An Empirical Study on the Herd Effect of China's Thermal Coal Futures Market

Zhou Xuxu, Li Tiantian

School of Management, China University of Mining and Technology (Beijing), Beijing, China

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Abstract: After the listing of thermal coal futures, the futures market price can converge with the spot market price trend, and the price discovery function can be fully utilized, but the hedging function is weak, which cannot help coal-fired enterprises avoid the risks arising from price fluctuations in the spot market. Based on the assumption of bounded rationality, this paper analyzes whether the low efficiency of hedging in the thermal coal futures market is affected by the herd effect from the perspective of behavioral finance, and analyzes if the herd effect of the thermal coal futures is symmetrical through the bear market and bull market effect measurement results of China's thermal coal futures market. It is found that there is no obvious herding effect in the thermal coal futures market and there is no obvious herding effect in the falling and rising stages of market prices, that is, the trading behaviors of the bear market and the bull market are rational. Therefore, the lower hedging efficiency is not related to the investment behavior of futures investors.

1. Introduction

Power coal is mainly used in thermal power generation, industrial boiler coal, domestic heating, steam locomotive, etc., 65% for thermal power generation, 20% for building materials, and 5% for chemical industry. It is an important coal consumption product in China's coal industry. It plays a key role in stabilizing China's economic development. It is the golden decade for China's coal industry development from the year 2002 to 2012. The price of thermal coal market has risen rapidly with the vigorous development of heavy industry. During the period of that decade, the spot price of thermal coal has experienced a short-term decline due to the impact of the global financial tsunami in 2008. But at the end of 2010,the government invested 4 trillion yuan to boost domestic demand, and the price of thermal coal climbed again, rising to 850 yuan/ton in 2011. In the second half of 2011, the price of thermal coal fell.

On September 26, 2013, thermal coal futures were officially listed on the Zhengzhou Commodity Exchange, indicating that thermal coal spot trading can be hedged through the futures market to avoid price risks in the spot market. Most coal companies mainly conduct agency transactions through institutional investors. Although institutional investors have rich investment experience, Scharfstein & Stein (1990) believes that there is a difference between the investment ability of the agent investors and the market information they have mastered. If there is a mainstream investment strategy, investors would be easy to follow the trend, which can not only attribute the risk of loss to market behavior, but also maintain its reputation. The thermal coal futures are listed for a short time, and the investment strategy is not mature. The herd effect will affect the judgment of the investors and even abandon the private information that is beneficial to the investment strategy, resulting in lower hedging efficiency. This paper uses the herding effect detection method to determine whether the low efficiency of hedging in the thermal coal futures market is affected by the bounded rational investment behavior.

2. Research Methods

Christie & Huang (1995) first proposed the cross-sectional yield standard deviation (CSSD) method. Chang, Cheng & Khorana (2000) improved the method and proposed the cross-sectional absolute deviation (CSAD). Compared with the CSSD method, CSAD has higher sensitivity and

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precision. This method mainly measures the deviation between the single stock return rate and the overall market return rate. In the single-variety measurement of the futures market, it mainly measures the deviation between the rate of return on individual futures contract and the futures product. The formula of CSAD is:

$$\text{CSAD}=\frac{1}{N}\sum_{i=1}^{N}|R_{i.t}-R_{m.t}| \tag{1}$$

According to the Capital Asset Pricing Model (CAPM):

$$E(R_i)=r_0+\beta_i E_t(R_m-r_0) \tag{2}$$

r_0 refers to the risk-free return on assets; $\beta_i E_t(R_m-r_0)$ refers to the risk premium of an asset; β_i is the market risk coefficient of an asset; R_i is the expected rate of return on individual assets; R_m refers to the market rate of return on combined assets. β_m, the system risk of combined assets, can be obtained from β_i.

$$\beta_m=\frac{1}{N}\sum_{i=1}^{N}\beta_i \tag{3}$$

The absolute deviation of the expected return on the asset and the market return, AVD, is:

$$AVD_{i.t}=|E_t(R_{i.t})-E_t(R_{m.t})|=|\beta_i-\beta_m|E_t(R_m-r_0) \tag{4}$$

The expectation of the cross-sectional absolute return deviation ( ) is:

$$ECSAD_t=\frac{1}{N}\sum_{i=1}^{N}AVD_{i.t}=\frac{1}{N}\sum_{i=1}^{N}|\beta_i-\beta_m|E_t(R_m-r_0) \tag{5}$$

By performing first-order and second-order derivation of $ECSAD_t$ respectively,formulas can be obtained as follows:

$$\frac{\partial ECSAD_t}{\partial E_t(R_m)}=\frac{1}{N}\sum_{i=1}^{N}|\beta_i-\beta_m|>0 \tag{6}$$

$$\frac{\partial^2 ECSAD_t}{\partial E_t(R_m)^2}=0 \tag{7}$$

It can be concluded from the formula that CSAD and market return rate increase linearly. If there is a herding effect, the single asset return rate and the market return rate should be consistent. Then the CSAD does not show a linear increase relationship. A strong herding effect phenomenon will have a reverse trend relationship. According to this principle, the following regression model was constructed to test the existence and intensity of the herd effect.

$$CSAD_t=\alpha_0+\alpha_1|\mathrm{R}_{m,t}|+\alpha_2 R_{m,t}^2+\varepsilon_t \tag{8}$$

When measuring the herd effect in the futures market, it is mainly judged whether there is a linear relationship between the profit rate dispersion of the futures contract and the overall yield of the futures market. The coefficient α_2 of $R_{m,t}^2$ is first seen by regression, and if it is significantly zero, it should be seen whether α_1 is positive. If it is positive, it means that there is no herd effect. If it is negative, there is a herd effect. If α_2>0, then there is no obvious herding effect; if α_2<0, it means that there is a herd effect in this market.

3. Data Selection

This paper collects daily trading data of all futures contracts of Zhengzhou Commodity Exchange thermal coal futures from September 26, 2013 to October 11, 2017 from the RESST financial database. Based on the daily trading closing price and daily transaction data, the price of

the thermal coal futures market was first calculated. A unified data unit was required since the trading unit of thermal coal futures contract was changed from 200 tons/hand to 100 tons/hand on May 15, 2015,and the transaction code was changed from TC to ZC. Most of the trading prices of non-main contract in the calculation process are zero, so the non-main contracts need to be eliminated. Some of the main contracts having zero trading prices on the market and close to the delivery date also need to be excluded. The price trend of Figure 1 is obtained by plotting the calculated market price (Pm) of the thermal coal futures contract.

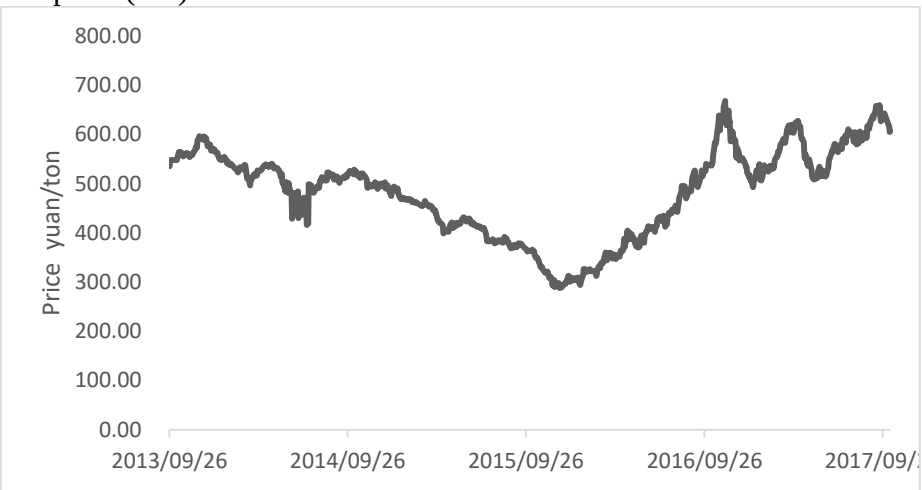

Figure 1 Price trend of thermal coal futures market

Drawings show that the thermal coal futures trading has a significant downward trend from November 26, 2013 to December 4, 2015, so it is necessary to measure the herding effect of the downward trend. There is a clear upward trend from December 7, 2015 to November 8, 2016, so it is necessary to measure the herding effect of the upward trend in this stage.

Through calculation, a total of 983 sets of effective time series data of cross-sectional absolute deviation (CSAD) and thermal coal futures market yield rate(R_m) were obtained. This paper firstly tested the herd behavior of the thermal coal futures market through the 983 sets of data, and then tested the herd behavior in the descending and rising stages respectively. The single main thermal coal futures contract measured was seclected as TC401, TC405, TC409, TC501, TC505, TC509, TC601, ZC605, ZC609, ZC710, ZC705, ZC709, ZC801, ZC805, ZC809, and the software used is Eviews9 and Excel2016. A scatter plot of the calculated cross-sectional absolute deviation (CSAD) and the thermal coal futures market yield is plotted in Figure 2:

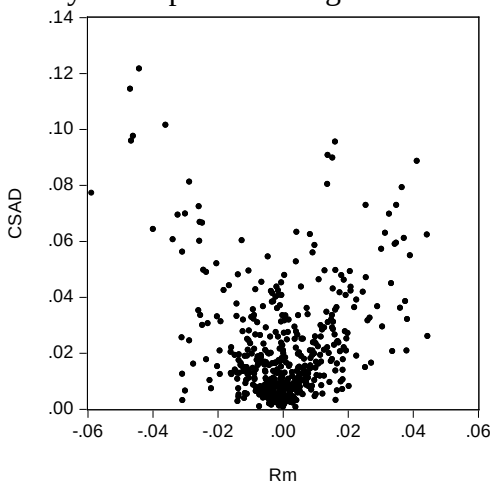

Figure 2 Cross-sectional absolute deviation CSAD and market yield R_m

It can be seen from the scatter plot that there is a certain linear relationship between the decline phase of the yield of the thermal coal futures market and CSAD, and the linear relationship of the rising phase of the yield of the thermal coal futures market is not very obvious. The following is a

regression empirical study of the two.

Table 1 Statistical Characteristics of variables in the mode

Variable	Mean	St.d	Skewness	Kurtosis	J-B test	Sample quantity
$CSAD$	0.0174	0.0317	8.4307	106.8564	453427 [0]	983
$\lvert R_{m\lvert} \rvert$	0.0106	0.0130	4.2612	38.7705	55382 [0]	983
$(R_m)^2$	0.0002	0.0012	17.6087	393.5017	6296600 [0]	983
$CSAD^{up}$	0.0170	0.0166	2.8387	15.4870	1764 [0]	225
$\lvert R_m^{up} \rvert$	0.0136	0.0119	1.0606	3.591490	45.465 [0]	225
$(R_m^{up})^2$	0.0003	0.0005	2.5377	11.1767	868.319 [0]	225
$CSAD^{down}$	0.0190	0.0418	7.0167	68.1153	91696 [0]	496
$\lvert R_m^{down} \rvert$	0.0089	0.0144	5.7809	51.6499	51676 [0]	496
$(R_m^{down})^2$	0.0002	0.0017	13.7875	227.2201	1054724 [0]	496

Note: The probability value (P value) corresponding to the value in parentheses below the JB test data

4. Empirical Results and Analysis

4.1 ADF test

In the regression analysis, it is necessary to perform the stationarity test of the time series data, that is, the Augmented Dickey-fuller test. If the time series data is non-stationary data, differential processing is needed. In this paper, when performing global regression, regression in the rising phase and regression in the falling phase, the ADF is first used to test the time series stationarity of the nine variables of the three equations. It can be known from Table 2 that the time series ADF values of the nine variables are much smaller than the critical values of 1% and 5%, and the DW values are in accordance with the requirements between 1.8 and 2.1, so the time series of the nine variables of the three equations are both stationary sequences, and further regression analysis can be performed accordingly.

Table 2 Unit Root Test results for various variables in the mode

Variable	Differences	(C,T,K)	DW value	ADF value	5%critical value	1%critical value	Stationarity
$CSAD$	0	(C,0,1)	2.09	-11.83	-3.86	-3.43	Stable
$\lvert R_{m\lvert} \rvert$	0	(C,T,1)	2.06	-14.73	-3.41	-3.96	Stable
$(R_m)^2$	0	(C,0,1)	2.01	-11.80	-3.42	-3.98	Stable
$CSAD^{up}$	0	(C,T,1)	1.95	-11.88	-3.43	-4.00	Stable
$\lvert R_m^{up} \rvert$	0	(C,T,1)	1.93	-8.47	-3.42	-3.99	Stable
$(R_m^{up})^2$	0	(C,T,1)	1.82	-7.85	-3.43	-4.00	Stable
$CSAD^{down}$	0	(C,T,1)	2.01	-7.22	-3.42	-3.99	Stable
$\lvert R_m^{down} \rvert$	0	(C,T,1)	2.01	-9.21	-3.43	-3.99	Stable
$(R_m^{down})^2$	0	(C,T,1)	2.02	-9.34	-3.42	-3.99	Stable

Note: C and T in parentheses indicate the intercept term and time trend term in the test equation, respectively, and the number 1 represents the lag period.

4.2 Model regression results

The regression results of the equation for the herd effect of thermal coal futures from September 26, 2013 to October 11, 2017 are shown in Table 3.

Table 3 Cross sectional absolute deviation regression results

α_0	α_1	α_2	$\boldsymbol{R^2}$
$\mathbf{0.002}^{***}$	-0.142^{**}	-0.516	0.346

Note: *** indicates that the statistical value test results are significant at the critical level of 1%,** indicates that the statistical value test results are significant at the critical level of 5%, and * indicates that the statistical value test results are significant at the critical level of 10%.

It can be seen from the regression results that α_0 and α_1 are equal to 0.002 and -0.142, respectively, and significant at the critical levels of 1% and 5%, respectively. The overall regression fitting degree of the equation is relatively low, and the data of α_2 is -0.516, which is less than zero. It is believed that the thermal coal futures market has a herd effect, but the coefficient is not significant. Therefore, the thermal coal futures market has no obvious herding effect.

There is a stage of obvious downward trend from November 26, 2013 to December 4, 2015, and the bear market regression results are shown in Table 4.

Table 4 Bear market cross-sectional income absolute deviation regression results

α_0^{down}	α_1^{down}	α_2^{down}	R^2
$\mathbf{0.001}^{*}$	-0.181^{**}	0.702	0.326

It can be seen from Table 4 that the regression result of α_2^{down} in the bear market is positive and insignificant, while α_1^{down} is negative and significant at 5%. However, according to the model judgment criteria, there is no obvious herding effect in the stage of price decline in the thermal coal futures market.

The regression results with a clear upward trend from December 7, 2015 to November 8, 2016 are shown in Table 5.

Table 5 Absolute deviation of bull market cross-sectional returns

α_0^{up}	α_1^{up}	α_2^{up}	R^2
$\mathbf{0.010}^{***}$	0.436^{**}	2.975	0.23

It can be seen from Table 5 that the coefficient of the equation regression is positive in the bull market stage, so there is still no obvious herding effect in the price rise period in the thermal coal futures market.

It can be seen from the regression results of the three sets of equation models that there is no obvious herding effect in the thermal coal futures market. In the bear market and the bull market, no obvious herding effect was detected, erther. Therefore, the empirical method did not detect the herding effect of the thermal coal futures market. The low efficiency of thermal coal futures hedging is not directly related to investors' strategies. In the bear market and the bull market stage, investors are not affected by the sluggish or high market prices, and they are still able to maintain a rational investment strategy.

5. Conclusion

According to the analysis of the model, there is no obvious herding effect in China's thermal coal futures market, and the herd effect is not detected in the bear market and the bull market.However, Ma Li (2016) believes the fact that the herding effect in the investment market has not been measured by the CSAD method does not mean the market has no herding effect, because the price rising and falling limits may limit the measurement accuracy of the herd effect.

This paper believes that there is no obvious herding effect in the thermal coal futures market.

There are several reasons for that: First, the listing time of thermal coal futures is short, less historical information can be referred for investors , they adopt a wait-and-see attitude, and are not in a hurry to trade; Second, investors in China's financial market tend to have more obvious investment behaviors in the stage of price decline. However, in the stage of declining thermal coal futures prices, large contract trading is adopted in China's thermal coal futures with high trading threshold, limited investors that participate in futures market transactions, lower activity, and smaller speculative space. Finally, in recent years, China has strengthened the control of atmospheric pollution. Although coal is still an important basic energy of China, “coal to gas” and “coal system” Gas is the focus of future energy strategy development, and investors tends to be more rational about the investment of traditional energy commodity futures .

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