nanhua Steam Coal Index and Nanhua Industrial Products Index have a positive impact on the change of steam coal price, the difference is that the former reaches its maximum in the first period and fades away in the third period, while the latter reaches its maximum in the second period and tends to the y=0 axis only after the sixth period. In terms of economic environment, the negative impact of the change in the US dollar index on the change in the price of steam coal is great, reaching a maximum in the first period and tending to 0 after the sixth period, the change in the exchange rate has the greatest impact on the change in the price of steam coal, with a negative impact close to -0.4 in the first period and reaching a peak in the second period, after which the impact gradually disappears as the number of periods increases. Briefly, during this period, the impact situations of financial factor changes after the shock are mostly long-term impact and the degree of impact is larger. At this time, the factors that cause a positive impact include: the change of steam coal futures closing price, the change of Nanhua Steam Coal Index, the change of Nanhua Industrial Products Index. The factors that cause a negative impact include: the change of US dollar index, the change of exchange rate, the change of Nanhua Composite Index.

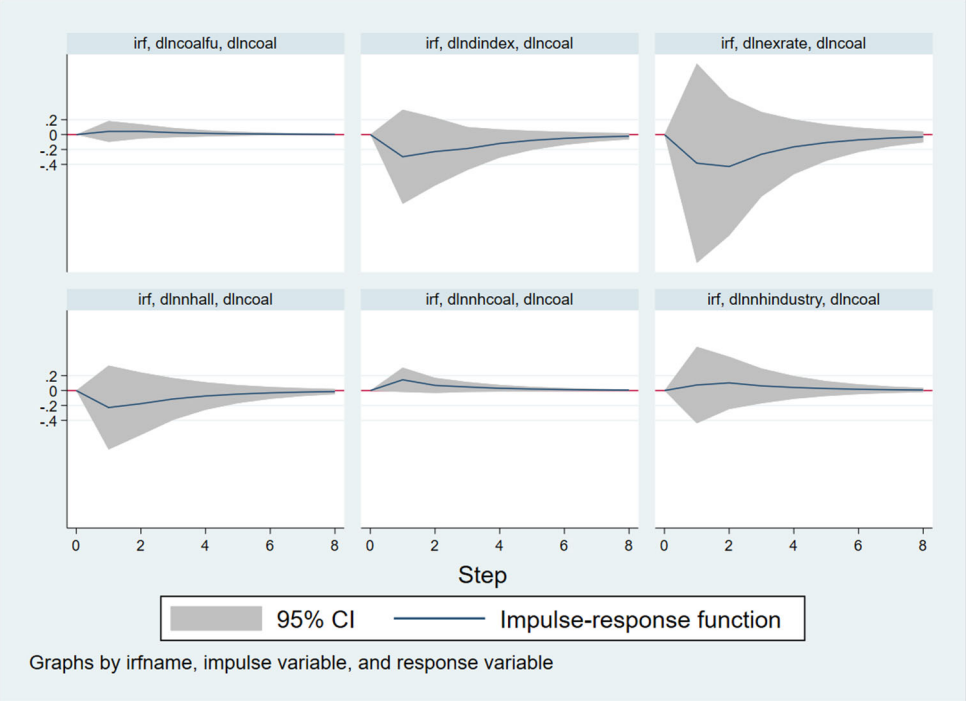

Figure 6. Impulse response plot of each factor on dlncoal from 2021 to 2022

Comparing Figure 5 and Figure 6, it is easy to find that from 2021 onwards, the impact of financial factor changes caused by external macro environment shocks on steam coal price changes has shifted dramatically. First, the impact of the shock lasts longer and becomes deeper, i.e., it changes from a short-term impact to a long-term impact. Second, the impact caused by the change of the dollar index is positive from 2016 to 2020 and negative from 2021 onwards, while the impact caused by the steam coal futures closing price is negative from 2016 to 2020 and positive from 2021 onwards.

3.8. Variance Decomposition Analysis

The variance decomposition, which explains the importance of one variable over another, is often used when discussing what kinds of variables one variable is affected by in addition to its own variation over a time interval. This section continues the study chosen in the previous section and sets the vertical axis scale from 0 to 0.015.

According to Table 11, it can be seen that: in the time period from 2016 to 2020, from the futures market perspective, the variance contribution of the changes in the Nanhua indices and the changes in the closing price of steam coal futures to the changes in steam coal prices is generally less than 1% and remains stable with the growth of the number of periods, where the highest contribution comes from the changes in the closing price of steam coal futures, which is stable at around 0.712% in the fifth period and beyond. The lowest comes from the Nanhua Industrial Products Index, which is stable at around 0.111%. From the economic environment perspective, the contribution of exchange rate changes and changes in the dollar index is even smaller, with the dollar index contributing only 0.01%. Briefly, the highest explanatory power of the price change of steam coal during this period is still itself, other financial factors can cause some impact, but not so obvious comparatively.

Table 11. Variance decomposition of each factor on dlncoal from 2016 to 2020

	σ	dlncoal%	dlnnhcoal%	dlnnh in-dus-try%	dlnnhall%	dln coal fu%	dln ex rate%	dln dindex%
1	0.005	100	0	0	0	0	0	0
2	0.005	98.867	0.685	0.087	0.148	0.156	0.049	0.009
3	0.005	98.759	0.709	0.109	0.17	0.187	0.058	0.01
4	0.005	98.75	0.711	0.11	0.171	0.189	0.059	0.01
5	0.005	98.748	0.712	0.111	0.172	0.189	0.059	0.01
6	0.005	98.748	0.712	0.111	0.172	0.189	0.059	0.01
7	0.005	98.748	0.712	0.111	0.172	0.189	0.059	0.01
8	0.005	98.748	0.712	0.111	0.172	0.189	0.059	0.01

According to Table 12, it can be seen that: in the time period from 2021 to 2022, from the perspective of futures market, the greatest explanatory factor for the steam coal price change is the change in Nanhua Steam Coal Index, which has stabilized above 7% in the fourth period and beyond. Besides, Nanhua Industrial Products Index and Nanhua Composite Index can also explain the tested object to some extent. From the perspective of economic environment, the explanatory power of the exchange rate change and the change of the US dollar index are similar, both maintaining above 0.3% at larger periods. Briefly, during this period, the higher explanatory power to coal price volatility is shown by itself as well as the Nanhua Steam Coal Index, compared with the weaker influence caused by other financial factors.

Table 12. Variance decomposition of each factor on dlncoal from 2021 to 2022

	σ	dlncoal%	dlnnhcoal%	dlnnh in-dus-try%	dlnnhall%	dln coal fu%	dln ex rate%	dln dindex%
1	0.018	100	0	0	0	0	0	0
2	0.023	93.59	5.52	0.332	0.138	0.08	0.144	0.196
3	0.024	91.948	6.859	0.329	0.19	0.144	0.257	0.272
4	0.025	91.345	7.335	0.33	0.207	0.162	0.298	0.323
5	0.025	91.122	7.512	0.329	0.214	0.169	0.312	0.341
6	0.025	91.028	7.587	0.329	0.217	0.172	0.318	0.349
7	0.025	90.988	7.619	0.329	0.218	0.173	0.321	0.352
8	0.025	90.971	7.632	0.329	0.218	0.174	0.322	0.353

Comparing Tables 11 and 12, it can be seen that there is a significant change in the explanatory power of financial factor changes for steam coal price changes from 2021 onwards. First, the explanatory ability of the change of Nanhua Steam Coal Index for the change of steam coal price has increased significantly, and it follows by the decrease of the explanatory ability from the change of steam coal price itself. Secondly, regardless of the futures market factors or economic environment factors, except for the changes in the closing price of steam coal futures, their explanatory power for the changes in steam coal prices basically increased to varying degrees.

4. Conclusion

This paper explores the impact of financial factors on steam coal prices through VAR models and divides the time interval into two categories, which are from 2016 to 2020 and from 2021 to 2022, based on the abnormal changes in coal prices in 2021, discusses and compares the differences in the impacts separately. Results show:

First, some of the factors that may affect commodity markets and major commodity markets do not have a significant impact on coal prices, i.e., factors that play an important role in macro commodity market pricing do not necessarily also have a similar effect on coal prices. Coal market participants should conduct an in-depth analysis of it and not directly apply the research results found in the macro commodity markets to coal markets.

Second, for the price change of steam coal market, the variable formed by its own lag one version and the change of Nanhua Steam Coal Index have a one-way spillover effect on it in two time intervals, that is, the change of Nanhua Steam Coal Index can drive the change of steam coal market price, which is a reflection of the linkage between the price change of steam coal market and financial factors. Thus, coal market participants need to consider the role of more factors when making decisions, otherwise the forecasts made can only be different from the realistic results.

Third, in general, price changes in the steam coal market are not significantly influenced by financial factors, of which the futures market has a greater impact in comparison. This is due to the current low level of financialization in China's coal industry and the fact that it is more influenced by fundamental factors such as supply, demand, and policy. In conjunction with the previous finding, coal market participants can, at least for now, focus on the futures market first and the economic environment second when roughly estimating coal prices. Overall, this paper suggests that participants should refer to financial market and environmental disturbances when making decisions, but the influence of fundamental factors (e.g., supply and demand) should always be used as the primary basis for judgment.

Fourth, influenced by the interaction of globalization factors such as the COVID-19 epidemic in 2021, the Russian-Ukrainian war, and energy transition, as well as local factors such as power outages and power restriction issues across China, the Chinese steam coal market price surged beyond

expectations, and since then, the link between steam coal prices and financial factors has deepened, i.e., the ability of financial factors to influence and explain steam coal prices has generally increased compared to the pre-2021 period. Based on this finding, investors who want to participate in the coal market need to be aware of the increasingly strong linkage between this market and financial markets through the interaction of various macro factors, and seize investment opportunities in similar global events in the future.

Fifth, for the steam coal futures index and the U.S. dollar index, their influence on power coal prices shows the opposite direction in the period from 2016 to 2020 compared to the period from 2021 to 2022, which also reflects that the influence of financial factors on steam coal prices is not relatively stable and easy to catch, but will change in nature with the change of the general environment. Therefore, market participants need to consider more external environmental factors when investing, paying particular attention to abnormal fluctuations in commodity prices, and adjust their investment strategies in a timely manner.

Acknowledgment

I thank Southwestern University of Finance and Economics. This work was supported in part by the research conditions it provides.

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