Effect of coal price on the economy in China

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Abstract

Coal is the main economic resource in China. To study the effect of coal price on the economy, a vector auto regression model was established through a co-integration test based on the coal price and economic variables. An empirical analysis of the relationship between coal price fluctuation and economic variables was conducted by using an impulse response function and variance decomposition method. Results demonstrate that a co-integration relationship exists between the coal price and economic variables. Coal price fluctuation has a short-term and long-term positive effect on CPI, a short-term negative effect and long-term positive effect on PPI, a short-term positive effect and long-term unobvious impact on GDP. From the impulse response analysis, within the forecast period, coal price fluctuation has an obvious positive effect on CPI in long time and PPI unobvious positive effect on GDP at beginning, its positive effect on GDP enhances as the forecast period increases. The analysis of the contribution shows that coal price fluctuation influences economic variables to different extents. A coal price management mechanism should be established and perfected to reduce the impact of coal price fluctuation on the economy. Furthermore, the energy consumption structure should be improved.

Keywords: Coal price fluctuation, Co-integration test, VAR model, Impulse response, Variance decomposition.

1 Introduction

Coal is the foundation of energy in China, and has higher proportion in energy consumption structure. It is difficult to change the energy landscape in the short term, so coal is vital to the economic development of China. The coal industry is the leading industry of the energy and upstream industry in China, Coal price fluctuations will exert a significant influence on the economy by affecting industrial departments and the price of commodities. As a result, studying the effect of coal price on the economy is highly significant for energy policy perfection and energy structure adjustment.

Considering that the energy consumption structure of most countries in the world is dominated by petroleum, foreign studies on the effect of energy price fluctuation on the economy mainly focus on the effect of petroleum price fluctuation on economic development. Only few studies on the effect of coal price fluctuation on economic development have been conducted. M. Kulshreshtha and J.K. Parikh[1]elaborated the relationship between coal price and income in their study on the coal demand of India's energy consumption department. Seung-HoonYoo[2] established a model by using time series and discovered the two-way causality relationship between coal consumption and economic growth in Korea. S.L. Satti et al.[3], ChandranGovindaraju[4,5], and M.E. Bildirici and T.Bakirtas[5]founda cause-and-effect relationship between coal consumption and economic growth. I. Berk and H. Yetkiner[6]positedthat the growth rate of energy price influences the actual GDP growth rate.

Owing to the late development of coal market in China, only a few domestic studies have been conducted on the effect of coal price on the economy are available. Most of these studies are qualitative descriptions. Quantitative analyses of the relationship between coal price fluctuation and associated economic indexes rely mainly on the general equilibrium (CGE), input–output, and econometric models. Lin Boqiang et al.[7]adopted CGE and pointed out that coal price growth generates economic austerity in China. Xin Ruijun[8]employed CGE to study the effect of coal price fluctuation on industries in Xinjiang and revealed the negative effect of coal price growth on GDP. Yuan Pengfei et al.[9] explored the comprehensive effect of energy price growth on economic growth by using the CGE model and concluded that compared with the price growth of other types of energy, coal price growth reduces GDP and increases the price of commodities slightly. Zhou Aiqian and Zhang Qin et al.[10] established an input–output model and reported that coal price growth influences several industries significantly. By conducting an input–output analysis, Wang Wei et al.[11] posited that coal price fluctuation influences the production and distribution of electricity and heat. GuoYongmei[12]reported that coal price growth can facilitate the local economic growth of coal production

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areas. Ding Zhihua et al.[13-15] employed the econometric model and discovered a long-term stable equilibrium relationship between coal price and the economy.

However, the abovementioned studies failed to reach an agreement regarding the effect of coal price fluctuation on the economy. Domestic literature review reveals that coal price fluctuation changes economic variables but affects the economy of different regions to different extents because of the different energy consumption levels and economic structures of regions.

Coal is an important strategic resource in China. The rich coal reserve not only provides energy support for economic development but is also an important factor that effect on economy. Drastic coal price fluctuation effects on economic development significantly. This study focuses on the effect of coal price fluctuation on the economic development. Corresponding countermeasures to avoid price impact are proposed.

2. Data source and method

The monthly coal price fluctuation data of our nation from January 2001 to June 2014 were analyzed. All data were obtained from the Ceinet Industry database for the sake of reliability, and coal price was determined as the producer price index of coal mining and washing industry. The economic variables involved include consumer price index (CPI), producer price index (PPI), and gross domestic product (GDP). GDP involves quarterly data, which has to be converted into monthly data. Considering the modeling needs, a natural logarithm was employed in all data series to reduce heteroscedasticity between data and increase data stability without influencing the result analysis. The logarithm series of mining price (MP), CPI, PPI, and GDP are lnMP, lnCPI, lnPPI, and lnGDP, respectively.

Analysis software Eviews 6.0 was utilized to build the vector auto regression (VAR) model. Co-integration analysis, impulse response function, variance decomposition, and other approaches were adopted to analyze the correlative mechanism between coal price and the economic variables.

The VAR model is a simultaneous form of the autoregression model. If y_{1t} is related to y_{2t} and the two autoregression models are built separately, the relationship between these two variables will not be captured.

$$y_{1t} = f\left(y_{1,t-1}, y_{1,t-2}, \ldots\right) \quad (1)$$

$$y_{2t} = f\left(y_{2,t-1}, y_{2,t-2}, \ldots\right) \quad (2)$$

Once the simultaneous form is obtained, the relationship between the two variables can be determined. Taking the VAR model of one-period lagged variables y_{1t} and y_{2t} as an example, the VAR model can be expressed as

$$y_{1t} = c_1 + \pi_{11.1} y_{1,t-1} + \pi_{12.1} y_{2,t-1} + u_{1t} \quad (3)$$

$$y_{2t} = c_2 + \pi_{21.1} y_{1,t-1} + \pi_{22.1} y_{2,t-1} + u_{2t} \quad (4)$$

3 Empirical analysis

3.1 DATESTATIONARITYTEST

Stationarity was the first variable tested. Time series stationarity indicates that statistical laws on time series do not change with time; that is, the features of the stochastic process during which the variable time series data are generated are time-invariant. The ADF approach was adopted for the unit root test of the same variables, and the results are shown that the time series of coal price and economic variables are not stationary, however, ordinary differential analysis indicates that each time series is stationary.

3.2 DATA STATIONARY TEST JOHANSEN CO-INTEGRATION REGRESSION TEST

The main principle of the Johansen test is that if the co-integration vector matrix contains a non-zero characteristic root and how many non-zero characteristic roots are contained. The existence of non-zero characteristic roots indicates that a co-integration relationship exists among various time series. The results in Table 1 indicate that under the level of 5%, the trace and maximum eigenvalue statistics have a co-integration relationship, and a long-term equilibrium relationship exists between coal price and economic variables.

TABLE 1 Johansen test for coal price and economic variables

Hypothesized No. of CE(s)	Eigenvalue	Trace test	Trace test C.V.	Maximum eigenvalue	Maximum eigenvalue C.V.
None *	0.2232	54.6609	40.1749	39.6640	**24.1592**
At most 1	0.0742	14.9969	24.2759	12.0992	**17.7973**
At most 2	**0.0183**	**2.8976**	**12.3209**	**2.89755**	**11.2248**

Notes: "" indicates that the original assumption is rejected under the 0.05% significant level.*

3.3 VAR MODEL

The co-integration test demonstrates that a long-term equilibrium relationship exists between the coal price and CPI, PPI, and GDP. This relationship was analyzed by establishing a VAR model.

Lagged orders, which significantly affect the test results, need to be set to build the VAR model. Low orders disregard several important variables, whereas high orders reduce the freedom of the model and thus lead to a considerable standard deviation in parameter estimation and a reduction inaccuracy. The lag period was determined according to the lag length criteria. In Table 2, the smallest lag periods of the five evaluation indexes are represented by "*". According to the minimum AIC and SC criteria, the optimal lag period was set to 2, and a VAR (2) model was established.

TABLE 2.Appropriate lag intervals of the VAR model determined by lag length criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1702.015	NA	21454.36	21.32519	21.40207	21.35641
1	-986.6216	1386.075	3.425830	12.58277	12.96717	12.73886
2	-876.8911	207.1164*	1.061950*	11.41114*	12.10305*	11.69210*

Notes: ""indicates the lag order selected by the criterion.*

Eviews 6.0 was employed to build the four-variable VAR model of coal price and economic variables. The model estimation results are shown below.

$$\begin{bmatrix} \ln CPI \\ \ln PPI \\ \ln GDP \\ \ln MP \end{bmatrix} = \begin{bmatrix} 9.51 \\ 2.38 \\ 6.38 \\ -17.55 \end{bmatrix} + \begin{bmatrix} 0.82 & 0.12 & 0.002 & 0.03 \\ 0.25 & 1.79 & -0.08 & -0.021 \\ 0.81 & 0.97 & 0.47 & 0.02 \\ 0.50 & 0.79 & -0.08 & 1.32 \end{bmatrix} \begin{bmatrix} \ln CPI(-1) \\ \ln PPI(-1) \\ \ln CDP(-1) \\ \ln MP(-1) \end{bmatrix} + \begin{bmatrix} 0.04 & -0.11 & 0.06 & -0.05 \\ -0.22 & -0.84 & 0.08 & 0.022 \\ -0.83 & -0.73 & 0.28 & -0.02 \\ -0.37 & -0.77 & 0.13 & -0.35 \end{bmatrix} \begin{bmatrix} \ln CPI(-2) \\ \ln PPI(-2) \\ \ln CDP(-2) \\ \ln MP(-2) \end{bmatrix}$$

All characteristic roots in the model shown in Figure1 are in the unit cycle; therefore, the VAR model has a stable system. After testing the residuals of the VAR (2) model, the model residuals were found to follow a normal distribution and have no autocorrelation or heteroscedasticity. Estimation results also suggest that the joint parameter survey is significant. The model determination coefficient(R) is between 0.94 and 0.98; therefore, the statistical property of VAR (2) is favourable.

According to the established VAR (2) model, the influencing coefficients of lag 1 and lag 2 of coal price to CPI are 0.03 and −0.02. This result indicates that coal price growth can increase CPI in lag 1 and reduce CPI in lag 2. Given that the sum of influencing coefficients of lag 1 and lag 2 is bigger than 0, coal price growth will increase CPI in the long run. Meanwhile, the influencing coefficients of lag 1 and lag 2 of coal price to PPI are -0.021 and 0.022. This result indicates that coal price growth decreases PPI in lag 1 but increases PPI in lag 2. Given that the sum of influencing coefficients of lag 1 and lag 2 is larger than 0, coal price growth will increase PPI slowly in the long run. Coal price growth affects the changes of CPI more quickly than PPI. Furthermore, the influencing coefficients of lag 1 and lag 2 of coal price to GDP are 0.02 and −0.02. Given that the sum of influencing coefficients of lag 1 and lag 2 is 0, this result shows the unobvious effect of coal price growth on GDP in the long run. To sum up, coal price fluctuation has a short-term and long-term positive effect on CPI, a short-term negative effect and long-term positive effect on PPI, a short-term positive effect and long-term unobvious effect on GDP.

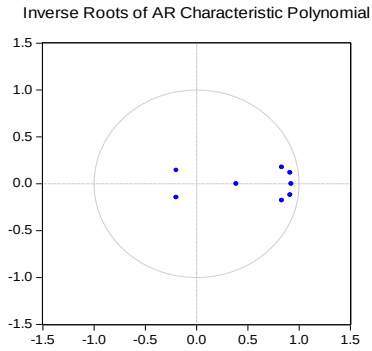

FIGURE 1 VAR model stability (root diagram of AR eigenpolynomial)

3.4 IMPULSE RESPONSE AND CONTRIBUTION ANALYSES

Impulse response analysis and variance decomposition of the VAR model are necessary to obtain a deeper understanding of the variation law of this long-term equilibrium relationship after impact.

3.4.1 Impulse response analysis

The response route of the economic variables to coal price fluctuation in 20 forecast periods under the disturbance of one standard coal price deviation is shown in Fig.2. The full line denotes the variation path of economic variables influenced by coal price fluctuation, and the dotted lines are the numerical values of economic variables (adding and subtracting two times of standard deviation) representing the maximum variation range of the economic variables.

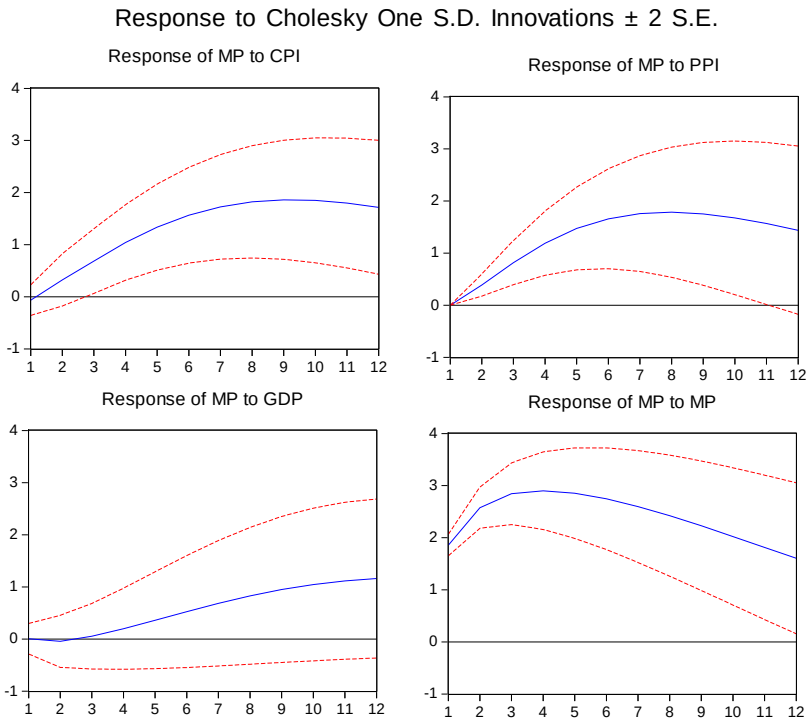

FIGURE 2. Impulse response function of coal price

As shown in Figure 2, one standard deviation of random disturbance of coal price immediately increases CPI in the current forecast period. CPI reaches the peak at the 10th forecast period and then decreases gradually. Such positive effect appears throughout the forecast period. Similarly, PPI immediately benefits from this disturbance and reaches the peak at the 8th forecast period. Such effect declines gradually but remains positive in the forecast period. There is no change on GDP from the disturbance at the first two forecast period, GDP benefits from the3rd forecast period. Such positive effect increases gradually in the later forecast period. Coal price increases immediately upon receiving one standard deviation of positive impact. Such positive impact reaches the peak at the 4rdforecast period and decreases gradually but remains positive in the later forecast period.

To sum up, within the forecast period, coal price fluctuation has an obvious positive effect on CPI in long time and PPI unobvious positive effect on GDP at beginning, its positive effect on GDP enhances as the forecast period increases. Furthermore, coal price fluctuation affects CPI and PPI more significantly than GDP.

3.4.2 Contribution analysis

Variance decomposition means that the interactions between variables can be expressed by percentages of prediction error variances after a variable in the system suffers one unit of effect. Variance decomposition reflects the relative importance of random information. That is, the variation of each endogenous variable in the system is decomposed into all constituent parts relevant to random disturbance terms to determine the relative importance of innovation in the endogenous variables of the model. Variance decomposition analysis was conducted to analyze the influence of coal price on the economic variables.

Table 3 reveals that coal price can affect itself. Its contribution to coal price fluctuation in the 1st forecast period reaches 99.87%, which decreases gradually until it becomes stable (approximately55.81%) at the 12thforecast period. The contribution of coal price to CPI is zero in the 1st forecast period but increases to 0.79% in the 2nd forecast periodandapproximately11.60%in the 12thforecast period. The contribution of coal price to PPI is approximately6.95% in the 1st forecast period, and then decreases gradually until it reaches2.32% at the 12thforecast period. The contribution of coal price to GDP is zero in the 1st forecast period, increases to 1.56%in the 5thforecast period, and decreases gradually to 1.04% at the 10thforecast period.

The analysis of the contribution shows that coal price fluctuation influences economic variables to different extents. In the short term, PPI is affected most significantly, followed by CPI and GDP successively.

TABLE 3. Variation decomposition results for the effect of coal price on economic variables

Period	Percent LNDJ variance due to LNDJ（%）	Percent LNSR variance due to LNDJ（%）	Percent LNCZ variance due to LNDJ（%）	Percent LNJG variance due to LNDJ（%）
1	0.0000	6.9458	0.0000	99.8745
2	0.7871	5.3622	0.6157	97.4849
3	0.7244	4.6767	1.3358	92.8462
4	0.5374	4.1356	1.5607	87.0941
5	0.6005	3.7005	1.5628	81.2337
6	1.0562	3.3314	1.4526	75.7927
7	1.9302	3.0140	1.3115	70.9835
8	3.2070	2.7468	1.1824	66.8436
9	4.8558	2.5360	1.0885	63.3294
10	6.8381	2.3907	1.0440	60.3689
11	9.1054	2.3199	1.0565	57.8863
12	11.5968	2.3290	1.1286	55.8124

As the forecast period increases, the effect on CPI increases gradually and PPI decreases gradually, whereas the effect on GDP remains about 1%. CPI and PPI are main economic variables that reflect the price level. This result means that coal price fluctuation generally has a long-term stable effect on price level.

4 Conclusions and suggestions

4.1 CONCLUSIONS

The VAR (2) model was established in this study through a co-integration test, and the effect of coal price fluctuation on the economic variables from January 2001 to June 2014 was discussed by using an impulse response function and variance decomposition. The results demonstrate the following.

(1) The co-integration test revealed the co-integration relationship between MP and CPI and PPI and GDP.

(2) The established VAR (2) model showed that coal price fluctuation has a short-term and long-term positive effect on CPI, a short-term negative effect and long-term positive effect on PPI, a short-term positive effect and long-term unobvious impact on GDP. In the short run, Coal price fluctuation influences on CPI and GDP positively, and on PPI negatively. In the long run, coal price fluctuation has a positive effect on CPI and PPI, and an unobvious effect on GDP.

(3) According to the impulse response analysis, within the forecast period, coal price fluctuation has the longest positive effect on CPI and PPI and the shortest unobvious effect on GDP, which turns positive quickly. Furthermore, it affects CPI and PPI more significantly than GDP.

(4) The contribution analysis shows that coal price fluctuation influences economic variables to different extents. In the short term, it influences PPI most significantly, followed by CPI and GDP successively. As the forecast period increases, the effect on CPI increases gradually and PPI decreases gradually, whereas the effect on GDP remains about 1%.

4.2 POLICY SUGGESTIONS

The effect of coal price fluctuation on economic variables in Shanxi Province was discussed through a correlation analysis. Two policy suggestions are proposed.

(1) Establish and perfect a coal price management mechanism. The empirical test conducted in this study revealed that coal price fluctuation has a long-term positive effect on price level (CPI and PPI). To avoid drastic price changes caused by large coal price fluctuation, a coal price management mechanism should be established and perfected. A strategic coal reserve system should be built, and short-term coal supply−demand should be balanced to prevent significant coal price fluctuation.

(2) Change the energy consumption structure. This paper posits that coal price fluctuation influences China's price level significantly. To improve the response of price level to coal price fluctuation, the energy consumption structure should be improved promptly. The dependency on coal consumption should be reduced, and cheaper types of energy, such as wind and thermal energy, should be developed.

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