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Analysis on the Relationship Between Coal Production and Coal Demand in Downstream Industries in Shanxi Province

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Abstract

Raw coal production is closely related to downstream demand, and it is crucial to grasp the relationship between downstream demand changes and changes in raw coal production. This quantitative relationship is not only an academic study, but also has practical significance for government management and enterprise production. In view of this, the relationship between raw coal production and downstream demand is studied through the systematic understanding of the current research status at home and abroad, and the relationship between raw coal production and downstream demand is studied through a combination of econometric model and Eviews analysis, qualitative and quantitative analysis. Data is obtained through official channels. Model the variables to obtain quantitative relationships. The final model was obtained by using the modified test of multicollinearity and serial correlation.

Keywords: coal industries in Shanxi Province, production and demand, econometric model

1. Introduction to the Study Object

1.1 Research Background

According to the data of the statistical annual report of Shanxi Province, the coal production in Shanxi Province reached a total of 832 million tons by the end of 2016. Since 2010, the coal production in Shanxi Province has shown a year-on-year rising trend. Especially, after the integration of coal resources in the province and the continuous mergers and reorganization of coal enterprises, the coal production in Shanxi Province, has undergone a qualitative change, and has been approaching 1 billion tons. In 2016, the total number of mines in Shanxi Province exceeded 450, and in the next 5 to 10 years, the coal production overcapacity will be eased to a certain extent as the construction of new mines will no longer be approved despite escalating coal production in Shanxi province. At the same time, with the continuous popularization of coal mining mechanization, the coal production in Shanxi Province has increased significantly, and under such environment, some mines with depleted resources will be gradually closed. Nevertheless, according to the "resource curse" theory in economics, countries or regions with abundant natural resources are prone to lose the impetus for change and innovation due to excessive dependence on natural resources, and are locked in a state of unfree and underdevelopment (Dong Q., 2005). Therefore, in today's macro context of sustainable social and economic development, it is particularly important of Shanxi Province to deeply study the coal economy develops efficiently. The basis of efficient development of coal economy is to clarify the contribution of downstream demand variables to raw coal output.

1.2 Theoretical Analysis

Coal is the pillar industry of Shanxi Province and plays a large role in its economic growth. To analyze the coal demand of Shanxi Province, an econometric model is required. The following variables are proposed by referring to relevant literature and taking into account the actual situation of Shanxi economy.

(1) Raw coal output

(2) Power output

(3) Coke output

(4) Steel output

2. Modeling of Time-series Data

2.1 Selection of Variables and Data

2.1.1 Introduction to Variables

(1) Raw coal production in Shanxi Province during the year

(2) Power output in Shanxi Province during the year

(3) Coke production in Shanxi Province during the year

(4) Steel production in Shanxi Province during the year

2.1.2 Sample Selection and Data

Table 1.

Year	Raw coal output (10,000 tons)	Power output (10,000 kWh)	Coke (10,000 tons)	Steel (10,000 tons)
2000	25152	624	4967	473
2001	27600	710.32	4988	607
2002	36762	842	5852	770
2003	45232	953.64	9747	997
2004	51495	1078.99	6805	1294
2005	55426	1316.5	7150	1654
2006	58142	1526.4	8775	1949
2007	63021	1760.5	9723	2503
2008	65577	1793.78	8144	2351
2009	61535	1873.8	7705.83	2648.49
2010	74096	2150.56	8502.1	3048.82
2011	87228	2344	9047.91	3490.42
2012	91333	2534.99	8612.66	3950.17
2013	92167	2641.1	9022.4	4671.44
2014	92794	2647.04	8765.9	4325.39
2015	96680	2457.45	8039.88	3846.96
2016	83044	2510.51	8185.99	4429.20
2017	87221	2765.53	8383.14	4335.4
2018	92634	3087.63	9256.16	4903.3

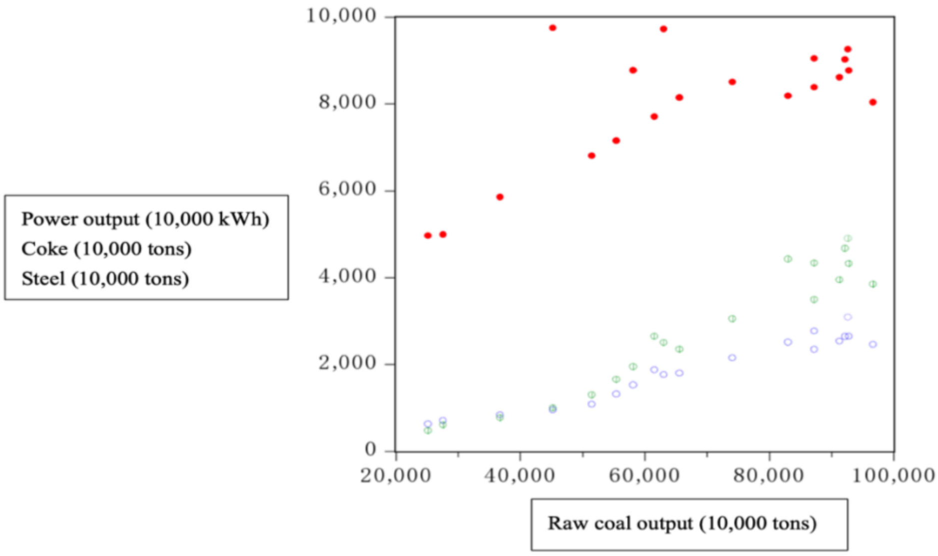

Figure 1.

3. Estimated Results of the Model

3.1 Parameter Setting and Significance of the Model

$$ln(raw\ \widehat{coal\ output_t}) = \beta_0 + \beta_1 ln(power\ output_t) + \beta_2 ln(coke\ output_t) + \beta_3 ln(steel\ output_t) + \mu$$

In the above model:

β_0 measures intercept, but the intercept itself has no real economic significance

β_1 measures the percent change in raw coal output in Shanxi Province for a 1% change in power generation in Shanxi Province

β_2 measures the percent change in raw coal output in Shanxi Province for a 1% change in coke production in Shanxi Province

β_3 measures the relative amount of raw coal output in Shanxi Province when steel production in Shanxi Province changes by 1%

μ refers to random error item

3.2 Least Squares Estimation Model

Table 2.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 19:13
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.389807	1.604723	3.358714	0.0043
LNX1	-0.047577	0.443658	-0.107238	0.9160
LNX2	0.207303	0.144894	1.430725	0.1730
LNX3	0.539047	0.308309	1.748397	0.1008

R-squared	0.971272	Mean dependent var	11.05276
Adjusted R-squared	0.965526	S.D. dependent var	0.412903
S.E. of regression	0.076665	Akaike info criterion	-2.114092
Sum squared resid	0.088162	Schwarz criterion	-1.915263
Log likelihood	24.08387	Hannan-Quinn criter.	-2.080442
F-statistic	169.0436	Durbin-Watson stat	1.844321
Prob(F-statistic)	0.000000		

Adjusted as: $$\widehat{ln(raw\ coal\ output_t)} = \beta_0 + \beta_1 ln(power\ output_t) + \beta_2 ln(coke\ output_t) + \beta_3 \ln(\text{steel output}_t)$$

(3.358) (-0.107) (1.430) (1.748)

R^2=0.9712 Adjust R^2=0.9655 F=169.0436 D.W.=1.844321

In the above equation, the values in parentheses are t-test values. From the data of the regression equation, it can be seen that this regression equation has a strong explanatory power for the raw coal production in Shanxi Province, i.e., 97.12% of the raw coal production can be explained from this regression equation. Taking the significance level of 0.1, i.e., the confidence interval is 90%, and since the F-test value of the model is greater than the threshold, the significance of the regression equation is considered to hold and the goodness of fit is fairly good. By analyzing the t-test value, we can conclude that, at a given significance level, steel production and coke production have a significant impact on the GNP of Shanxi Province, while power output has no significant impact on the GNP of Shanxi Province.

4. Multicollinearity

4.1 Multicollinearity Test for Simple Correlation Coefficient

4.1.1 Evidence of Partial Correlation Coefficient

In the model obtained by using the least squares regression, R^2 is larger and close to 1, and **F=169.0436**, which is greater than the threshold of the F statistic at the 5% significance level. Therefore, the logarithm of raw coal output in Shanxi Province has a significant overall linear relationship with the above explanatory variables. However, since one of the LNX1 parameters failed the t-test, thus it is concluded that there is multicollinearity between the explanatory variables. Correlation of Covariance Analysis was further selected to obtain the matrix of bias correlation coefficients between the variables and to the bias correlation coefficients.

Table 3.

	LNY	LNX1	LNX2	LNX3
LNY	1.000000	0.978426	0.804758	0.983373
LNX1	0.978426	1.000000	0.763053	0.996510
LNX2	0.804758	0.763053	1.000000	0.776721
LNX3	0.983373	0.996510	0.776721	1.000000

It can be found that the correlation coefficients of lnX1 and lnX1 are both above 0.9, but the regression coefficients of X1 and X2 in the explanatory variables of the output results fail the significance test. It is considered that there is multicollinearity between the explanatory variables.

4.1.2 Eliminating Multicollinearity by Running a Stepwise Regression

The regression analysis of Ln(Y_t) on lnX1, lnX2, and lnX3, respectively, was made as follows.

Table 4.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 19:50
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.033406	0.308919	16.29359	0.0000
LNX1	0.809839	0.041473	19.52671	0.0000

R-squared	0.957318	Mean dependent var	11.05276
Adjusted R-squared	0.954807	S.D. dependent var	0.412903
S.E. of regression	0.087777	Akaike info criterion	-1.928723
Sum squared resid	0.130983	Schwarz criterion	-1.829309
Log likelihood	20.32287	Hannan-Quinn criter.	-1.911899
F-statistic	381.2925	Durbin-Watson stat	0.876235
Prob(F-statistic)	0.000000		

Table 5.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 19:50
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.665383	2.633687	-1.391731	0.1819
LNX2	1.641334	0.293632	5.589766	0.0000

R-squared	0.647635	Mean dependent var	11.05276
Adjusted R-squared	0.626908	S.D. dependent var	0.412903
S.E. of regression	0.252206	Akaike info criterion	0.182161
Sum squared resid	1.081335	Schwarz criterion	0.281576
Log likelihood	0.269471	Hannan-Quinn criter.	0.198986
F-statistic	31.24548	Durbin-Watson stat	1.135912
Prob(F-statistic)	0.000033		

Table 6.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 19:52
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.801430	0.191232	35.56630	0.0000
LNX3	0.551192	0.024687	22.32704	0.0000

R-squared	0.967022	Mean dependent var	11.05276
Adjusted R-squared	0.965082	S.D. dependent var	0.412903
S.E. of regression	0.077156	Akaike info criterion	-2.186668
Sum squared resid	0.101202	Schwarz criterion	-2.087253
Log likelihood	22.77335	Hannan-Quinn criter.	-2.169843
F-statistic	498.4968	Durbin-Watson stat	1.569626
Prob(F-statistic)	0.000000		

The results of the Eviews analysis were used to determine the explanatory variables to be included in the model by the size of, i.e., lnX1, lnX2, and lnX3 were determined by paying attention to the results of their t-tests when each explanatory variable was added to decide whether to exclude them or not, and then resolved specifically based on the analysis of the model.

(1) After adding lnX1 explanatory variable to the initial model, the fit was good and the lnX1 parameter passed the t-statistical test.

Table 7.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 19:50
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.033406	0.308919	16.29359	0.0000
LNX1	0.809839	0.041473	19.52671	0.0000

R-squared	0.957318	Mean dependent var	11.05276
Adjusted R-squared	0.954807	S.D. dependent var	0.412903
S.E. of regression	0.087777	Akaike info criterion	-1.928723
Sum squared resid	0.130983	Schwarz criterion	-1.829309
Log likelihood	20.32287	Hannan-Quinn criter.	-1.911899
F-statistic	381.2925	Durbin-Watson stat	0.876235
Prob(F-statistic)	0.000000		

(2) The goodness of fit improves when the X2 was introduced, and X2 passed the significance test.

Table 8.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 20:11
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.140516	1.019005	3.081944	0.0071
LNX1	0.721899	0.059537	12.12530	0.0000
LNX2	0.283983	0.146705	1.935741	0.0708

R-squared	0.965417	Mean dependent var	11.05276
Adjusted R-squared	0.961094	S.D. dependent var	0.412903
S.E. of regression	0.081443	Akaike info criterion	-2.033878
Sum squared resid	0.106128	Schwarz criterion	-1.884756
Log likelihood	22.32184	Hannan-Quinn criter.	-2.008640
F-statistic	223.3270	Durbin-Watson stat	1.219503
Prob(F-statistic)	0.000000		

(3) X2 was removed and the fitting degree was slightly improved when introducing the X3 model, but lnX1 failed the t-test.

Table 9.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 20:14
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.202115	1.016909	7.082360	0.0000
LNX1	-0.179855	0.447889	-0.401562	0.6933
LNX3	0.672564	0.303308	2.217426	0.0414

R-squared	0.967351	Mean dependent var	11.05276
Adjusted R-squared	0.963270	S.D. dependent var	0.412903
S.E. of regression	0.079133	Akaike info criterion	-2.091433
Sum squared resid	0.100193	Schwarz criterion	-1.942311
Log likelihood	22.86861	Hannan-Quinn criter.	-2.066195
F-statistic	237.0316	Durbin-Watson stat	1.760490
Prob(F-statistic)	0.000000		

Through the above test, it can be concluded that the correlation between the X2 coke output and the X3 steel output is very high. This is because coke is a raw material for steelmaking based on the actual condition in China. However, considering that the regression coefficient of X3 is not significant and fails the t-statistical test, we finally remove the X3 explanatory variable by stepwise regression to obtain the following final model:

Table 10.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 20:11
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.140516	1.019005	3.081944	0.0071
LNX1	0.721899	0.059537	12.12530	0.0000
LNX2	0.283983	0.146705	1.935741	0.0708

R-squared	0.965417	Mean dependent var	11.05276
Adjusted R-squared	0.961094	S.D. dependent var	0.412903
S.E. of regression	0.081443	Akaike info criterion	-2.033878
Sum squared resid	0.106128	Schwarz criterion	-1.884756
Log likelihood	22.32184	Hannan-Quinn criter.	-2.008640
F-statistic	223.3270	Durbin-Watson stat	1.219503
Prob(F-statistic)	0.000000		

$$\boldsymbol{ln(raw\ \widehat{coal\ output_t}) = 3.140 + 0.722\ ln(power\ output_t) + 0.284 ln(coke\ output_t)}$$

(3.082) **(12.125)** **(1.936)**

R^2=0.9654 **Adjust R^2=0.9610** **F=223.3270** **D.W.=1.219503**

5. Serial Correlation

Table 11.

Dependent Variable: LNY
Method: Least Squares
Date: 06/14/20 Time: 11:08
Sample: 2000 2018
Included observations: 19

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNX1	0.721899	0.059537	12.12530	0.0000
LNX2	0.283983	0.146705	1.935741	0.0708
C	3.140516	1.019005	3.081944	0.0071

R-squared	0.965417	Mean dependent var	11.05276
Adjusted R-squared	0.961094	S.D. dependent var	0.412903
S.E. of regression	0.081443	Akaike info criterion	-2.033878
Sum squared resid	0.106128	Schwarz criterion	-1.884756
Log likelihood	22.32184	Hannan-Quinn criter.	-2.008640
F-statistic	223.3270	Durbin-Watson stat	1.219503
Prob(F-statistic)	0.000000		

Because the Durbin-Watson stat value is 1.219503, the D.W. value is greater than DL and less than DU after checking the D.W. test table, so the autocorrelation cannot be determined and the LM test is needed.

Table 12.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.982651	Prob. F(1,15)	0.1795
Obs*R-squared	2.218167	Prob. Chi-Square(1)	0.1364

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/11/20 Time: 20:43
Sample: 2000 2018
Included observations: 19
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.198495	0.999080	0.198678	0.8452
LNX1	0.002372	0.057813	0.041033	0.9678
LNX2	-0.024312	0.143441	-0.169491	0.8677
RESID(-1)	0.363679	0.258283	1.408066	0.1795

R-squared	0.116746	Mean dependent var	-4.25E-16
Adjusted R-squared	-0.059905	S.D. dependent var	0.076786
S.E. of regression	0.079052	Akaike info criterion	-2.052757
Sum squared resid	0.093738	Schwarz criterion	-1.853927
Log likelihood	23.50119	Hannan-Quinn criter.	-2.019107
F-statistic	0.660884	Durbin-Watson stat	1.716819
Prob(F-statistic)	0.588775		

Because the p-values of lnX1 and lnX2 are greater than 0.05, but F is less than the threshold, the linear relationship is not significant, NW correction is applied!

6. Final Model Results and Description

6.1 Final Model Results Obtained After Correction

Table 13.

Dependent Variable: LNY
Method: Least Squares
Date: 06/11/20 Time: 21:28
Sample: 2000 2018
Included observations: 19
Weighting series: 1/ABS(RESID)
Weight type: Inverse standard deviation (EViews default scaling)
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 3.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.512707	0.554159	4.534266	0.0003
LNX1	0.691621	0.025086	27.57027	0.0000
LNX2	0.377015	0.060552	6.226259	0.0000

Weighted Statistics

R-squared	0.984071	Mean dependent var	52.72859
Adjusted R-squared	0.982079	S.D. dependent var	127.0509
S.E. of regression	0.042735	Akaike info criterion	-3.323665
Sum squared resid	0.029220	Schwarz criterion	-3.174543
Log likelihood	34.57482	Hannan-Quinn criter.	-3.298428
F-statistic	494.2176	Durbin-Watson stat	1.096180
Prob(F-statistic)	0.000000	Weighted mean dep.	11.11424
Wald F-statistic	429.7294	Prob(Wald F-statistic)	0.000000

Unweighted Statistics

R-squared	0.962397	Mean dependent var	11.05276
Adjusted R-squared	0.957696	S.D. dependent var	0.412903
S.E. of regression	0.084925	Sum squared resid	0.115397
Durbin-Watson stat	1.308651		

Final Model:

$$\boldsymbol{ln(\widehat{raw\ coal\ output_t}) = 2.513 + 0.692\ ln(power\ output_t) + 0.377\ ln(coke\ output_t)}$$

6.2 Test of Economic Significance of the Model

The coefficients of LnX1 and LnX1 are positive, indicating that the power output in Shanxi Province and coke output in Shanxi Province have a significant positive effect on the raw coal production in Shanxi Province. That is, for every 1% increase in the power output in Shanxi province, the raw coal production in Shanxi province increases by 0.692%; for every 1% increase in coke demand in Shanxi province, the raw coal production in Shanxi province increases by 0.377%.

6.3 Statistical Tests

R^2=0.9623, Adjust R^2=0.9576, the model fits well. The significance tests of the coefficients of both LnX1 and LnX2 pass the test at the given significance level of 0.05. The t-value test indicates that the effects of these variables on savings deposits are significant at the given level of significance. **F=494.2176**, and the probability value of F-test is 0, which indicates that the effect of these variables jointly on raw coal production in Shanxi province is significant.

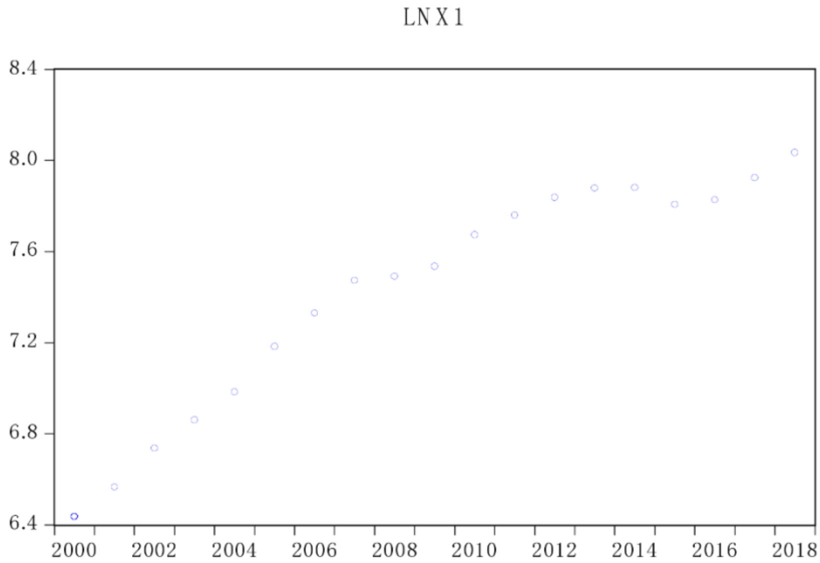

Figure 2.

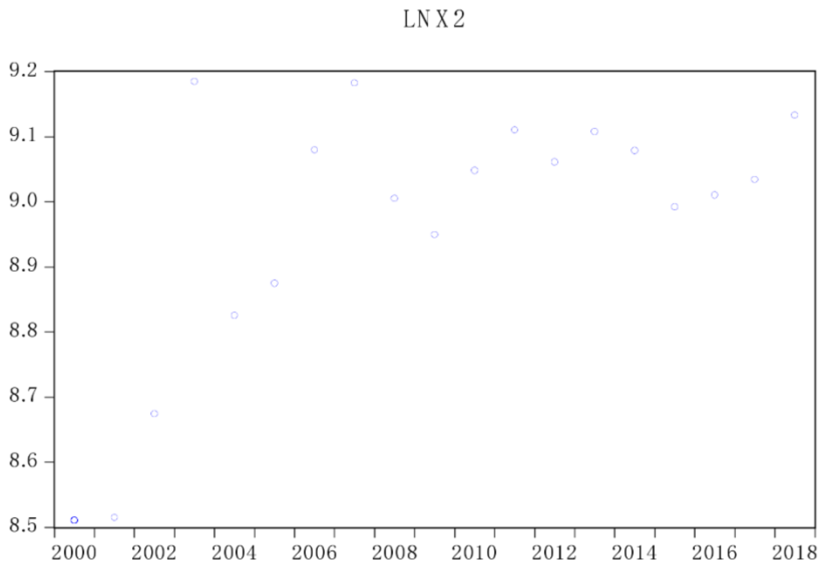

Figure 3.

7. Conclusion and Outlook

The total power output and coke output in Shanxi Province have a significant positive effect on the raw coal production in Shanxi Province. **For every 1% increase in power output in Shanxi Province, the raw coal production in Shanxi Province increases by 0.692%; for every 1% increase in coke demand in Shanxi Province, the raw coal production in Shanxi Province increases by 0.377%.**

Due to the reduction in coal demand and overcapacity, the price does not rise but falls; the abolition of the dual-track system of electricity and coal prices makes some power plants resist the market coal prices, restricting the growth of coal prices; the increase in coal operating costs, including logistics and transportation costs (especially in Shanxi, where coal production capacity is concentrated), coal resource taxes, labor costs, safety production inputs and environmental management, and other factors. Due to these reasons, the rise in coal prices has been greatly reduced, coupled with the continuous increase in costs, which have seriously reduced the profits of coal production enterprises and affected economic development. Shanxi's economic growth is more dependent on the development and utilization of coal resources, and it cannot be separated from the utilization of coal in the short term, and it seems that it will gradually improve in the long run. Therefore, in the short term, Shanxi Province should improve coal exploration, mining and clean coal technology, save coal resources, eliminate low-capacity and high-polluting enterprises, and rationally plan the development and utilization of coal; In the long run, it is necessary to develop and utilize a variety of renewable energy sources, completely change the thinking of economic development, and realize the optimization and grading of the structure of production and industry (Zhang J., 2013).

In light of the reality, the coal industry is still the pillar industry of Shanxi, and the development of the coal economy plays a pivotal role in the economic growth of Shanxi. Such phenomenon is difficult to change in the short term, but the contribution rate of coal to the economic growth of Shanxi is decreasing year by year, which also indicates that the dependence of Shanxi Province's economic growth on coal is gradually reducing. This is also the inflection point of economic transformation in Shanxi Province. From the perspective of Shanxi Province, the rise in the price of coal resources in recent years has brought new opportunities to the development of Shanxi's economy, how to make the opportunities into reality, especially to make Shanxi's per capita GDP produce both qualitative and quantitative changes, then changing the mode of economic growth and developing a circular economy will be the only way (Zhang J., 2013).

The specific measures are as follows: First, we must vigorously punish enterprises with poor safety, low production capacity and serious environmental pollution, and gradually eliminate coal enterprises with backward technology, poor product quality, serious waste of resources and severe pollution; Second, we must mainly improve the utilization rate of coal resources, and formulate a reasonable and scientific coal mining plan. Coal resources are non-renewable resources and the energy basis for human development. Therefore, we should continuously improve the technological level of coal exploration, introduce more advanced high-tech mining technology and equipment, improve the mining rate of coal resources, and expand the total amount of available coal resources from the source; Third, we must pay attention to the coordinated development of the coal economy and the environment, introduce clean coal technologies such as advanced coal mining, processing and utilization technologies, fully digest waste in production and utilization, and embark on the road of green development.

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