

Analysis of Price Volatility and Influencing Factors in Carbon Emissions Trading Pilot Markets

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Abstract—With the rapid development of the domestic carbon market, the related problems caused by carbon price fluctuations have become the key research direction of building a national unified carbon market. This paper focuses on the carbon trading price of Guangdong carbon emission trading market. The price volatility of Guangdong carbon trading market from 2017 to 2019 was described and analyzed by GARCH model. Then, through theoretical hypothesis, quantile regression model is selected to study the influence degree of different factors on carbon price fluctuation. The results show that the carbon price yield of Guangdong has the characteristics of "peak and thick tail". At the same time, the trading price of Guangdong carbon market is most affected by the CSI 300 index, followed by the air quality index, and the influence degree of traditional energy is followed by coal price, oil price and natural gas price. Finally, some relevant policy suggestions are given.

Keywords— Carbon emission trading; Price fluctuation; GARCH model; Influencing factor; Quantile regression model

I. INTRODUCTION

In recent years, the rapid economic development has brought about serious environmental pollution problems, curbing global warming has become the focus of attention of all countries in the world, and more and more countries have joined the ranks of low-carbon emission reduction. The signing of the Paris Agreement marks another step forward on the road of global joint governance of human living environment, and carbon emission trading has been applied in concrete practice by more countries. As a responsible country, China has launched eight carbon trading markets since 2011, and actively promoted the pilot carbon emission trading system. At the end of 2017, a unified carbon trading market covering the whole country was officially launched, involving many industries such as electricity, steel and cement. Although the structure of China's carbon trading market has initially taken shape, it is still in its infancy. The carbon emission trading prices of multiple pilot markets vary greatly, and there are often abnormal fluctuations, which also increases the risks of the carbon trading market and is not conducive to the establishment of a unified national carbon trading market. The factors affecting the price fluctuation of the carbon emission trading pilot market are still in the process of continuous exploration.

The carbon emission trading market is a new type of market that combines environmental improvement with financial trading and has great potential for development. Therefore, in order to explore the factors that affect the carbon emission trading price and the degree of impact, this paper takes the carbon emission data of Guangdong Exchange as the research object, and selects factors from the demand side for empirical analysis, in order to provide theoretical basis for the stable construction of China's carbon emission trading market. Since China's carbon trading market is developed later than the global carbon market, relevant theoretical studies are mainly focused on the international carbon market. On the basis of previous studies at home and abroad, this paper further interprets the influencing factors of carbon price fluctuation, and adds the external market factors that are still

little studied, in order to provide guidance for the establishment of a perfect carbon market in China theoretically. Judging from the development status of China's existing carbon pilot market, China's carbon market is developing fast and has a good prospect. Research on the factors affecting carbon price in China's carbon trading market can provide certain basis for policy makers to carry out macro-control and promote the orderly development of the carbon market.

II. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

A. Literature Review

The development of carbon market in foreign countries was earlier, the EU carbon market was launched in 2005, and most scholars' research on carbon market also focused on the EU carbon market. Ren et al. (2017) used the GARCH family model to better calculate the volatility of carbon trading prices in Shenzhen, and found that the return rate was negatively correlated with the expected risk ^[1]. Lv Jingye et al. (2019) found that the carbon price in Hubei was greatly affected by external shocks and the fluctuation of carbon price showed a leverage effect due to information asymmetry ^[2]. Through the summary of relevant literature, the influencing factors of carbon price fluctuation are roughly analyzed as follows:

1. Energy Factor

Liu Junyang et al. (2020) found that industrial prosperity and coal prices have a long-term positive impact on carbon trading prices by studying the price fluctuations and influencing factors of Beijing carbon trading market ^[3].

2. Macroeconomic Factor

Landis et al. (2018) analyzed and studied the relationship between carbon emission trading price, tax law finance, fuel transportation, and social equity based on the general equilibrium model ^[4].

3. Climatic Factor

Roshan et al. (2019) studied the relationship between energy demand and carbon emissions and found that warm weather would increase the demand for cooling energy, which would further increase carbon dioxide emissions ^[5].

4. Policy Factor

The study found that with the introduction of some national policies, carbon prices will be more or less affected. Using multiple regression analysis, Wu Huijuan and Zhang Zhiguang (2020) found in their empirical study that too loose setting of emission reduction threshold in policies is the key reason for low carbon price [6].

B. Theoretical Analysis and Research Hypothesis

Coal and oil have always been an important basic energy to promote the sustainable development of China's economy. At the same time, in order to achieve the sustainable development of the economy, the country pays more and more attention to the development and application of clean energy. With the promotion and use of renewable energy, enterprises have reduced the demand for traditional energy, which will reduce the amount of greenhouse gases such as carbon dioxide, and ultimately make the carbon trading price drop. Therefore, this paper proposes the first hypothesis:

H1: The price of traditional energy has a negative impact on the trading price of Guangdong carbon market.

There are many measurement indicators about environmental factors, among which the main measurement indicator related to air detection is AQI (Air Quality Index). The size of the index corresponds to the quality of the environment respectively, and the larger the index is, the worse the air quality is. Therefore, this paper proposes the second hypothesis:

H2: The air quality index has a positive effect on the trading price of Guangdong carbon market.

Since Hubei carbon market and Guangzhou carbon market are relatively mature markets at present, I guess whether the price fluctuation of Hubei carbon market will have a certain impact on the price of Guangzhou carbon market. Therefore, this paper proposes the third hypothesis:

H3: Hubei carbon market trading price has a positive impact on Guangdong carbon market trading price.

When the overall economic environment is on the rise, enterprises will choose to expand production scale in order to further maximize profits, and the competitive behavior of some enterprises may bring more environmental pollution. In order to meet the emission reduction quota of the government, the demand for carbon emission rights will increase. Therefore, this paper proposes the fourth hypothesis:

H4: The degree of macroeconomic development has a positive impact on Guangdong carbon market price.

III. RESEARCH DESIGN

A. Data Source and Sample Selection

China's carbon trading market has different time and market maturity. According to the transaction volume and trading volume, the trading of Guangzhou carbon market is

more active, so the trading data of this market is more representative. Therefore, the research object of this paper is selected as the carbon emission rights trading market in Guangzhou, and the research period is from 2017 to 2019. The daily closing prices of Guangzhou carbon market for three years were collected and inactive dates were excluded, and the total research data was 647.

1. Energy Price Index

This paper selects coal price index, Daqing crude oil spot price index and natural gas price index as the study variables.

2. Air Quality Index

This paper selects Guangdong AQI index to measure the impact of environmental factors on Guangdong carbon emission trading price.

3. External Market Index

This paper selects the daily closing price of Hubei carbon market as the research variable to study the spillover effect of Hubei carbon trading price on Guangdong carbon trading price.

4. Macroeconomic Index

In this paper, the CSI 300 index is selected as the research variable.

B. Construct GARCH Model

In this paper, the logarithmic difference of carbon emission trading price in Guangzhou is studied. As can be seen from the results in Table 1, the mean value is 0.000814, standard deviation is 0.038821, skewness is -0.238852, kurtosis is 4.090217, JB value is 40.61462, and probability is 0.000000. It shows that the sequence has the characteristic of "peak and thick tail" and refuses to obey the hypothesis of normal distribution.

TABLE 1. Descriptive Statistics of Return Series

Return	Mean	Std.	JB	P
GuangZhou	0.000814	0.038821	40.61462	0.0000

In order to accurately describe the relationship between variables and avoid the impact of accidental high correlation caused by some instability of data on the empirical study, the commonly used ADF method is adopted here to test the stationarity of data. As can be seen from Table 2, the value of t statistic is -14.04233, and the corresponding P value is close to 0, indicating that the series is stable.

TABLE 2. Stationarity Test

Stationarity test	ADF	1%	5%	P
T	-14.04233	-3.439724	-2.865567	0.0000

LM method proposed by Engel is used to test the residual error of the model. The results are shown in Table 3. All P-values in the ARCH LM test with lag order 1 to 5 are 0, so there is an ARCH effect.

TABLE 3. ARCH Effect Test

ARCH Test	ARCH (1)	ARCH (2)	ARCH (3)	ARCH (4)	ARCH (5)
P	0.0000	0.0000	0.0000	0.0000	0.0000

After passing the above tests, the GARCH (1,1) model is constructed here for volatility analysis. This model is

suitable for most time series studies, and its fitting effect is better and more concise.

According to the results in Table 4, the sum of ARCH coefficient and GARCH coefficient is very close to 1, indicating that the price will continue to fluctuate in the future. The GARCH coefficient is 0.7176, which means that 71.76% of the current volatility impact will continue in the next period. It can also be found that the ARCH coefficient is 0.276710, indicating that the carbon price is affected by the previous price by 0.276710.

According to the GARCH model, the prediction of the next period is made. As can be seen from FIG. 1, the predicted return series of the next period still presents the feature of "volatility aggregation", but compared with the original series, it can be significantly observed that the fluctuation amplitude of the predicted new series is significantly lower than that of the original series, and the fluctuation amplitude of the series is gradually decreasing as time goes on. Prices eventually levelled off. As a pilot carbon market at the forefront of development, Guangdong Carbon Exchange has set a good example in the stability of carbon prices and system design, which will further promote the process of establishing a unified carbon market in China.

TABLE 4. GARCH Modeling Results

Mean value equation				
Variable	Coefficient	Std.	Z	P
C	0.002518	0.001235	2.038522	0.0415
R(-1)	-0.676238	0.157066	-4.305436	0.0000
R(-2)	-0.271135	0.100041	-2.710226	0.0067
AR(1)	0.387056	0.154560	2.504247	0.0123
AR(2)	-0.228375	0.084221	-2.711607	0.0067
Variance equation				
ω	6.00E-05	9.69E-06	6.192204	0.0000
ARCH(α)	0.276710	0.037142	7.449968	0.0000
GARCH(β)	0.717563	0.021835	32.86269	0.0000

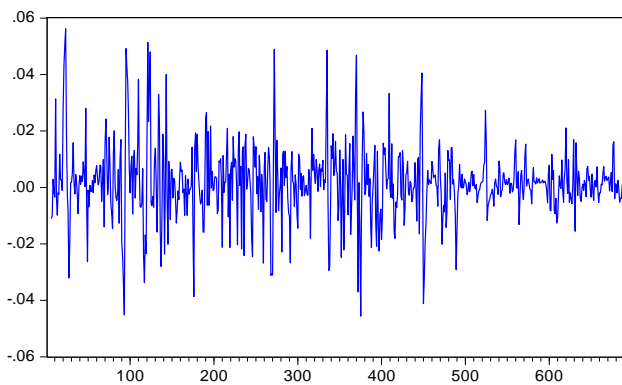


Fig. 1. Predictive sequence diagram

C. Construct Quantile Regression Model

Using Eviews8.0, quantile regression was carried out on the influencing factors of carbon emission trading price in Guangdong, and the influences of six indexes including coal price, crude oil price, natural gas price, Hubei carbon market price, air quality index and CSI 300 index were analyzed under different price levels.

1. Energy Factor

It can be seen from Table 5 that coal price index, crude oil price index and natural gas price all have negative correlation with carbon emission rights trading price, and the correlation

coefficient is different. The results show that the coal price has no significant impact on the carbon trading price in Guangdong Province at the level of 0.25, and presents a positive impact relationship. When the sub-points are at the levels of 0.50 and 0.75, it can be found that the impact of coal price on carbon trading price in Guangdong is significant, and the impact coefficient is further increasing, showing a negative impact relationship. So hypothesis one is tested.

2. Environmental Factor

The research results show that AQI index has a significant positive impact on the carbon emission trading price in Guangdong at three different quantile levels: low, medium and high, and the corresponding coefficients are 0.610, 0.648 and 0.636, respectively, indicating that no matter what level of carbon trading in Guangdong, The local environment has a significant positive impact on the price of carbon emissions trading. So hypothesis two is tested.

3. External Market Factor

It can be found from the research results that when the sub-points are 0.25 and 0.50, there is almost no difference in the degree of influence of Hubei carbon trading price on Guangdong carbon trading price, and the influence is positive, which is 0.038 and 0.037 respectively. However, when the quantile level is 0.75, the influence coefficient becomes smaller, which indicates that when Guangdong carbon trading price is at a higher level, the influence of Hubei carbon trading price on Guangdong carbon trading price becomes smaller. The influence of Hubei carbon trading price on Guangdong carbon trading price has been weakened. So hypothesis three has been tested.

4. Macroeconomic Factor

It can be seen from the obtained results that as the carbon price of Guangdong changes from low to high, the impact of CSI 300 index on the trading price increases significantly, indicating that the higher the carbon price of Guangdong, the greater the impact of macro economy on it, and the impact is positive. So hypothesis four has been tested.

TABLE 5. Quantile Regression Results

	Quant25		Quant50		Quant75	
	C	t	C	t	C	t
LnCOAL	0.176	0.420	-0.434**	-1.997	-0.950***	-5.515
LnOIL	-0.270***	-4.643	-0.209***	-4.722	-0.249***	-5.273
LnNG	-0.124***	-4.367	-0.175***	-8.595	-0.178***	-7.148
LnHBCP	0.038***	2.704	0.037***	3.068	0.027*	1.672
LnAQI	0.610***	35.537	0.648***	42.762	0.636***	35.706
LnHS300	0.781***	7.035	1.021***	13.068	1.108***	12.826
C	-4.707	-2.458	-2.641**	-2.407	0.284	0.289

***, ** and * are significant at the level of 0.01, 0.05 and 0.1 respectively

The slope equality test and symmetry test of quantile level at 0.75 are carried out below to prove that the regression results obtained under different quantile coefficients are not problematic.

TABLE 6. Slope equality Test

Test Summary	Chi-Sq.Statistic	Chi-Sq.d.f	Prob.
Wald Test	16.38975	12	0.1740

TABLE 7. Symmetry Test

Test Summary	Chi-Sq.Statistic	Chi-Sq.d.f	Prob.
Wald Test	25.25950	21	0.2361

IV. CONCLUSIONS AND SUGGESTIONS

A. Research Conclusions

Based on the study of relevant definitions and theories of carbon emission trading, this paper studied in detail the characteristics and influencing factors of daily price fluctuations in Guangdong carbon trading market from 2017 to 2019. The first is the study of carbon price volatility. The empirical results of GARCH model show that the carbon price volatility in Guangdong is gradually stable, and the price fluctuation in the next period is predicted, and it is found that the price fluctuation is still continuing, but the fluctuation range is gradually decreasing. Then, the influence factors of Guangdong carbon emission trading price fluctuation are studied, and the influence degree of the four factors is compared respectively. The conclusion is as follows:

The price trend of the carbon trading pilot market in Guangdong has fluctuated greatly from the beginning to gradually weaken, and presents a state of "volatility accumulation". Through the forecast, it is found that there will be small fluctuations for a period of time in the future, but generally speaking, the fluctuation range is gradually smaller and the price is gradually stable.

In terms of price influencing factors, when the carbon price is at a high level, the influence degree of each factor is more obvious. The macro-economy has the largest influence on carbon price, and the influence is positive. Then there is the positive impact of environmental factors; In terms of energy factors, the influence of coal price is obviously greater than that of oil and natural gas, and the influence is negative. Finally, Hubei carbon market price also has a positive impact on Guangdong carbon market price fluctuation.

B. Policy Suggestions

With the rapid development of social economy, while enjoying the convenience brought by the industrial revolution and the scientific and technological revolution, human beings have unknowingly destroyed their living environment. The rapid increase of carbon dioxide emissions has caused a significant rise in global temperature and the melting of large areas of icebergs, which has seriously threatened the survival of human beings. The birth of "carbon emission trading", a tool with both environmental protection and financial characteristics, has brought great convenience to environmental protection and emission reduction. In the process of birth, development and gradual maturity, this tool still has some shortcomings, especially when China draws on the development experience of the EU carbon market and

includes carbon emission trading tools in pilot tests in many places. Based on the experimental results in recent years and the above empirical analysis, the following suggestions are put forward.

First, in view of the development status of China's carbon emission trading pilot market, China should give full play to the leading and exemplary role of the market with good development momentum, appropriately expand the distribution of quotas, enhance market liquidity, and include more industries, such as wind power, photovoltaic and other projects, to further stimulate market activity and enhance market liquidity.

Second, encourage the innovation of environmental protection technology, so that enterprises can carry out production development more cleanly and efficiently. On the one hand, it can greatly save the use of resources, provide resource utilization efficiency, and change the mode of economic development; On the other hand, it can reduce the carbon emissions of enterprises, take the road of green development, reduce the cost of enterprises to pay for carbon emission rights, and achieve sustainable development.

Third, it is necessary to establish a standardized supervision and management organization to actively explore the linkage relationship between markets in view of the similarities and differences in the development of various markets, further promote the information disclosure of various markets, reduce the trading risks brought by information asymmetry to participants, and issue early warning signals before the risk is coming, so as to stabilize the development of the carbon market.

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