Research on the effect of coal price fluctuation on China's economy based on VAR model

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Abstract

This paper uses VAR model to construct a dynamic system for the relationship between the coal price and domestic economic growth , the price level, the money supply and the unemployment rate in the coal industry by studying sample data selected from January 2007 and April 2017. The analysis of Granger causality test shows that the coal price is the Granger cause of domestic economic growth, price level and coal industry unemployment rate. Based on the VAR (2) ,impulse response and variance decomposition analysis model showed that coal price fluctuations and price level fluctuated in the same direction; the increasing of coal prices lagged 2 order will slow the growth of industrial added value; When the price of coal lagged 1 order increases, the money supply will increase, and the price of money will decrease when the price of coal lagged 2 order increases; in the long term, higher coal price will make a higher unemployment rate; The influence of coal price on employment has increased since the fifth period, and the fluctuation of coal price has contributed greatly to the employment in the coal industry.

Keywords

Coal price fluctuation; VAR model; impulse response ;economic growth.

1. Introduction

Coal is an important consumer energy in China. According to China Statistical Yearbook in 2016, the total coal production accounted for 72.1% of the total energy production, and coal consumption accounted for 64% of the total energy consumption[1]. Coal prices have entered the new period after the government pricing of the "single track" system and "double track" system. In 2002, The government chose not to control coal prices, and then coal prices began to rise slightly. Until June 2008, the price of coal rose rapidly and fluctuated violently. Influenced by financial crisis in 2008, coal prices fell sharply. After the crisis, coal prices returned to normal from 2009. In the first half of 2012, due to the instability of the international political and economic environment, the worldwide demand for coal dropped, which led to a fall in coal prices. As China's economic development slowed down, the domestic coal demand declined, but market participants still increased the investment in coal resources mining, and the problem of coal production capacity surplus was particularly prominent. China's total output of coal increased by 4.8% in one year, and the import of coal increased rapidly. The cost of imported coal was lower than the cost of coal mining. In 2013, the domestic coal prices reduced firstly and then went up gradually. Coal demand began to go up, but there still an oversupply in the coal market as a whole. The coal imports continued to grow gradually, but due to excess production capacity, coal prices showed a weak downward trend. At the end of 2013, coal prices picked up and then fell rapidly. Since 2014, coal prices have risen slightly, and there is a clear trend of random fluctuations. The fluctuation of coal price not only affects the industry itself, but also has a great impact on the related industries, and then affects the development of the national economy.

Due to the difference of energy consumption structure between western countries and China, most foreign researches focus on impacts of the fluctuation of oil price on a nation' s economy. Cunado considers that the oil price fluctuation is a factor for economic recessions. These impacts have more obvious influence on the macro economy of OPEC nations[2]. Cologni used cointegrated VAR model for the G-7 countries in order to study the direct effects of oil price shocks on output and prices, and the reaction of monetary variables to external shocks[3]. Lardic, studied the long-term relationship between oil prices and economic activity, proxied by GDP[4]. Papapetrou considers that the degree of negative correlation between oil prices and economic activity strengths during periods of rapid oil price changes and high oil price change volatility[5]. Jones thinks that oil prices had little impact on the global recession of 2008—9[6]. LI Wenbo uses the sample of time series data to conduct a quantitative analysis on the influence of coal price fluctuation on the economic growth of China with the aids of Chow Test, Granger causal relationship inspection method and the impulse response function method[7].

Though there are many researches on the influence of energy price on economy, studies of of oil price fluctuation on the economy of European and American countries and they rarely refer to that on the economy of developing countries, such as China. In addition, people hardly see any literature researching the influence of coal price fluctuation on the economy of China. In view of this, this paper selects monthly data from January 2007 to April 2017 as the study objects. Firstly use the Granger causality test to study the dynamic relationship between various economy indexes of China and coal price, and then established the VAR (2) model, using the impulse response function and variance decomposition to study the relationship between coal price and various economy indexes of China so as to comprehensively analyze the influence degree and law of coal price volatility to China's economy indexes.

2. Research methods and models

In this paper, we mainly use the Granger Causality Test, VAR model, impulse response function and variance decomposition to do the research. We build the VAR model of the coal price and other economic variables, then the dynamic relationship between these variables is studied by means of two methods, impulse response and variance decomposition.

1) VAR model

The vector autoregressive model (VAR) is a typical unstructured model, based on the statistical properties of the data to establish the model, building the model by using variables of each endogenous system as a system behind the values of all variables . The single variable vector autoregressive model is extended to multiple autoregressive model composed of multivariate time series variables.

This paper mainly studies the relationship between coal prices and various economic variables, which belongs to complex system. Therefore, this paper uses VAR model in the research. The VAR model is paid more and more attention by researchers. The VAR model expression with variable number P and lag period n is constructed as follows:

$$V_t = \alpha + \sum_{i=1}^{n} \beta_i V_{t-i} + \varepsilon_t \quad (1)$$

Where V_t represents the ($p \times 1$) vector of the uniformly variance stationary random process; β_i is the coefficient matrix; V_{t-i} represents the variable of the V_t vector lagged i order, and ε_t represents a random shock.

2) Impulse response function

The impulse response function can be used to describe the impact of the magnitude of a standard deviation on the current and future values of the selected variables, which can visually depict the dynamic paths between variables. In this paper, the impulse response function can test the effects of coal price volatility on other economic variables, the intensity and the duration of the effects.

3) Variance decomposition method

Variance decomposition method can reflect the degree of interaction between vectors when a certain variable in system is hit by a unit of the impact . The change of each endogenous variable in the system is decomposed into the components associated with the stochastic disturbance term (innovation) of each equation in order to understand the relative importance of each shock to the endogenous variable in the model.In this paper, the variance decomposition method is used to study the contribution rate of coal price volatility to coal industry employment.

3. Data and variable selection

This paper selects the monthly data of 5 research variables between January 2007 to April 2017, and analyzes the dynamic relationship between coal price volatility and domestic economic growth and the price level, monetary supply, coal industry employment.

1) Coal prices. In 2015 the global coal consumption decreased by 1.8% and the proportion of coal in the global primary energy consumption is 29.2%. The coal consumption in China accounted for 64%, which still occupies the dominant position in China's energy consumption structure. In the first half of 2012, due to the instability of the international political and economic environment, the worldwide demand for coal dropped, which led to a fall in coal prices. China's total output of coal increased by 4.8% in one year, and the import of coal increased rapidly. The cost of imported coal was lower than the cost of coal mining. In 2013, the domestic coal prices reduced firstly and then went up gradually. Coal demand began to go up, but there still an oversupply in the coal market as a whole. The coal imports continued to grow gradually, but due to excess production capacity, coal prices showed a weak downward trend. Since 2014, the price of coal has risen slightly, and there is a trend of obvious random fluctuation. In this paper, the national coal price index (PI) is used as the coal price variable, using LPI to represent the variable transformed by logarithm .

2) Price level. The consumer price index (CPI) can reflect the purchasing power of a country's consumers and the prosperity of its national economy. In this paper, CPI is selected as the research variable, using LCPI to represent the variable transformed by logarithm .

3) The rate of economic growth. By carding the relevant literature, the GDP and the industrial added value IAV are used to measure the speed of a country's economic development. Although there is a rapid fall in coal prices in 2008, GDP growth did not decline significantly. Taking the availability of data into consideration, the paper selected the industrial added value (IAV) to represent the economic growth rate, using LIAV to represent the variable transformed by logarithm.

4) Money supply. According to previous studies, M1 is more stable and controllable than M2 in the study of monetary policy. Select M1 to represent the total supply of money, using LM1 to represent the variable transformed by logarithm.

5) Industry unemployment rate. Unemployment rates for mining workers, data sources, WIND database. The unemployment rate is expressed in UR, using LUR to represent the variable transformed by logarithm.

4. Empirical analysis

First, the unit root test is performed on the variables. If the sequence is unstable, the sequence is differentiated until the sequence is stationary. The sequence is stationary in the N difference, then we think the original sequence is N order integral. When all sequences obey the same order, The Granger Causality Test is used. Based on the VAR model the impulse response and variance decomposition are used to study the dynamic relationship between variables.

4.1 ADF test

We use ADF to test the stability of the five indicators, which are LM1, LIAV, LPI, LCPI and LUR. The ADF test result of original sequence is shown in Table 1, and the result of the first order differential sequence is shown in table 2:

Table 1 ADF test result of raw variables

variables	Test type(c,t,d)	ADF	1%level	5%level	10%level	conclusion
LM1	(c,0,4)	-2.061625	-3.484653	-2.885249	-2.579491	Non-stationary
LPI	(c,0,4)	-2.545495	-3.485115	-2.88545	-2.579598	Non-stationary
LIAV	(c,0,4)	-2.489833	-3.485115	-2.88545	-2.579598	Non-stationary
LCPI	(c,0,4)	-1.596497	-3.485115	-2.88545	-2.579598	Non-stationary
LUR	(c,0,4)	-6.320223	-3.486064	-2.88545	-2.579598	Stationary

Table 2 ADF test result of first order differential variables

variables	Test type(c,t,d)	ADF	1% level	5% level	10% level	conclusion
DLM1	(c,0,4)	-15.61878	-3.484653	-2.885249	-2.579491	Stationary
DLPI	(c,0,4)	-6.120852	-3.485115	-2.88545	-2.579598	Stationary
DLIAV	(c,0,4)	-13.49955	-3.485115	-2.88545	-2.579598	Stationary
DLCPI	(c,0,4)	-13.73455	-3.485115	-2.88545	-2.579598	Stationary
DLUR	(c,0,4)	-9.59751	-3.486064	-2.88545	-2.579598	Stationary

Note: (C, t, d) means that the test equation contains intercept terms, time trend items and lag orders. The lag order is determined according to the SC minimum criterion.

As is shown in Table 1 and table 2, except the LUR sequence of unemployment rate, the other original sequences are Non-stationary at the significant levels of 1%, 5% and 10% separately, while all their first order differential sequences are stationary. The differential sequences of the five variables are represented by DLM1, DLPI, DLIAV, DLCPI and DLUR.

4.2 Granger Causality Test

In order to determine the relationship among variables, the Granger causality test is used. According to the SC minimum principle, the lag order is 4. Part of the result of the Granger causality test is shown in table 3:

Table 3 Results of Granger causality test

Null Hypothesis	F-Statistic	P-value	conclusion
DLM1 does not Granger Cause DLCPI	2.29616	0.0137	Refused
DLPI does not Granger Cause DLCPI	2.26763	0.015	Refused
DLIAV does not Granger Cause DLCPI	2.68292	0.0041	Refused
DLCPI does not Granger Cause DLIAV	2.06422	0.0278	Refused
DLPI does not Granger Cause DLIAV	3.16052	0.0009	Refused
DLIAV does not Granger Cause DLPI	0.51312	0.0901	Refused
DLCPI does not Granger Cause DLPI	1.08433	0.03834	Refused
D DLUR does not Granger Cause DLPI	1.28596	0.002416	Refused
DLPI does not Granger Cause DLUR	1.01083	0.04464	Refused

As can be seen from table 3, at 5% o significant level, DLM1 does Granger Cause DLCPI, indicating that monetary policy will lead to changes in the price level. There are obvious two-way Granger causality between DLCPI and DLPI, which shows that the change of coal price will lead to a change in price level, and the change of price level will influence the volatility of coal price. There is a close correlation between coal prices and price levels. There is an obvious two-way Granger causality between DLIAV and DLCPI, indicating that industrial growth rate and price level interact with each other. At the significant level of 1%, the growth rate of coal price and industrial added value is mutual Granger causality, and the change of coal price will lead to the change of the growth rate of industrial added value. There is a clear two-way Granger causality between unemployment and coal prices. There is no Granger causality between coal prices and monetary policy.

4.3 Building VAR Model

In order to further study the dynamic relationship between coal price fluctuation and other economic variables, the 5 dimension VAR model is built. The number of delay periods is 2, and the VAR (2) model is established. The estimation results of AR (2) model are shown in table 4:

Table 4 Estimation results of VAR (2) model

	DLCPI	DLIAV	DLM1	DLPI	DLUR
DLCPI(-1)	-0.192188	0.369106	0.293221	-0.00898	-0.00463
	[-1.99903]	[2.43913]	[2.13104]	[-0.83370]	[-0.82216]
DLCPI(-2)	0.108263	-0.01645	0.069368	0.016101	-0.01068
	[1.12787]	[-0.10887]	[0.50494]	[1.49668]	[-1.90127]
DLIAV(-1)	0.115367	-0.62075	0.12107	0.001545	-0.00177
	[1.85549]	[-6.34286]	[1.36056]	[0.22172]	[-0.48642]
DLIAV(-2)	0.089279	-0.29962	0.015252	0.004994	-0.00427
	[1.51988]	[-3.24059]	[0.18142]	[0.75858]	[-1.24286]
DLM1(-1)	0.133766	-0.17458	-0.40893	-0.00062	-0.00074
	[1.87782]	[-1.55704]	[-4.01109]	[-0.07811]	[-0.17755]
DLM1(-2)	0.054586	-0.0999	-0.15865	0.000299	-0.00288
	[0.77465]	[-0.90067]	[-1.57312]	[0.03781]	[-0.69780]
DLPI(-1)	0.756155	0.967054	0.322399	0.935763	0.020281
	[0.94396]	[0.76699]	[0.28122]	[10.4232]	[0.43269]
DLPI(-2)	0.83411	-0.05028	-1.80255	-0.36736	-0.02562
	[1.01409]	[-0.03883]	[-1.53125]	[-3.98508]	[-0.53241]
DLUR(-1)	-0.60249	6.246587	2.49763	-0.0878	0.091728
	[-0.38392]	[2.52886]	[1.11204]	[-0.49919]	[0.99894]
DLUR(-2)	1.566058	-2.41856	-1.80602	0.060265	0.070781
	[0.98845]	[-0.96983]	[-0.79648]	[0.33940]	[0.76351]
C	-0.013395	-0.01301	0.007736	0.001364	-0.0002
	[-0.63195]	[-0.39005]	[0.25501]	[0.57437]	[-0.16161]
R-squared	0.934067	0.975825	0.920089	0.954239	0.980226

Note: [] indicates the t-statistic

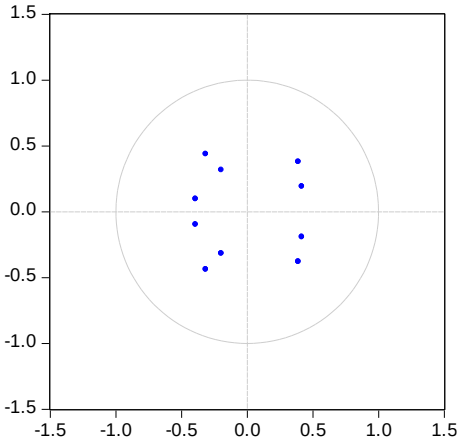

Figure 1 Inverse roots of the characteristic polynomial of VAR (2)

From the estimated results of Table 4, the R-square value of the whole model is large, which shows that the overall fitting effect of the model is very good. The estimation results of VAR (2) model are as follows:

1) The influence of coal price volatility on price level. For estimating equation with DLCPI, the estimated coefficients affecting the price of coal series lagged 1 order and 2 order on price level were 0.756155 and 0.83411, less than 1, indicating that the coal price fluctuations and the price level fluctuate in the same direction.

2) The influence of coal price volatility on the growth rate of industrial added value. For estimating equation with DLIAV, the estimated coefficients are 0.967054 and -0.05028 respectively, indicating

that the increasing of coal prices lagged 2 order will slow the growth of industrial added value.

3) The influence of coal price volatility on money supply. With DLM1 as the dependent variable in estimating equation, the estimated coefficients of the equation are 0.322399 and -1.80255. When the price of coal lagged 1 order increases, the money supply will increase, and the price of money will decrease when the price of coal lagged 2 order increases.

4) The influence of coal price fluctuation on the unemployment rate. With DLUR as the dependent variable in estimating equation, the estimation coefficients are 0.020281 and -0.02562, respectively. When the price of coal lagged 1 order increases, the unemployment rate increases, and the unemployment rate declines when the price of coal lagged 2 order increases. In the long run, rising coal prices will cause a high unemployment rate.

According to Inverse roots of the characteristic polynomial of VAR (2), the calculation of AR characteristic polynomial of model fins that the inverse roots of the characteristic polynomial are all located in the unit circle(As shown in figure 1),indicating that the VAR(2)model established is stable.

4.4 Impulse response and variance decomposition

In order to test the response of coal price , price level, the rate of economic growth, money supply and industry unemployment rate to the positive impact of one coal price's standard deviation unit, an impulse response function and variance decomposition are used to do further research. In this paper, the impulse response function of each economic variable is given, and the pulse response function is shown in figure 2:

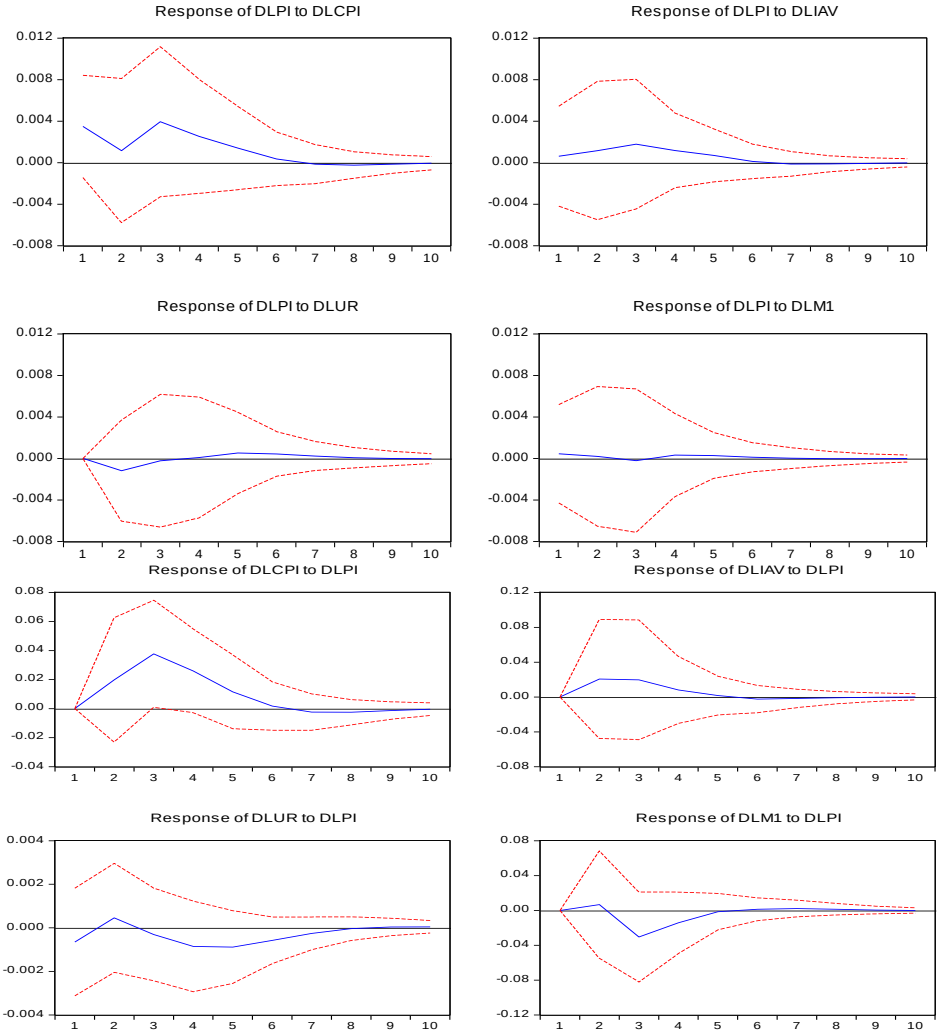

Figure 2 Response of price level and other indexes to impacts of coal price

From Figure 2, the consumer price index will decrease first then increase and then decreased with the positive impact of a unit of coal price standard deviation, from the beginning of the sixth period, the

growth of price level in 0, the impact coal prices on the price level from the sixth disappeared. The positive impact of a unit standard deviation of coal prices will lead to an increment in industrial added value firstly and then begin to decrease, reaching the maximum in the third phase, and then begin to decrease. From the sixth period, the growth rate of industrial added value was 0, and The impact of coal price on the growth rate of industrial added value disappeared. The influence of coal price on the money supply has been in the 0 growth state, which is consistent with the Granger causality test.

Based on VAR (2) model, variance decomposition analysis of each variable is carried out. Table 5 gives the variance decomposition results of the unemployment rate.

Table 5 Variance decomposition results of unemployment rate

Period	S.E.	DLCPI	DLIAV	DLM1	DLPI	DLUR
1	0.013512	0.00647	0.678551	0.099418	0.234741	98.98082
2	0.013629	0.409893	1.022861	0.114375	0.344545	98.10833
3	0.013996	2.979844	2.705308	0.498043	0.374597	93.44221
4	0.014033	3.094694	2.706161	0.495589	0.745044	92.95851
5	0.014071	3.15353	2.74009	0.497168	1.135851	92.47336
6	0.014084	3.158724	2.739289	0.496816	1.300244	92.30493
7	0.014087	3.171398	2.738216	0.496601	1.33277	92.26102
8	0.014087	3.171727	2.738871	0.496722	1.33357	92.25911
9	0.014087	3.17245	2.738909	0.496718	1.334294	92.25763
10	0.014087	3.172419	2.73891	0.496713	1.33527	92.25669

As can be seen from table 5, the biggest contribution of coal prices to the unemployment rate appears in the fifth phase, and the impact of coal prices on employment is lagging behind in the 5 stage. The influence of coal price on employment has increased since the fifth period, and the fluctuation of coal price has contributed greatly to the employment in the coal industry.

5. Conclusion

This paper selected the monthly data of 5 research variables between January 2007 to April 2017, then build the VAR model, analyzing the dynamic relationship between domestic economic growth and consumer price index, money supply and the unemployment rate of coal industry. Based on the construction of VAR model, the dynamic relationship between five variables is studied by means of impulse response and variance decomposition, and some important conclusions are obtained.

1) DLM1 is DLCPI's Granger Cause, indicating that monetary policy will lead to changes in the price level. There are obvious two-way Granger causality between DLCPI and DLPI. There are obvious two-way Granger causality between DLCPI and DLPI. There is a clear two-way Granger causality between unemployment and coal prices. There is no Granger causality between coal prices and monetary policy.

2) The coal price fluctuations and the price level fluctuate in the same direction. The increasing of coal prices lagged 2 order will slow the growth of industrial added value. When the price of coal lagged 1 order increases, the money supply will increase, and the price of money will decrease when the price of coal lagged 2 order increases. In the long run, rising coal prices will cause a high unemployment rate.

3) The impact coal prices on the price level from the sixth disappeared. From the sixth period, the growth rate of industrial added value was 0, and The impact of coal price on the growth rate of industrial added value disappeared. The influence of coal price on employment has increased since the fifth period, and the fluctuation of coal price has contributed greatly to the employment in the coal industry.

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