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THE EMPIRICAL STUDY ON THE COAL PRICE AND QUANTITY OF THE SUPPLY AND DEMAND – BASED ON VAR MODEL

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Abstract. *In order to investigate the coal quantity of the supply and demand on the impact of the coal price, the paper, based on the VAR model, using the date from 1985 to 2011, analyzes the correlation between quantity of the supply and demand and the coal price with the comprehensive use of time series stationarity test, impulse response functions and variance decomposition. The results show that quantity of the supply and demand has a significant influence on the coal price, and finally the paper provides a reference for the enterprise production and economic development.*
Keywords: Coal price, Quantity of the supply and demand, VAR

1. **Introduction.** With the development of economy, the oil, gas and other energy consumption increased, and the proportion of coal demand is falling. However, because our country presents stage energy reserves "rich coal, inferior, less gas", coal is still the main primary energy source. The fluctuations in coal prices will affect the enterprise supply, and may also affect the development of national economy, so the study of coal prices is imperative. Sun and Peng [5] use ARMA model to forecast the price of coal, and the prediction result and the actual data are very close. Dong and Zhang [6], using the grey forecasting theory, establish the dynamic model to predict the price of coal, through the actual calculation and error analysis prove that the establishment of the model is correct, and for the prediction of coal market price, provide a reliable method and means. Wei et al. [7] using the same method, find the forecast result accords with the actual situation. The formation of the coal price is the result of joint action of many factors, including its own value, supply and demand, the price of transportation cost, upstream and downstream related goods, coal policy information, international coal prices and so on, and these factors affect the value of coal and coal supply and demand affect the price of coal. So the article chooses the relationship between the coal price and the quantity of supply and demand as the research object, and through in-depth study of coal price and the amount of supply and demand relations, provide the reference for the coal production and the stable national economy and healthy development of the enterprise.

2. **Vector Auto-Regression Model.** Because the price of coal and coal supply and demand quantity are two-way interaction, the relationship between supply and demand fluctuations in coal prices will stimulate the change of the quantity, and adversely affects the quantity of coal supply and demand in coal prices, leading to fluctuations in coal prices. VAR model has a good application characteristic, variance decomposition and impulse response based on VAR model should function on the one hand, to analyze the

random disturbance variables for the research of dynamic impact, on the other hand can dynamically explain related sequence, explain various policy changes and economic change of target dynamic effect of economic variables. The following is a general form of the VAR (p) model:

$$y_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \cdots + \Phi_p y_{t-p} + Hx_t + \varepsilon_t \quad t = 1, 2, \ldots, T$$

2.1. **Unit root test.** Because the time series is studied in this paper, in order to avoid spurious regression, the first for each variable stationary test, only a smooth variable VAR model equations OLS estimates in order to obtain consistency estimated parameters. In this paper, the Augmented Dickey Fuller test (ADF) is conducted for stationary test of time-series data, and determines the number of lags according to the Akaike Information Criterion (AIC). ADF test is completed by the following three models (no intercept and trend, intercept, intercept and trend):

$$\Delta y_t = \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

$$\Delta y_t = \alpha + \beta t + \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

2.2. **Construction of the VAR model.** Due to that the VAR model did not impose zero constraints to parameters and model parameters of the OLS estimators have consistency, only and need to estimate the parameters of the quite a lot, in this paper, for example, parameters reach $Kn^2 = 18$ (where K means lag, n for variable number). Therefore, whether to estimate model parameters have significant, will be retained in the model, which makes the explanation of a single parameter estimates of economic significance is difficult, so we estimate the results of the model are studied and practical significance. Associated with VAR model, impulse response function can capture the impact of one variable to another variable dynamic impact path, and overall reaction on the dynamic relationship between various variables, through the analysis of impulse response function of information to understand the connotation of the VAR model. To prevent the VAR model due to the order of the exchange between variables for the sensitivity of the response function, avoid orthogonal response variables in the order of dependence, we use the test of any relationship between two variables respectively general shock response, the method of separate building $\ln Y$ and $D \ln X_1$, $\ln Y$ and $D \ln X_2$ their VAR model is analyzed. Y represents the price of coal, the X_1, X_2, respectively denote the coal supply and demand quantity, in order to overcome the data in the heteroscedasticity phenomena, natural logarithm is adopted to establish the VAR model. Natural logarithm is defined as follows: $\ln Y = \log(Y)$, $\ln X_1 = \log(X_1)$, ...

2.3. **Impulse response function.** Impulse response function reaction is one of the endogenous variables in the VAR of the impact to the rest of the endogenous variable effects. Impulse response function and variance decomposition difference between, it is important impact evaluation of different structure systems by analyzing the contribution, and the contribution of each structure impacts other endogenous variable transformation. However, for simplicity in this paper, the influence relationship between variables, impulse response function is slightly careful again. Therefore, Sims proposes and defines the RVC

(that is, the relative variance contribution rate):

$$RVC_{j\to i}(s)=\frac{\sum_{q=0}^{s-1}\left(c_{ij}^{(q)}\right)^2\sigma_{jj}}{\mathrm{var}(y_{it})}=\frac{\sum_{q=0}^{s-1}\left(c_{ij}^{(q)}\right)^2\sigma_{jj}}{\sum_{j=1}^{k}\left\{\sum_{q=0}^{s-1}\left(c_{ij}^{(q)}\right)^2\sigma_{jj}\right\}},\quad i,j=1,2,\ldots,k$$

$RVC_{j\to i}(s)$ is considered the first j variable for the role of the ith variable is not obvious; on the contrary, $RVC_{j\to i}(s)$ in the said j variables affecting the variable i effect is remarkable. By analyzing the production and the relative contribution of the consumption of coal prices could quantitatively and relatively rough to grasp the influence of the relationship between variables. RVC (relative to the variance contribution rate) is based on the results of impulse response analysis which found the reason to analyze $D\ln X_1$, $D\ln X_2$ contribution rate of coal prices.

3. Empirical Study.

3.1. Data sources.

Articles as supply with coal production value, the value of coal consumption as demand, select the value of 1985-2011 as the research sample, the China statistical yearbook numerical shall prevail. The price of coal (Y), the output of coal (X_1), coal sales (X_2); Y is the dependent variable, the rest are independent variables. In order to overcome the data dimension and heteroscedasticity phenomena and to improve the stability of the data regularity, natural logarithm is adopted to establish the VAR model. Natural logarithm is defined as follows: $\ln Y=\log(Y)$, $\ln X_1=\log(X_1)$, ... Build a more concise and practical price of coal and coal production, coal sales between the VAR model.

3.2. Empirical study.

Before the VAR model is set up by study of the first variable, implementing stationarity test ADF test results are shown in Table 1.

Table 1. ADF test results

variable	ADF test value	5% critical value	conclusion
$\ln Y$	-3.738824	-3.595026	stationary
$\ln X_1$	-1.275454	-3.595026	non-stationary
$D(\ln X_1)$	-5.927988	-3.603202	stationary
$\ln X_2$	-0.721474	-3.233456	non-stationary
$D(\ln X_2)$	-3.351843	-2.986225	stationary

The results show that the time series of $\ln Y$ is smooth, $\ln X_1$, $\ln X_2$ after first order difference time series into a smooth, namely $\ln X_1$, $\ln X_2$ are first-order single whole I (1). VAR (2) all the reciprocal of the roots of characteristic polynomial are in unit circle, namely model to meet the stability conditions, so the results of variance decomposition and impulse response function are effective, as shown in Figure 1.

Build the lag of 2, variable vector autoregressive model number is 3:

$$D_t=c+\Gamma_1 D_{t-1}+\Gamma_2 D_{t-2}+\mu_t,\quad D_{t-1}=(\ln Y_{t-1},\ln X_{1t-1},D\ln X_{2t-1})^T$$

$$D_{t-2}=(\ln Y_{t-2},\ln X_{1t-2},D\ln X_{2t-2})^T$$

$c=(c_1,c_2,c_3)^T$, $\mu_t=(\mu_{1t},\mu_{2t},\mu_{3t})^T$, Γ_1, Γ_2 are matrces of 3×3, and $\mu_{it}\sim i.j.d.N(0,\sigma^2)$; $i=1,2,3$; $\mathrm{Cov}(\mu_{it},\mu_{jt})=0$ $(i\neq j)$, $i=1,2,3$.

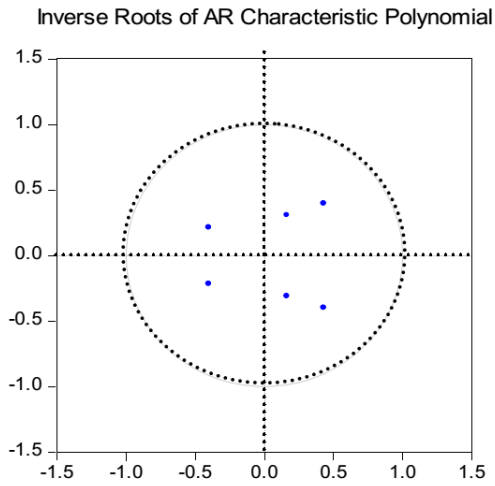

FIGURE 1. VAR model stationary test

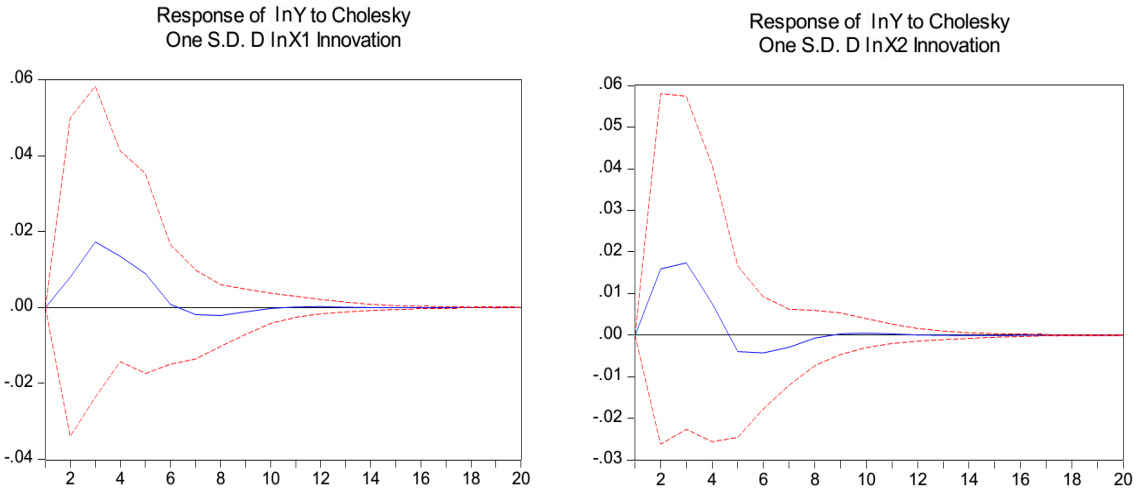

FIGURE 2. Impulse response function

Later it concluded that the parameter estimation of regression results are expressed as matrix form

$$\begin{bmatrix} \ln Y_t \\ D\ln X_{1t} \\ D\ln X_{2t} \end{bmatrix} = \begin{bmatrix} 2.923725 \\ -2.358162 \\ 14.66512 \end{bmatrix} + \begin{bmatrix} 0.300482 & 1.580012 & -0.010358 & 0.269164 & 0.258204 & 0.091573 & 0.621829 \\ 0.701006 & 0.599728 & -0.004064 & 1.000079 & -0.044578 & 0.521775 & 0.029947 \\ -0.797584 & -3.007556 & -1.198907 & -8.919948 & -0.664362 & -1.827572 & -0.349518 \end{bmatrix} \begin{bmatrix} \ln Y_{t-1} \\ D\ln X_{1t-1} \\ D\ln X_{2t-1} \end{bmatrix} + \begin{bmatrix} -0.422125 & -0.637235 & -0.088309 & -0.039857 & 0.222353 & -0.410809 & 0.009525 \\ 0.202044 & -0.151702 & -0.264407 & 0.528178 & -0.114520 & 0.377472 & -0.696709 \\ 2.394474 & -0.807647 & -0.186774 & -5.911819 & 1.283099 & 0.723101 & -0.229592 \end{bmatrix} \begin{bmatrix} \ln Y_{t-2} \\ D\ln X_{1t-2} \\ D\ln X_{2t-2} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \end{bmatrix}$$

$R^2 = 0.858841$, $\bar{R}^2 = 0.853434$, explain model of goodness of fit is good, the coal production, coal consumption has a significant influence on the price of coal.

From Figure 2, the following conclusions are got: (1) the current $D\ln X_1$ to a unit is shock, coal prices fluctuate $\ln Y$ jointly with the direction, then increase gradually; the highest point in the third period reached 0.017323, then dropped gradually, to 10 after performance is basically stable and always keeps a positive response. Visible, coal

production affects the price of coal more directly and quickly, lag period is relatively short; (2) a unit for $D\ln X_2$ is after shock, $\ln Y$ fluctuates in conjunction with the direction, then increases gradually, the highest point in the third period reached 0.017402, and then gradually retreated, 8 after basically stable performance. It indicates that the coal consumption to directly compare the effects of coal price, quickly.

Table 2. ADF test results

Period	S.E.	$\ln Y$	$D\ln X_1$	$D\ln X_2$
1	0.094774	100.0000	0.000000	0.000000
2	0.098475	96.71944	0.662655	2.617908
3	0.102009	91.14865	3.501381	5.349972
4	0.103488	89.14259	5.107090	5.750316
5	0.104017	88.37240	5.792575	5.835025
6	0.104108	88.22141	5.788881	5.989704
7	0.104177	88.13045	5.812213	6.057338
8	0.104209	88.09339	5.848942	6.057667
9	0.104218	88.08296	5.859282	6.057763
10	0.104219	88.08053	5.859507	6.059961

The contribution of analysis $D\ln X_1$, $D\ln X_2$ for coal prices. As can be seen from Table 2, $\ln Y$ is with lag influence on itself weight maintained at about 88%; after 8 period, it has $88\% \sim 100\%$ of explanation. The influence of $D\ln X_2$ weights 5.85% of rapid growth from 0 to 8, and maintained at about 5.85%, having 8 $0 \sim 5.85\%$ fluctuations explanation. $0 \sim 6.06\%$ fluctuations explanation comes from the coal consumption. These variables are the important factors that affect the price of coal, and the proportion of coal consumption is slightly greater than the proportion of coal production. The principal cause of this phenomenon is the overbuilding in the coal market in China; the market demand for coal prices is mainly determined by demand.

4. **Conclusions.** In this paper, through the establishment of the VAR model, variance decomposition and impulse response function price of coal and coal production, coal consumption is discussed; the correlation degree between the correlation study the following conclusions and recommendations show: when we research the price of coal, we must want to consider supply and demand quantity, and it is also the price to predict the main idea, with the increase of coal supply and demand quantity, the price of coal will grow. Through the research of the relationship between the two, it can be used to know the coal production, and provide reference for enterprise production and development of national economy.

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