Carbon Credit Price Research and Forecasting

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Abstract: This paper selects Beijing, Shanghai, Shenzhen and Guangdong carbon emission rights from January 2018 to August 2021 as the research objects. The impact of each factor on the price of their carbon credits is studied. Through multiple regression analysis, it is found that only Beijing and Shanghai can pass the model overall significance assumption. Examining the correlation coefficients, it is found that the price of natural gas and oil are negatively correlated with carbon credits, and coal is positively correlated with the price of carbon credits in both places. In this paper, the lenvenberg-marquardt algorithm is selected as the training function and its prediction is made by neural network.

Keywords: Carbon Emission Rights; Multiple Regression Analysis; Neural Network

Introduction

Since the 1990s, mankind has been concerned about the problems caused by excessive greenhouse gas emissions, and in 1997 the Kyoto Protocol was adopted for the first time at the United Nations with the objective of "stabilizing the level of greenhouse gases in the atmosphere at an appropriate level so as to prevent drastic climate change from causing harm to mankind". This is based on the meta-concept of emissions rights developed by Toronto professor Dalas in the 1990s. In the meantime, this meta-concept has led to the development of carbon sinks, carbon taxes and carbon credits, which are designed to limit and optimise carbon emissions in response to global warming. The UK government introduced a climate tax in 2001, and the EU carbon trading system was established in 2005 based on the Kyoto Protocol. At the end of the 20th century and the beginning of this century, China, as the largest developing country in the world, started late in controlling carbon emissions in the face of insufficient economic development and the basic situation of the people's living standards, which needed to be improved. However, in recent years, with the economic development and the people's pursuit of green water, clear mountains and a better and happier society as well as the international trend of emission reduction. The social issues of controlling carbon emissions, optimising the energy structure and changing the economic growth model have gradually entered the people's mind. To this end, President Xi Jinping proposed at the 75th UN Climate Conference that China should reach the carbon peak by 2030 and achieve carbon neutrality by 2060. China formally proposed a carbon emissions trading system in 2010, and in the following year seven cities, including Shenzhen, Beijing, Tianjin, Shanghai, Guangdong, Wuhan and Chongqing, were piloted as carbon emissions trading rights markets. 2013 saw the successive establishment of carbon exchanges in these seven cities. 2020 saw the further promulgation of the National Measures for the Administration of Carbon Emissions Trading (for Trial Implementation), marking the beginning of China's carbon emissions trading market in It is also an important step for China to reach the Paris Agreement.

1. Current status of research

As an important signalling indicator of carbon trading system, different scholars and schools of thought at home and abroad have given their explanations. Based on the EU carbon auction mechanism, Rong Gang constructs a model based on three aspects: trading system, market type, and the existence of price discrimination, and conducts an empirical study on the carbon trading market based on this model. Tan Ming uses a game theory approach to study carbon pricing in CDM projects and finds that there is a unique Nash equilibrium and a unique CERS equilibrium price. It was further concluded that the value of CERs in CDM projects is influenced by the market price of carbon emissions, the allocation ratio of CERs between developed and developing countries, and the technology acquired by developing countries through their CDM projects. Based on the factor analysis, Zhang Juan and Lin Xiaowei investigated the price of carbon credits from three aspects: economic, policy, and climate, and concluded that economic factors are positively related to the price of carbon credits, while climate factors are negatively related to the price of carbon credits. Chen Xiaohong and Wang Zhiyun also explored the impact of energy price, climate and market on the price of carbon emissions in three stages, and found that the mechanisms of different factors on the price of carbon emissions differed in different stages. Ma Zhongyun, on the other hand, introduces international markets into the consideration of economic, policy and climate factors, and concludes that international carbon emission prices move in the same direction as domestic carbon emission prices, but their influence is smaller. Chen Xiaohong and Wang Zhiyun use an EGARCH model to analyse the volatility of the spot price of carbon emission rights in the EU carbon trading market, and conclude that the characteristics of EUA prices vary at different emission reduction stages.

2. Empirical analysis

2.1 Data collection and indicator selection

This paper collects from the Guotai Junan database the average transaction price of carbon emission rights trading on trading days from June 18, 2013 to August 31, 2021 for the eight pilot carbon emission rights trading markets in Beijing, Shenzhen, Shanghai, Hubei, Chongqing, Tianjin, Fujian and Guangdong as raw data. Considering the integrity of the data, only five carbon emission markets, namely Beijing, Shanghai, Shenzhen and Guangzhou, were finally studied in this paper. Considering the uniformity of time units with other variables, this paper takes the average value of carbon emission trading price of each carbon emission trading market for the time unit of month. This paper also derives the monthly turnover of carbon emission rights in each market from the Guotai Junan database as an indicator of the activity of each carbon emission right market. In the hypothesis of corresponding energy factors, this paper selects indicators from three aspects: oil, coal and natural gas respectively. In order to include the price factors of each oil market as far as possible, the OPEC basket price is derived from the choice-financial terminal database as an indicator of oil prices. For coal prices, this paper selects the power coal futures settlement price from the choice-financial terminal database as the indicator for coal prices. In terms of natural gas, this paper selects the ex-factory price of natural gas from the Choice financial terminal database in Inner Mongolia.

2. Model Setting and Empirical Results

2.1 Multiple linear regression models

This paper assumes the following economic model:

$$Dealprice_{it}=C_1Dealamount_{it}+C_2Oilprice_t+C_3Coalpricet+C_4LNGprice_t+C_5PMI_t+C_6+u_t。$$

Dealpriceit represents the transaction price of carbon trading rights of category i at time t, Dealamountit represents the volume of carbon emission rights of category i at time t, Oilpricet represents the price of oil at time t, Coalpricet represents the price of coal at time t, LNGpricet represents the price of natural gas at time t, PMIt represents the value of Ut represents individual deviations.

In this paper, we first conduct a smoothness test, because this paper has chosen a time series, so there is the possibility of pseudo-regression, in order to eliminate this possibility, we conducted ADF unit root test for the data of the five groups of markets respectively through EVIEWS, the significance is taken as 5% , the results of which are summarized in Table 1:

Table 1

	Price of carbon credits	Carbon turnover	Oil prices (OPEC basket index)	Coal prices (main futures trading prices)	Natural gas prices (ex works in Inner Mongolia at new times)	PMI
ShenZhen	Unstable	Stable	Unstable	Unstable	Unstable	Stable
Shanghai	Unstable	Stable	Unstable	Unstable	Unstable	Stable

Beijing	Unstable	Stable	Unstable	Unstable	Unstable	Stable
Guangdong	Stable	Stable	Unstable	Unstable	Unstable	Stable

Multiple linear regressions were also conducted for each of the five markets and the results were summarised and summarised (Tables 2 - 6)

Table 2

	Price of carbon credits	Carbon turnover	Oil prices (OPEC basket index)	Coal prices (main futures trading prices)	Natural gas prices (ex works in Inner Mongolia at new times)	Constants
Coefficient	-3.21E-07	0.030260	-0.026494	0.001258	1.326653	28.76542
P-value	0.7999	0.7637	0.1082	0.4554	0.0090	0.2492

It can be seen that in the Shenzhen field, except for the PMI indicator which is significant, the rest hardly pass the hypothesis test and its adjusted R2 coefficient is only 0.125999, which is not a good regression.

Table 3

	Price of carbon credits	Carbon turnover	Oil prices (OPEC basket index)	Coal prices (main futures trading prices)	Natural gas prices (ex works in Inner Mongolia at new times)	Constants
Coefficient	4.55E-06	-0.065587	0.012604	-0.001595	0.035729	38.16096
P-value	0.0217	0.0789	0.1082	0.0133	0.8429	0.0001

It can be seen that in the Shanghai market all pass the hypothesis test except for the PMI indicator and oil price which are not significant, its adjusted R2 coefficient is only 0.2621, the regression effect is better than the Shenzhen market, and the F-test 0.004773 equation passes the wholeness test. Analysing the specific coefficients, there is a quantitative increase in the volume of carbon emissions traded and the price of carbon emissions traded in Shenzhen last month. If the significance is relaxed to 10%, the oil price coefficient also passes the hypothesis test. It can be seen that oil and natural gas prices are negatively correlated with the price of carbon credits, while coal prices are positively correlated with the price of carbon credits.

Table 4

	Price of carbon credits	Carbon turnover	Oil prices (OPEC basket index)	Coal prices (main futures trading prices)	Natural gas prices (ex works in Inner Mongolia at new times)	Constants
Coefficient	1.95E-07	-0.574812	0.009918	-0.007055	-1.153414	178.7621
P-value	0.0314	0.0016	0.7182	0.0187	0.1650	0.0001

It can be seen that in the Beijing market all pass the hypothesis test except for the PMI indicator and oil prices which are not significant, and its adjusted R2 coefficient has 0.522807, which is good as a micro data regression and the F-test p-value is 0.00022 The equation passes the wholeness test. Analysing the specific coefficients, there is a quantitative increase in the volume of carbon emissions traded and the price of carbon emissions traded in Shenzhen last month. The oil price coefficient also passes the hypothesis test. It can be seen that oil prices and natural gas prices are negatively correlated with the price of carbon credits.

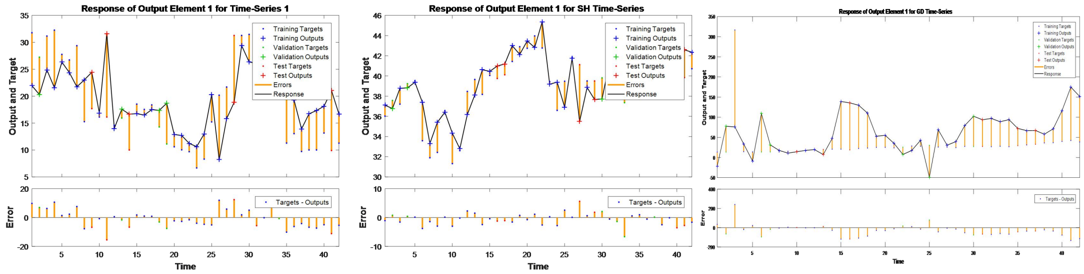
Table 5

	Price of carbon credits	Carbon turnover	Oil prices (OPEC basket index)	Coal prices (main futures trading prices)	Natural gas prices (ex works in Inner Mongolia at new times)	Constants
Coefficient	-2.53E-06	0.484315	0.035705	-0.006939	1.729788	74.91599
P-value	0.3551	0.4334	0.7293	0.5107	0.5697	0.6289

It can be seen that all indicators are insignificant in the Guangdong carbon market, none of them pass the hypothesis test, their adjusted R2 coefficient has 0.05, the fit is poor and the F-test p-value is 0.818, the equation does not pass the wholeness test.

2.2 Neural network based prediction

The multiple regressions above revealed that the data selected had difficulty in passing the assumption of smoothness of the multivariate time series. And most of the market fits do not add up to goodness of fit. In this paper, we consider that the factors that may influence the price of carbon credits are not simply linear, so we decide to train a neural network to predict the price of carbon credits. In this paper, the collected monthly data are divided into three parts: training set, test set and prediction set. The allocation is based on 70% of the training set, 15% of the test set and 15% of the prediction set. In this paper, lenvenberg-marquardt is chosen as the training function, the hidden layer is set to 10 dimensions, and the delay is set to 2. This is implemented through the neural time series work package in matlab2016a.



	Correlation coefficient between output and target
ShenZhen	0.5026
Shanghai	0.6681
Beijing	-0.4113
Guangdong	0.5299

It can be seen that the neural network prediction results are better than the multiple linear regression.

4. Conclusion

This paper summarises domestic and international perspectives and analyses the carbon credit prices in the Shanghai, Shenzhen, Guangdong and Beijing carbon credit trading markets in terms of the supply-demand relationship. The results found that among the four major markets, the Guangdong market regression overall equation was not significant, while Shenzhen, Shanghai and Beijing passed the equation overall test. Specific analysis of the coefficients reveals that oil price and natural gas price are negatively related to the carbon emission rights trading price in Shanghai and Beijing markets, while coal price is positively related to the carbon emission rights price. This may be due to the fact that participants in China's carbon emissions trading market are dominated by power companies and, while China's power generation is still dominated by thermal power, and because of the strong demand for electricity due to economic growth, price increases for coal are passed on to the price of carbon emissions. And compared to the small elasticity of demand for coal, when the price of oil and natural gas is more elastic, when oil and natural gas rise, companies will reduce their production plans, thus reducing the demand for oil and natural gas, further reducing the demand for carbon emission rights, and thus the price of carbon emission rights is reduced. However, the PMI index is less effective in explaining the price of carbon credits in local carbon trading markets.

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