Research on correlation between R&D investment and coal price in Coal Enterprises

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Abstract

Coal price reflect changes of the coal industry's supply and demand ,It not only reflects the current development of the industry,but also the core of scientific production in core enterprise.By domestic and international environment for economic development and environmental pressures since 2012,own overcapacity and weak demand impact.China's coal prices, coal overcapacity, coal enterprises have a large area of loss.Undeniable ,in this stage the coal resources are our main resource, both in the development of the national economy and national resource strategy plays an important role.Faced with this situation, the coal enterprises need to strengthen scientific and technological innovation and transformation development, therefore, the purpose is clearly the linear correlation coefficient of the coal prices fluctuations and coal R & D investment .under different coal prices,the enterprise should make reasonable adjustments of the coal price? The R&D input and the average coal price of China's coal industry in the past 1995-2016 years are tested by EViews software, ointegration test and Grainger causality test show that the coal price fluctuation has a long-term co integration relationship with the R&D investment in coal industry. And the fluctuation of coal price is the Grainger reason of R&D investment in coal industry, that is to say, the fluctuation of coal price will affect the investment of R&D in coal industry.

Keywords

Coal price R&D input, Cointegration test, Granger test.

1. Introduction

China is a big coal country. In a long period of time, coal will also be the main source of energy and important industrial raw materials in China. However, since 2012, the coal market has entered the most vulnerable period in the past ten years. The Chinese coal industry ended "golden ten years" into the "cold winter" period. The situation of oversupply in the national coal market is difficult to change in the short term, and the whole industry of the coal industry is facing major adjustment. In 2014 the government proposed China "in 2020 with a total energy consumption control in 48 tons of standard coal, the total coal consumption control at 42 tonnes," "2020 non fossil energy in primary energy consumption to 15%" at the same time, according to the "energy development strategy and action plan (2014-2020 years)" to the proportion of coal in 2020 the primary energy consumption in China will fall to around 62%, the domestic coal consumption and demand will continue to drop, so the coal price decline will not be contained, in addition to the needs of environment. It means that the future development of the coal industry is focused on the deep processing of coal and clean energy based on reform and innovation and technological progress.

According to the 2016 State Council issued the "national innovation driven development strategy outline", the national development and Reform Commission, the National Energy Board issued the 2016-2030 energy technology revolution innovation action plan and focus on innovation of energy technology revolution action roadmap of China's energy industry the next stage of development of the overall goal is to 2020 energy significantly enhance the capability of independent innovation, significantly enhance the international the competitiveness of China's energy industry, energy technology innovation system is formed; by 2030, the completion and adapt to the situation of energy

technology innovation system more perfect, to enhance the capability of independent innovation of energy technology, energy innovation overall level has reached the international advanced level, to promote the sustainable development of energy industry and the ecological environment of our country, which occupies a space for one person in the ranks the world energy power technology.

In the face of such a severe market environment and the overall strategy of national energy development, the transformation and development of the coal industry is very necessary. The key to successfully accomplish the transformation of industry is technological drive, that is, innovation investment and R&D transformation. That is to say, R&D innovation input is the core of transformation and development. So, in order to cope with the development trend of the coal market downturn, the promotion of coal listed companies profit, to ensure the development of production, this paper tries to explore the relationship between R&D investment fluctuations in coal prices and coal industry, to the conclusion of the coal industry R&D to provide relevant suggestions.

2. Literature review

In 1930s, Hicks pointed out that changes in the price of production itself can stimulate inventions, and this kind of price change causes special types of inventions to save relatively expensive elements. In 1978, Swabb.L pointed out that coal liquefaction can be realized through R&D activities, and it is possible to form an industry. At the same time, it is pointed out that R&D activities in coal industry cannot be separated from government support and market adjustment. Sohei Shimada (1986) pointed out that the coal industry in Germany is facing can still maintain a certain scale of R&D investment cheap coal competition and foreign economic situation downturn, and made a breakthrough in technology, and significantly improve mining conditions, the security situation; at the same time also greatly enhance the production efficiency, a significant impact on Germany's coal industry. Tang Lili (2005) judged the coal price from the cost structure and cost components, and put forward that China's coal industry should speed up infrastructure construction, vigorously develop new coal technology and improve productivity. Lu Fangyuan and Jin Dandan (2011) found that R&D input played a significant role in promoting economic development by using data panel model. The output elasticity of R&D staff input was greater than that of R&D input. Bai Junhong, Li Jing (2011) ,Li Wu (2015) use the maximum information coefficient MIC method, found that the growth of GDP and R&D investment correlation is significant.

Through literature review, it is found that the study of coal price is basically focused on predicting the future price trend of coal and exploring the impact of coal price fluctuation, especially the rise of coal prices on the development of enterprises and economic growth. The impact of R&D input on the productivity and profitability of enterprises is limited, but the impact of coal price fluctuation on R&D input, especially the adjustment period from ten years to the "cold winter" period, is relatively limited, which provides a research direction for this paper.

3. Fluctuation of coal price and R&D investment in coal industry in China

3.1 Analysis on the fluctuation of coal price in China

Coal is the main energy source of our country. The fluctuation of its price not only has a direct influence on the development of the whole industry, but also has an important influence on the related industries (such as electricity and steel), and even indirectly affects the consumption level of the residents. In the last ten years, the supply and demand of coal market in China is unstable and the price of coal fluctuates greatly. Table 1 is the coal price fluctuation table of China in -2016 in 2006.

The above table can be seen from 2006-2008 years, because the price of oil and electricity products continues to rise, and at the same time, affected by transportation and production costs, the price of coal continues to rise in the whole country, reaching the peak at the end of 2007. A slight decline in 2008 is 08 years since the global financial crisis has a huge impact on all industries; in 2009 the national coal prices into the recovery growth state; since 2010 has been on a downward trend since the beginning of 2012, this is because of China's economic development pattern began to change,

especially after eighteen, China's economic development by focusing on speed to focus on the quality and speed of economic growth slowed, and imported coal because of the impact of domestic coal demand, coal prices decline, "ten years" to this end.

Table 1 2006-2016 year national coal price fluctuation table (unit: yuan)

Year	National coal price	Price change rate
2006	274.77	4.9%
2007	289.61	5.40%
2008	380.55	31.40%
2009	374.84	-1.50%
2010	415.7	10.90%
2011	416.9	0.29%
2012	407.81	-2.18%
2013	402.88	-1.21%
2014	401.78	-0.27%
2015	398.58	-0.80%
2016	417.5	4.7%

Table 2 2006-2016 years of national coal R&D investment and the scale of coal industry

Year	R&D investment(ten thousand yuan)	R&D investment growth rate	Industrial scale (ten thousand yuan)	Industrial scale growth rate
2006	459007	17.9%	27131857	19.8%
2007	542725	18.2%	32619103	20.2%
2008	684096	26%	48691029	49.2%
2009	441213	35.5%	58730924	20.6%
2010	1016944	130.4%	77479361	31.9%
2011	1191489	17.2%	221092700	185%
2012	1590545	33.5%	282960200	27.9%
2013	1720788	8.2%	617392100	118%
2014	1720330	0.027%	626154900	1.4%
2015	1433000	-16%	648070322	1.35%
2016	1473000	2.7%	711581213	2.0%

From the chart, we can see that the R & D expenditure in China's coal industry is increasing year by year, especially after 2003, and its growth rate has accelerated significantly, and has reached its peak in 2007-2011 years. In the three years of 2006, 2007 and 2008, the investment in R&D of coal industry increased greatly. 2009 and 2010 years, the coal industry funds of R&D decreased greatly, compared to 2008 decreased by 35%, 26%, the possible reason is from the beginning of 2003 with coal prices rose sharply, the coal industry good momentum of development in order to increase the funding of science and technology innovation investment laid the foundation conditions, and 2008 at the end of the financial crisis in the coal industry suffered a temporary setback, prompting many coal enterprises to reduce investment in science and technology research and development activities; and in the 2009-2012 period with the development of economy recovery, rising coal prices, coal enterprise R& D investment increased again. From 2012 -2014 years with the eighteen big countries held, emphasizes the transformation of economic development mode, combined with the impact of

coal industry overcapacity and falling demand for domestic goods, the price of coal has been declining trend at the same time the coal industry R&D investment once again reduced, so the domestic coal industry investment funds from R&D statistics, once again confirms the influence of coal industry science and technology innovation activities by domestic and foreign economic fluctuations, R&D investment of enterprises and the coal enterprise's profit level there is a great relationship.

3.2 Selection of variables and data processing

By reading a large number of literature on enterprise R&D input-output, different scholars study the input-output problem of innovation from different perspectives. But with the summary that measure the enterprise's innovation index as the most basic "R&D personnel" and "R&D expenditure", "R&D staff accounted for the proportion of employees" and "enterprise R&D investment intensity (enterprise R&D investment accounted for the proportion of business income)". Considering the relationship between coal prices and R&D activities in the coal industry from 1995 to 2016, the annual price is independent variable, and R&D input intensity is selected as the dependent variable.

Table 3 Variable and its meaning

Variable type	Variable name	Symbol	Meaning
dependent variable	R&D investment	RD	Total R&D input in the industry reporting period
Independent variable	Coal price	P	Coal price in the reporting period

3.3 Empirical analysis of the influence of the change of coal price on R&D investment

In order to eliminate the existence of the heteroscedasticity in the time series, the logarithms of P and RD are taken respectively, which are expressed as LNP and LNRD. The trend of the original time series and the cointegration relationship remain unchanged after the logarithm is taken.

3.3.1 Test of data smoothness

According to the theory, the test results of Table 4 are obtained by using Eviews8.0 software to test the stability of P and RD.

Table 4 Test results of data smoothness

Variable	The value of ADF	The value of P	1% critical value	5% critical value	10% critical value
lnP	-0.458	0.881	-3.788	-3.012	-2.646
lnRD	-0.403	0.891	-3.788	-3.012	-2.646
DlnP	-4.313	0.003	-3.808	-3.020	-2.650
DlnRD	-3.954	0.007	-3.808	-3.020	-2.650

From the above table, we can see that the ADF values of lnP and lnR are all less than 10% critical values under the significance level, but the P values of the two unit root tests are 0.881 and 0.891, which are all greater than 0.05, and the unit root test is not stable. The ADF test under the first order difference of the two variables showed that the ADF value of LnP and LnRD was less than the critical value of the 5% significant level and the P value was less than 0.05. It can be judged that P and RD are single order stationary and conforming to cointegration test under the probability of 95%.

3.3.2 Cointegration test

Using eviews8.0 to test the time series LnP and LnRD by EG two step cointegration test, the regression equation of lnR and LnP is first established, and the following table results are obtained.

Table 5 Cointegration test results

Variable	correlation coefficient	Standard error	The value of T	The value of P
lnP	3.4651	0.2673	12.9602	0.0000
C(Constant term)	-6.7132	1.48638	-4.5164	0.0002

The regression equation is obtained after the cointegration regression of the explanatory variable and the explanatory variable by the OLS regression method, which is the regression residual term.

$$LnRD = 3.4651 * LnP - 6.7132 + e_t \quad (1)$$

$$t = (12.9601)\ (-4.5164)$$

$$R^2=0.8935,\ S.E=0.5222,\ D\text{-}W=0.3489$$

Because the D-W statistic value (0.3489) obtained by the regression equation is less than 1, there may be autocorrelation. In order to ensure the validity of parameter significance test and avoid significant autocorrelation, the least square method is effective, while the variance and standard error are invalid. We use the Lagrange multiplier (LM test) to test the autocorrelation of the residual sequence in the regression equation and determine the order of autocorrelation.

Table 6 LM lag phase test results

		The value of P
F- statistics	26.4121	0.0001
The product of the sample value and the R2	12.7954	0.0003

Table 7 Two phase test results of LM lag

		The value of P
F- statistics	16.4112	0.0001
The product of the sample value and the R2	14.2081	0.0008

According to the test results of Langella's daily multiplier method, tables 6 and 7 show that the test results of LM lag one and two periods are 12.7954 and 14.2081, respectively. The P values are 0.0003 and 0.0008 respectively, which are less than the given 5% significant level values, and reject the null hypothesis. It is possible to determine the autocorrelation of the residual sequence estimated by the OLS regression model. It needs to be adjusted by the generalized difference, and the co integration model of long-term equilibrium is established after adjustment. As the explanatory variables and the existence of 1 cointegration equation between the variables, and there is one order and two order autocorrelation, therefore the use of EViews software, through the generalized difference estimation model was adjusted, require the addition of AR (1), AR (2) sequence of said first order and second order random errors from the regression correlation, eliminate autocorrelation after with poor long-term equilibrium sub expressions are as follows.

$$LnRD = 0.9630 * LnP - 0.1574 - 0.0641 * RA(1) + 0.2669 * RA(2) \quad (2)$$

$$t = (5.5470)\ (-2.6497)\ \ (5.2285)\ \ (-2.1513)$$

Upper middle, $R^2=0.1562$, S.E=0.2777, D-W=1.9185。

Through the above model, it can be seen that the regression standard error D-W statistics after the generalized difference is greater than 1, and the R2 of the sample is higher and the goodness of fit is higher. The values in brackets is the value of t statistic value corresponding to the calculated regression in regression equation, the associated probability values were 0.0175, 0, 0.0001, 0.0471 are less than 5% level values, the regression coefficients all through the t test, the fluctuation of prices of China's coal industry has a significant impact on R&D investment industry. That is, there is a long-term cointegration relationship between China's coal price fluctuation and R & D investment. In order to retest the existence of the autocorrelation of the sequence, the LM multiplier test for the generalized difference equation is carried out again. The results are as follows:

Table 8 LM test results for the first phase of generalized difference delay

		The value of P
F- statistics	0.7143	0.4113
The product of the sample value and the R2	0.9091	0.3403

Table 9 LM test results for two periods of generalized difference delay

		The value of P
F- statistics	0.371317	0.6964
The product of the sample value and the R2	1.007465	0.6043

According to the test results of table 8 and table 9, LM (1) = 0.7143, LM (2) = 0.3713, and the associated probabilities are 0.4113, 0.6964, which are greater than 0.05, indicating that the first order and two order autocorrelation have been eliminated. In order to check whether the residual sequence of the model is stationary after the generalized difference adjustment, we use the ADF test method to test the stationary sequence of the residual error sequence of the above generalized differential regression equation, and get the test result as shown in Table 11. The results show that the residual sequence ADF test t statistic is -4.4342, the concomitant probability P=0.0028, and less than the critical value under 5% significant levels. The assumption that the unit root exists is rejected, indicating that there is no unit root in the residual sequence and is a stationary time series. Therefore, the causal relationship described by the above regression equation is not pseudo regression, and there is a stable linear relationship between variables. That is, there is a long-term equilibrium relationship between coal price fluctuation and R&D investment in China.

Table 10 Residual sequence unit root test

		T Statistics	probability
ADF test statistics		-4.4342	0.0028
critical value	1% level	-3.8315	
	5% level	-3.0299	
	10% level	-2.6551	

3.3.3 Error correction model

The empirical variables lnP and lnRD have verified that there is a long-term equilibrium cointegration relationship and stability, in order to test may also exist between variables of certain short-term dynamic relationship, to establish the error correction model by least square method, further analysis of China's coal price fluctuations on the dynamic relationship between investment in research and development, LnP, LnRD respectively for error correction the model variables and selects lagged residuals for errors, results in the following table:

Table 11 Regression results of error correction model

Variable	coefficient	Standard error	T test statistics	The value of P
C	-0.1659	0.1157	-1.4335	0.1710
DlnP	1.7474	0.6724	2.5985	0.0194
DlnP(-1)	-1.399	0.5835	-2.3981	0.0290
E(-1)	0.1987	0.0649	3.0622	0.0074

According to the above table, it is concluded that the structure of the error correction model is as follows:

$$DLnRD = -0.1659 - 1.7474 * DLnP - 1.399 DLnP(-1) + 0.1987 * e(-1) \quad (3)$$

$$t = (\text{-}1.4335)\ \ (2.5985)\ \ (\text{-}2.3981\ \ (3.0622)$$

$$R^2=0.4175,\ S.E=0.2266,\ F=3.8229$$

The regression equation of error correction model shows that all parameters are all through F test and DW test, the result is remarkable, and the fitting degree of error correction model is better. The LnP and a LnRD growth of 1% per LnRD, corresponding decreased 1.74% and 1.39%, a period of lag error correction model of E (-1) through the significant test, estimation of the coefficient of the error correction term is an integer, and the reverse revision mechanism is consistent with that of lnRD and deviation shows that the long-term stable equilibrium value in 19.87% be amended; the ECM model reflects the short-term fluctuations of lnR affected by lnP. According to the estimated results, the

short-term elasticity of China's coal price fluctuation to industrial R&D is 1.747. The regression results show that the current fluctuation of China's coal price has a significant impact on the amount of industrial R&D input, and the effect of the previous period error on the current fluctuation is also significant. This is also in accordance with the economic significance.

3.3.4 Granger causality test

The cointegration test shows that there is a long-run cointegration relationship between R&D input and price fluctuation in coal industry, but it is not clear whether there is any causal relationship between the two inputs. We use Granger causality test to test the causation of R&D input and price fluctuation. We choose 1, 2, 3, 4, 5 and 6 periods respectively.

Table 12 Test results of the relationship between coal price fluctuation and R&D input Granger

Lag period	Price fluctuation is not the reason for R&D investment			R&D investment is not the cause of price fluctuations		
	F	P	Result	F	P	Result
1	7.99	0.01	refuse	0.82	0.37	accept
2	5.00	0.02	refuse	0.71	0.50	accept
3	7.97	0.003	refuse	0.25	0.85	accept
4	6.81	0.008	refuse	0.71	0.60	accept
5	5.75	0.02	refuse	0.84	0.52	accept
6	3.77	0.15	accept	0.40	0.84	accept

According to the test results of table 5,In the 5 period lag, Grainger lnP is not lnRD reason that passed the F test, and the P value of the significance level is less than 0.05, which reject the null hypothesis, that the coal price fluctuation is Grainger R&D investment; for the original hypothesis R&D input is not due to price fluctuations, in the lag 6 period and the P values were more than 0.05 significant level receiving original hypothesis that Grainger is not R&D input price fluctuations.

4. Conclusion

4.1 Research conclusion

Through the empirical research on the coal industry and the coal price index of coal industry R&D spending, found that there is a cointegration relationship among the two, China's coal price fluctuation per one unit, the coal industry will change the corresponding R&D expenditure of 1.75 units; in the lag of coal price volatility 5 period is Grainger R&D input. That is, the coal industry's coal price fluctuations in the 5 period will affect the industry R&D expenditure.

4.2 Policy suggestion

(1) Change ideas, attach importance to R&D activities and strengthen R&D investment.

Profit is necessary for the survival and development of the enterprise, and it is also a necessary prerequisite for the realization of its own value. Independent innovation is a necessary means to realize the profit. The conclusion of "the progress of science and technology is the source of economic growth" has been confirmed by numerous economists. From the above analysis can be seen in the lack of development of China's coal industry investment, should proceed from the long-term interests, to increase R&D investment, promote high-end original technology to achieve continuous output to improve industrial competitiveness, technological innovation and the organic combination of the market price of coal, and thus promote the growth of innovation output and industrial scale of health growth.

(2) The company's R&D activities should be adapted to market orientation and pay attention to the impact of price fluctuations on R&D input.

Through the above empirical analysis, it is found that there is a long-run cointegration relationship between coal price fluctuation and R&D input. And in the 5 lag period, price fluctuation is the Grainger reason for R&D input, but R&D investment has the characteristics of large investment and long cycle. Therefore, fluctuations in the price of coal enterprises should be carefully adjusted,

scientific research activities, should focus on cultivating the independent intellectual property rights and brand, fully tap the product innovation capabilities and value-added space, achieve new product innovation can be effective against market fluctuations, so as to maintain the company's profit growth and keep unchanged input R&D.

(3) We should pay more attention to the long-term planning of R & D investment and avoid short-term behavior.

R&D activity is an important part of business operation and production, to a certain extent, affects the market share of products. However, R&D activities are characterized by large investment and high risk. Only scientific and rigorous management of R&D activities can make it more effective. Therefore, coal companies need long-term planning before they invest in R&D, so as to avoid short-term profit seeking behavior. Can do even in the market downturn, the R&D activities into the future development of enterprise strategy, to maintain the normal operation of research and development activities, and constantly improve the level of research and development, and the research achievements of enterprises timely and quickly into the core technology of enterprise products, and continuously meet the new market demand, increase market share.

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