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Study on the Impact of the Price of Carbon Emission Permit on the Market Value of Thermal Power Enterprises

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Abstract. *In order to solve the problem of environmental disruption caused by excessive greenhouse gas emission, China has released the National Carbon Emissions Trading Market Construction Plan (Power Generation Industry), launched the national carbon emission trading system, and the power generation industry has become the breakthrough that starts the trading market of carbon emission permit firstly. Therefore, it is of great significance to study the correlation between the carbon emission permit trading market of our country and the market value of thermal power enterprises. As the basic industry of the national economy, the importance of power industry is self-evident. Especially, the energy structure of China's power industry is single, relying heavily on coal for electricity. Carbon emissions are huge every year, and carbon emissions trading in the power industry has been put on the agenda. The study on the price of carbon emission permit and the market value of thermal power enterprises can not only provide more information for the government, but also provide a reference for investors. To this end, the price of carbon emission permit and the market price index of thermal power enterprises and three control variables are selected, and the selected variables data is processed to make them meet the conditions for establishing a VAR model. A classic VAR model is established using Eviews to study the impact of China's carbon emission permit price on the market value of thermal power enterprises. Through Granger causality test, impulse response function and variance decomposition of the established VAR model, it is concluded that the price of carbon emission permit has weak positive impact on the market value of thermal power enterprises. The reasons of the problems in the process of obtaining the results are analyzed, and corresponding countermeasures and suggestions are proposed. Finally, conclusions and the suggestions to save energy and reduce emissions and increase company value in the context of the development of the carbon emission permit market are put forward for power enterprises*

Keywords: *Price of carbon emission permit; Market value of thermal power enterprises; VAR model*

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1. Research background and significance

With the gradual transformation and upgrading of China's economy, the requirements for emissions of carbon dioxide and other greenhouse gas will become more and more stringent, so more and more related enterprises will enter the carbon emission permit trading market. As enterprises of high-carbon emission industry, the correlation between power enterprises' asset and carbon asset will become more and more important. Therefore, it is of great significance to carry out relevant analysis directly against China's national conditions. Based on this, this paper intends to adopt the research strategy to combine theory and empirical study. And the classic vector autoregressive VAR model is used to quantitatively analyze the correlation between domestic carbon emission permit trading price and the market value of thermal power enterprises and its inherent transmission mechanism based on combing the operation status of domestic carbon emission permit trading market and the market value of thermal power enterprises. It will have the following significance of reference:

Firstly, it can help us understand the dynamic changes of the carbon emission permit trading market in time and also help the government to observe the effectiveness of the external influence of the carbon emission permit trading market on the energy conservation and emission reduction of power enterprises from the perspective of company value to study and grasp the relationship between the carbon emission permit trading price and the market value of thermal power enterprises.

Secondly, it is vital to investors, policy makers and scholars to study the influence of the turbulence in the trading price reform of carbon emission permit on the market value of thermal power enterprises.

2. Study Design and Variable Selection

In the 1980s, based on the time series autoregressive model (AR), Christopher Sims designed the vector autoregressive model (VAR). His prediction effect is based on the simultaneous equation model. It's an important tool for analyzing and predicting the relationship between interconnected multivariate time series.

The VAR model has the following characteristics: (1) In the VAR modeling process, we only need to complete two tasks: first, predict in advance which types of variables are related to each other. We must include these variables in VAR model to be constructed; second, determine the optimal lag time so that the model constructed can reflect the interaction between various variables as much as possible. (2) In the model, whether the parameter estimate is significant, we will still leave it in the model. (3) The explanatory variables of the model do not include any current variables. In this way, it's good for the estimation and prediction of the model.

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2.1 Price of carbon emission permit

Although China has announced launching the national unified carbon emission permit trading market officially at the end of 2017, the prices of these carbon emission permit trading markets are not truly unified. Before the unification, there were a total of eight trading pilot markets of carbon emission permit in the country. These eight pilot markets were: Beijing, Shanghai, Guangdong, Hubei, Tianjin, Chongqing, Shenzhen, and Fujian. Taking into account the activeness of each carbon emission permit trading market, the total annual transaction volume of these four pilot markets: Beijing, Shanghai, Guangdong, and Hubei accounts for more than three-quarters of the eight pilot's transaction. The compliance rate is high. Transactions are relatively active. Therefore, the weighted average of carbon emission permit trading price in these four markets is selected as the domestic carbon emission permit trading price, which is representative. Chongqing, Shenzhen, and Fujian, because of their inactive transactions, low compliance rates, too little data volume, data achieving difficulty, and too late startup time, are excluded directly in this paper.

2.2 Market value of thermal power enterprises

Thermal power generation is still the main power generation way in China, and power generation accounts for a large proportion. Only thermal power technology must be continuously improved, can the requirements of harmonious society be met and more value be brought to society and enterprises. In the empirical research of this paper, the market value of thermal power enterprises uses the thermal power index (code: 884874.WI) provided by the Wind database. The index is calculated by the Wing database based on the daily trading volume and trading price of listed enterprises in the thermal power industry, which can better reflect the current market value of domestic listed enterprises in the thermal power industry.

2.3 Other price index

In the process of power generation by electric power enterprises, power is generated mainly by burning fossil energy and generating carbon emissions, so the coal price, crude oil price and natural gas price of fossil energy related to power generation enterprises are used as control variables. By adding these control variables, the error of empirical analysis is reduced. The data sources are the coal index provided by the Wind database, the spot price of Brent crude oil and the spot price of natural gas delivery at Henry Center. Since the spot price of Brent crude oil and Henry natural gas delivery are both in US dollars, the intermediate price of the exchange rate of US dollars to RMB is selected to be converted into RMB prices.

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3. Empirical Research

3.1 Stationarity test

In exploring the specific correlation between the carbon emission permit trading price and the value of thermal power generation enterprises, in order to reduce data fluctuations and avoid heteroscedasticity, the logarithm of the original two-year daily data is taken firstly in this paper to obtain time series of natural logarithms respectively.

After using Eviews for ADF unit root test, we found that after taking the logarithm of the original data, the five time-series are not stable and do not meet the premise of VAR construction and subsequent inspection and analysis, so first-order difference is required for all data. The data stationarity test was performed again, and the test result showed that the five time-series were stable at this time. The summary of the two unit-root tests before and after is shown in Table 1.

Table 1 ADF unit root test result

Variable name	T statistic	P value	Stationary
LnPower	-1.664230	0.4491	Unstable
dLnPower	-30.43516	0.0000	Smooth
LnCarbon	-1.813017	0.3741	Unstable
dLnCarbon	-3.510515	0.0082	Smooth
LnCoal	-2.149640	0.2254	Unstable
dLnCoal	-28.83209	0.0000	Smooth
LnOil	-1.500293	0.5331	Unstable
dLnOil	-26.18691	0.0000	Smooth
LnGas	-2.261944	0.1849	Unstable
dLnGas	-9.756386	0.0000	Smooth

In Table 2, “Power” represents the market value of thermal power enterprises, “Carbon” represents the carbon emission permit trading price, “Coal” represents the coal price index, “Oil” represents the spot price of Brent crude oil, and “Gas” represents the spot price of natural gas delivery at Henry Center. “Ln” represents the logarithm taken for them, and “d” represents the first-order difference.

3.2 Optimal lag order

In the empirical research in this paper, the optimal lag order is determined according to the AIC Akaike information amount criterion. The principle for selecting the optimal lag order is to select the lag period when the AIC has the minimum value.

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Table 2 VAR model lag order test result

Lag	LogL	AIC
0	6820.702	-19.9874
1	6926.62	-20.2247
2	6966.995	-20.2698
3	7011.88	-20.3281
4	7038.331	-20.3324
5	7063.844	-20.3339
6	7097.08	-20.35801*
7	7116.474	-20.3416
8	7130.77	-20.3102
9	7160.687	-20.3246
10	7180.561	-20.3096

The optimal lag order selected according to the AIC criterion is 6-order, and because the selected data is the daily data of the past two years, the 6-order lag is relatively small compared to the entire data period. The daily data time is sufficient to reflect the changing situation, and the 6 lag-order is also reasonable. Therefore, the optimal lag time of VAR model was finally determined to be 6.

3.3 VAR construction result and AR root test

The sufficient and necessary condition for the stability of VAR model is that all eigenvalues of the 5×5 order parameter matrix must be within the unit circle, or the modulus of the eigenvalues must be less than 1. After the AR root test is performed on the constructed model, the resulting AR root diagram of the model is shown in Figure 1, and the distribution of each point is within the unit circle, indicating that the model constructed is relatively stable and will not affect the standard deviation of the impulse shock function.

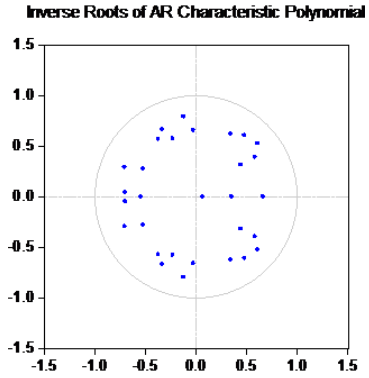

Figure 1 AR root diagram of VAR model

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3.4 Granger causal relationship

Based on the multivariable VAR model constructed in this paper, the Granger test is now performed with Eviews6 software. Because the optimal lag order of VAR model determined aforesaid is 6, 6 lag-order is also chosen here.

Table 3 Granger causality test result

Null hypothesis	Chi-sq	P value	Conclusion
The price of carbon emission permit is not the Granger cause of market value of thermal power enterprises	13.09450	0.0416	Reject
Crude oil price is not Granger cause of carbon emission price	16.29418	0.0123	Reject
Coal price is not the Granger cause of market value for thermal power enterprises	20.75753	0.0020	Reject

The result shows that with confidence coefficient of 0.5, the price of carbon emission permit is the Granger cause of the market value of thermal power enterprises, and the market value of thermal power enterprises is not the Granger cause of the price of carbon emission permit. The changes of the price of carbon emission permit is helpful to explain the market value of thermal power enterprises.

3.5 Impulse response function

In previous empirical evidence, we have basically verified the correlation between the market value of thermal power enterprises and the trading price of carbon emissions permit. Now we need to determine whether the influence between these variables is positive or negative, and we need to understand the time lag of such situation, so an impulse response function needs to be established.

Cholesky impulse response function analysis was performed on the VAR model.

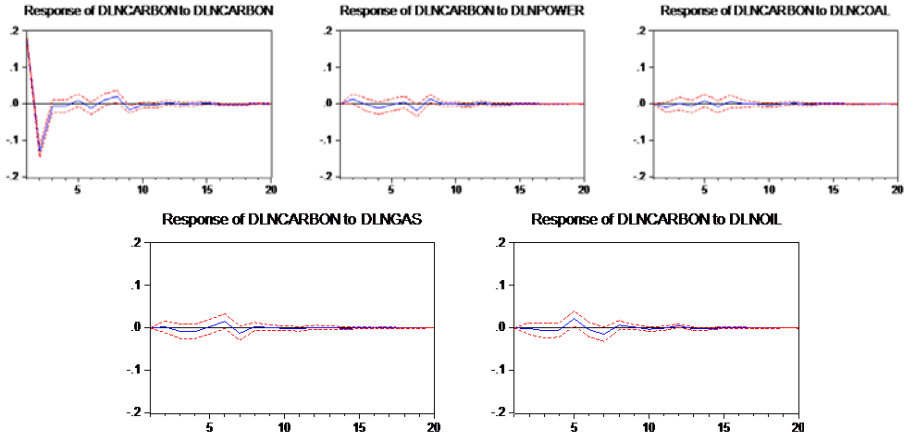

Figure 2 Impulse response function of carbon emission permit trading price

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The impulse of the carbon emission permit trading price has the greatest impact on itself in the first period, with an impact coefficient of 0.2. In the second period, the impact falls to the lowest point and rebounds and fluctuates. The second peak occurs in the eighth period. After the twentieth period, it starts to converge to 0 and is completely digested. The impact of trading price of carbon emission permit on the market value of thermal power enterprises has a peak in the second period, with a positive impact coefficient of 0.028. In the fourth period, there is negative impact, followed by volatile trend, then starting to converge to 0 in the sixteenth period. The impact of the price of carbon emission permit on coal price is negative in the second period, with a coefficient of -0.015, and then fluctuates until the sixteenth period tending to zero. The impact of the price of carbon emission permit on natural gas price and crude oil price is slightly positive in the second period, followed by a slight fluctuation to the fifteenth period, which tends to zero.

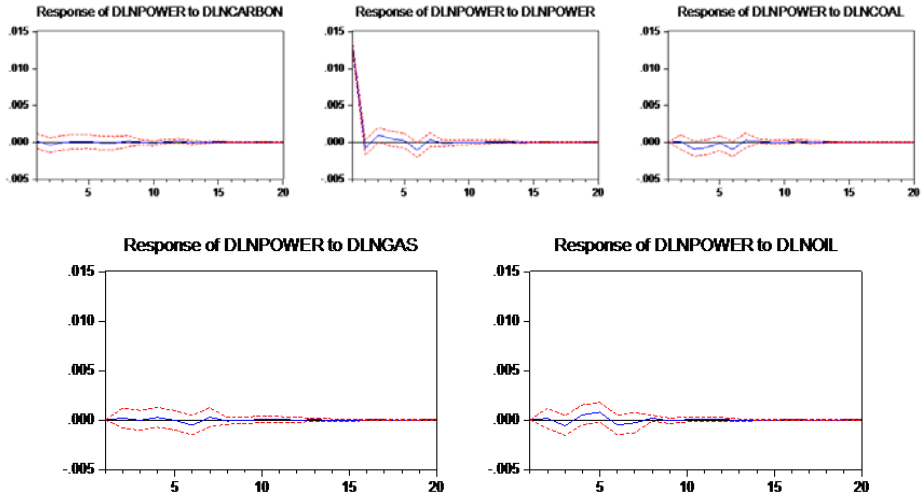

Figure 3 Impulse response function of market value of thermal power enterprises

According to the output result of the impulse response function for the market value of thermal power enterprises, we can see that the impact of the market value of thermal power enterprises has the largest impact on itself in the current period, with an impact coefficient of 0.013, which tends to zero after the fifteenth period. The impact of the market value of thermal power enterprises on the price of carbon emissions permit has negative impact in the second period, with a coefficient of 0.001, and then fluctuates slightly at zero, and tends to zero after the fifteenth period. The market value of thermal power enterprises has small positive impact on coal price, natural gas price, and crude oil price in the second period, and then fluctuates for a long time. It does not stabilize until the fifteenth period.

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3.6 Variance decomposition

Table 4 Variance decomposition of carbon emission permit trading price

Period	S.E.	DLNCARBON	DLNPOWER	DLNCOAL	DLNGAS	DLNOIL
1	0.179581	100	0	0	0	0
2	0.221933	99.41111	0.418487	0.150563	0.016533	0.003311
3	0.222267	99.20514	0.420736	0.152896	0.134067	0.087159
4	0.222936	98.68587	0.671658	0.233277	0.278014	0.131178
5	0.224531	97.51587	0.673347	0.429974	0.291773	1.089034
6	0.225613	96.84472	0.724704	0.531845	0.787167	1.111563
7	0.227494	95.48044	1.312180	0.632441	1.062342	1.512600
8	0.229052	95.02724	1.708167	0.625018	1.069167	1.570407
9	0.229583	95.03893	1.700373	0.622191	1.065830	1.572672
10	0.229648	94.9971	1.699420	0.647711	1.067056	1.588715
11	0.229724	94.96281	1.725143	0.647432	1.075780	1.588831
12	0.229894	94.85428	1.762760	0.660706	1.078462	1.643791
13	0.229932	94.82463	1.774368	0.667095	1.080488	1.653420
14	0.229951	94.80930	1.777629	0.668049	1.082683	1.662336
15	0.229978	94.80406	1.781832	0.668324	1.082543	1.663237

It can be seen from the table that in the variance decomposition of the price of carbon emission permit in the lag period from 1 to 20, in 1 lag period, it only contributes 100% of itself. From the second period, the variance contribution of the market value of thermal power enterprises, coal price index, natural gas price and crude oil price to the carbon emission permit trading price are 0.42%, 0.15%, 0.02%, and 0.00%. By the seventh period, the variance contribution of the market value of thermal power enterprises, natural gas price, and crude oil price have all been more than 1%. The variance contribution of various indicators has stabilized after the 15th period. The variance contribution of the market value of thermal power enterprises is 1.78%, which is ranked only second to the variance contribution of the carbon emission permit trading price itself. The variance contribution of the market value of thermal power enterprises, coal price, natural gas price, and crude oil price to carbon emission permit is basically stable at 1.78%, 0.67%, 1.08%, and 1.67%.

Table 5 Variance decomposition of the market value of thermal power enterprises

Period	S.E.	DLNCARBON	DLNPOWER	DLNCOAL	DLNGAS	DLNOIL
1	0.013081	0.009308	99.99069	0	0	0
2	0.013113	0.103492	99.86067	0.000541	0.01853	0.016763
3	0.013193	0.105572	99.20125	0.460221	0.019224	0.213734
4	0.013233	0.110071	98.73297	0.736496	0.054918	0.365543
5	0.013259	0.114129	98.37949	0.743148	0.055560	0.707672
6	0.013354	0.120361	97.58743	1.224629	0.219091	0.848492
7	0.013367	0.131423	97.46226	1.254989	0.257404	0.893927
8	0.013372	0.144679	97.41464	1.265282	0.263018	0.912382
9	0.013372	0.144712	97.40957	1.265229	0.263537	0.916950
10	0.013373	0.159558	97.39218	1.266311	0.264954	0.916993
11	0.013375	0.163669	97.36264	1.284293	0.266856	0.922540
12	0.013377	0.179012	97.34584	1.285112	0.267158	0.922879
13	0.013377	0.185891	97.33836	1.285029	0.267630	0.923088
14	0.013378	0.187646	97.33638	1.285002	0.26777	0.923198
15	0.013378	0.189806	97.33363	1.284968	0.268356	0.923242

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In the first period, 99.99% of the impact on the variance contribution is from the market value of thermal power enterprises themselves, and 0.01% is from carbon emission permit trading price. In the sixth period, the variance contribution of coal price index to the carbon emission permit trading price is more than 1%, and the impact is relatively obvious. After the stabilization around the fifteenth period, the variance contribution of the carbon emission permit trading price, coal price index, natural gas price, and crude oil price to the market value of thermal power enterprises are 0.19%, 1.29%, and 0.27% and 0.92%.

4. Conclusion

The empirical result in this paper shows that the correlation between the carbon emission permit trading price and the market value of thermal power enterprises is very small. After consulting and analyzing the data, the main reasons are as follows:

Firstly, in the data selection stage of carbon emission permit trading price, the main reasons are the lack of active trading, low compliance rate, too little data, difficult access to data, and late start time, etc. in some pilot markets.

Secondly, in order to establish a VAR model, we take the logarithm on the original data, and then makes difference on the unstable sequence, which will also have certain impact, and to a certain extent, lack the authenticity that the original data can show.

Thirdly, China is currently in the exploration and construction stage of carbon emission permit trading market. As a traditional large carbon emission country, China still relies on traditional energy source to a greater extent.

Fourthly, China’s coal-electricity integration process is slow. The current domestic energy price mechanism is “market coal, planned electricity” model, which is the main factor that causes distortions in the electricity market and contradiction in coal and electricity price.

5. Suggestion

In the empirical part, the transmission route between China’s carbon emission permit trading price and the market value of thermal power enterprises has been deduced, and the accuracy of this transmission mechanism has been proved with empirical research. Based on this mechanism, we propose the following recommendations:

Firstly, the current market of carbon emission permit is immature, the information of participating enterprises is not transparent, and the degree of compliance is not high. As a result, the price of carbon emission permit trading has little relevance with the market value of thermal power enterprises. Therefore, government departments should appropriately relax the regulate and control for carbon emission permit trading price and make it freer, but the management of participating enterprises needs to be strengthened so that they can strictly abide by

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relevant regulations of the carbon emission permit trading market. In this way, it can be more effective to direct the carbon emission permit trading market to develop well.

Secondly, if electric power enterprises want to survive better in the current carbon emission market, they need to strictly abide by the rules of the carbon emission permit trading market. These rules are not only restrictions, but also the current development trend.

Thirdly, the price of carbon emission permit trading has the correlation with the market value of thermal power enterprises in the same direction. Therefore, the price of carbon emission permit trading can guide power enterprises to develop better and faster. To increase the market value of thermal power enterprises, they should follow the trajectory of carbon emission permit trading price and should not be operated in the opposite direction.

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