The influencing factors of China carbon price: a study based on carbon trading market in Hubei province

Hao Li and Ming Lei

Guanghua School of Management, Peking University, Haidian district, Beijing 100871, PR China

Abstract. For the carbon market, good trading mechanism is the basis for the healthy development of the carbon trading market. In order to explore the core problem of carbon price formation, our research explores the influencing factors of the price of carbon trading market. After the preliminary statistical analysis, our study found that Hubei Province is in the leading position among seven pilots in the carbon trading volume and the transaction, so our study of carbon price takes Hubei Province as sample of the empirical research. Multi-time series model and ARCH model analysis method are used in the research, we use the data of Hubei carbon trading pilot from June 2014 to December 2016 to carry out empirical research, the results found that industrial income, energy price, government intervention and the number of participating corporation have significant effect on the carbon price, which provides a meaningful reference for the other pilots in-depth study, as well as the construction of a national carbon trading market.

1. Introduction

China attaches great importance to the construction of carbon trading market, clearly announcing "to establish and improve the greenhouse gas emissions accounting system, and gradually establish a carbon emissions trading market", "increase forest carbon sinks" and other initiatives in the "12nd Five-Year Plan". In December 2011, China delegated at the Durban Climate Conference that it would explore carbon emissions trading through the measures such as the establishment of voluntary emission trading mechanism, strengthening the construction of carbon emissions trading support system and so on. China pointed out that to promote the construction of a unified national carbon emissions trading market in “13th Five-Year” plan. In 2011, the General Office of the National Development and Reform Commission formally approved the pilot work on carbon trading in seven provinces and cities, including Shanghai, Beijing, Guangdong, Shenzhen, Tianjin, Hubei and Chongqing. As the market construction has just started, China carbon trading market operation is still very lack of experience, and the design of trading mechanism, the allocation of quota and punishment mechanism are considered to be the three difficult problems in the current pilot operation. Especially, the price mechanism is the core of the trading mechanism. [1] found that supervising the underlying characteristics of carbon price changes can help governments formulate correct policies to keep efficient operation of carbon markets. So, with the existing empirical data from carbon trading pilot, we explored price factors of China’s carbon trading market, which is of great significance for reasonable price formation mechanism to promote the market steady and healthy.
Until December 9th, 2016, Hubei carbon trading market has 293 million tons trading volume and the total turnover is 6.943 billion yuan. In addition to the primary market, the Hubei secondary market trading volume is 291 million tons, accounting for 39%; turnover is 6.903 billion yuan, accounting for 42.32% of the country. Among them, the total turnover of online spot market is 3121.08 million tons, accounting for 49.36% of the country, turnover is 701 million yuan, accounting for 42.29% of the country. The specific situation is shown in Figure 1.

Datasource: China carbon trading website, www.tanpaifang.com

Figure 1. The ratio of national carbon trading volume in seven pilots.

Since December 31, 2016, the carbon trading volume of national quota is 393 million tons and the total turnover is 9.32 billion yuan. Among them, the online trading volume is 63.2279 million tons and the turnover is 1.658 billion yuan. In December, the national carbon market turnover rose as a whole and secondary market average daily volume of national quota is 641,900 tons, up to 17.56%.

Since April 2014, the price of carbon market in Hubei has remained stable, leading a stable position among the seven carbon trading pilots, the regional average price trend of carbon market is shown in Figure 2.

Datasource: China carbon trading website, www.tanpaifang.com

Figure 2. National carbon price trend in seven pilots.

By comparing the carbon transactions of the seven carbon trading pilots, we found that the Hubei area has remained stable not only in terms of carbon trading volume and turnover, but also has been in a leading position in seven pilot projects, so we consider Hubei Province carbon trading market as an empirical research object.
2. Literature review
Carbon trading price mechanism has long been the concern of foreign scholars. In recent years, with the international carbon trading market is becoming increasingly active, foreign scholars in this area of empirical research is also increasingly rich. At present, the domestic and foreign researches of carbon market price formation mechanism and influencing factors include: [2] apply MA (1) -GARCH (1,1) model to investigate the EU ETS market, having found that there is a very huge gap between emission price behavior and other commodities'. In order to study arbitrage and purchasing strategies, [3] argue that carbon trading prices do not have any seasonal characteristics, and that the complete carbon dioxide price process should show a time and price-dependent volatility structure. [4] were used to study the three major exchanges under the European carbon trading system. The cost model and the stochastic differential equation were used for empirical research and they found that the system design of carbon quota storage and commercial borrowing between different stages is effective to pricing and arbitrage frameworks. [5], based on structural change theory, found that energy prices were one of the main drivers of the first phase of EUA spot prices. [6] used Self-exciting Threshold Autoregressive, Smooth Transition Auto Regression and Markov-Switching Autoregressive methods, found that there is relationship between carbon and macroeconomic activities. Research from the perspective of the supply of carbon prices found that the carbon market is under the guidance of the market, and quota issuance and mechanism design changes caused by the quota is expected to have a significant impact on carbon prices. [5] identified two major adjustments to the EUA price experience between 2005 and 2007, believing that the first adjustment was closely related to the excessive distribution of EUA. [7] studied the prices of EUA products traded on three exchanges and found that EU ETS's ban on intertemporal storage significantly affected the price of EUA.

Although domestic and foreign scholars have carried out a series of empirical studies on the carbon trading price mechanism, most of them are based on the EU carbon trading market (EU ETS), China's carbon trading market has become the world's second largest carbon trading market since 2013, but the study of carbon price is far from due attention, there are only few research on the price mechanism of carbon market in China, and there is no literature on the price mechanism of a specific pilot. In addition, the domestic research is still in the initial stage and because of the difference in China's political environment, this paper intends to take Hubei Province carbon trading pilot as a sample and consider the government intervention as a policy factor affecting the market. On the basis of theoretical analysis, to carry out quantitative empirical research on the carbon trading market price factors, which does good for China's other carbon trading market mechanism design, perfect pricing and construction of the national carbon trading market.

3. Empirical research
This part takes the carbon trading pilot in Hubei Province as the sample, carrying on the empirical research and the analysis, and we discuss the influencing factors of the current carbon trading price in our country.

3.1. Data and index design of carbon trading in Hubei province
We selected all the carbon financial instruments in the carbon trading stage of Hubei Province, that is, the carbon trading data from June 2014 to December 2016 as a sample for empirical research. All data are from the Hubei Carbon Emissions Trading Center website and the Wind database. The data are as follows,

3.1.1. Hubei province carbon trading price data. The price variable is selection of the carbon transaction price from each trading day, the sample ranges from June 2014 to December 2016.

3.1.2. Macroeconomic data. [8] studied the relationship between the European industrial sector and the carbon price. The results show that the activities of the industrial sector in Germany, Spain, Poland and the UK have impact on carbon prices, while German electricity production has the greatest impact...
on carbon prices. This study chooses the income of industrial enterprises as a measure of macroeconomic. As the income of industrial enterprises is a kind of monthly data, so we do smoothing for daily data.

3.1.3. Energy price data. According to DEHST's 2006 study, coal has a carbon content of 25% higher than that of oil and 70% higher than that of natural gas, so we believe that the ratio of coal / natural gas and is particularly important factor for quota prices. In addition, in the short term, the volatility of energy demand caused by abnormal reasons has a significant impact on the demand for quotas. Most coal is fixed in the form of long-term contract so their transaction price is fixed, which makes its day trading data more difficult to obtain. Electricity enterprises are the biggest traders, and their market transactions will have a relatively significant impact on market quotas. When electricity price and power generation increases, there will be more carbon emissions and quota demand, to promote the price rise; and vice versa, and coal is the main power generation materials, so we select the Hubei price index of coal for electricity and the retail price of liquefied natural gas in Hubei as the energy price variable.

3.1.4. Weather data. As other studies shown by [9], abnormal fluctuations in energy prices over the short term are also affected by abnormal weather changes such as temperature, rainfall, and so on. Extreme weather will affect the demand for energy, for example, cold weather in winter will increase the demand for electricity or energy heating, hot summer for cooling will also lead to a relatively high demand for electricity. Rainfall, wind speed and sunshine time will affect the use of carbon-free electricity and hydropower, wind and solar energy. To this end, the weather has been widely considered to have had a significant impact on past carbon trading prices. So we select the maximum temperature as a factor, and Wuhan is a representative of Hubei pilot temperature data and t the daily rainfall in Hankou District, Wuhan City, Hubei Province as the rainfall variable. The daily weather data comes from the sorting of statistical data on China's meteorological data network.

3.1.5. Government data. China's carbon trading market is an emerging market, rooted in China's transition economy, the dual characteristics of emerging and transition led to slight difference of China's carbon trading market and western countries, it is necessary to examine the special political environment before we study Chinese carbon trading market price mechanism. In this study, we select the regional government and market relations scores provided by Fan and Wang (2016) to quantify the degree of government intervention in the carbon trading market. [10] found that the EU ETS market was significantly affected by electricity demand. But differently, in China, Greenhouse gas emissions quotas, i.e. carbon finance instruments is the largest supply factor, according to the time to join the carbon trading market, all registered members would determine the emission reduction baseline and the annual emission reduction targets, and they must be reviewed by the regulatory body. So the carbon trading market may be affected by the number of registered corporates. In the study, we use the number of carbon emissions quota management enterprises , which are registered members in carbon trading market in Hubei Province.

3.2. Empirical design of carbon trading price in Hubei province
In order to explore the influence of various factors on the pilot price of Hubei carbon trading, our study uses the method of multiple time series regression to establish the regression equation between the influencing factors and carbon trading price. In order to better reflect these market characteristics, we apply the ARCH model to investigate the sample data. The autoregressive conditional heteroskedasticity model (ARCH) was first proposed by Engle in 1982. The model takes all available information as a condition and uses some kind of autoregressive forms to characterize variance. In this report, we use the data of Hubei carbon trading pilot in the previous research to find the autocorrelation by the residual analysis of the reconstructed model and determine the lag order of 3 according to the partial autocorrelation graph model.
Initially, we set up the empirical equation. The empirical establishment is using natural gas to the relative price of coal to avoid multiple collinearity. The test equation is as follows:

$$P_t = \beta_0 + \beta_1 \text{income}_t + \beta_2 \text{gas/coal}_t + \beta_3 \text{temp}_t + \beta_4 \text{rain}_t + \beta_5 \text{gov}_t + \beta_6 \text{cor}_t + \mu_t$$

(1)

Among them, the explained variable is $P_t$, that is, the daily price of carbon trading pilot in Hubei. The explanatory variables are $\text{income}$, $(\text{gas / coal})$, $\text{temp}$, $\text{rain}$, $\text{gov}$ and $\text{cor}$, respectively, are the income of industrial enterprises in the same period, the relative price of natural gas to coal, the maximum daily temperature, the amount of daily precipitation, the degree of government intervention and the number of carbon quota management enterprises.

Then, all the carbon trading price data were tested. For the equation (1), the multivariate time series regression is performed first, then the residuals are checked. According to Table 1, the autoregressive phenomena can be found in the residuals, and the conditional heteroskedasticity is found by the LM test. And determined to meet the ARCH (3) model.

| Table 1. LM Test Results | Table 2. ARCH (3) Model Results |
|--------------------------|--------------------------------|
| **VARIABLES**            | **VARIABLES**                  |
|                          | **(1) price**                  |
|                          | **(2) ARCH**                   |
| $L.r$                    | income                         |
| 0.541***                 | -3.45e-05***                   |
| (0.0406)                 | (2.59e-06)                     |
| $L2.r$                   | gas/coal                       |
| 0.265***                 | 32.86***                       |
| (0.0401)                 | (0.590)                        |
| Constant                 | temperature                    |
| 0.00867                  | 0.00577                        |
| (0.0367)                 | (0.00484)                      |
| Observations             | rain                           |
| 629                      | -0.000311                      |
| R-squared                | (0.000379)                     |
|                          | gov                            |
|                          | 4.916***                       |
|                          | (0.422)                        |
|                          | cor                            |
|                          | -0.00361***                    |
|                          | (0.00131)                      |
|                          | $L.arch$                       |
|                          | 0.561***                       |
|                          | (0.0804)                       |
|                          | $L2.arch$                      |
|                          | 0.225***                       |
|                          | (0.0485)                       |
|                          | $L3.arch$                      |
|                          | 0.173***                       |
|                          | (0.0308)                       |
|                          | Constant                       |
|                          | -128.2***                      |
|                          | (2.171)                        |
|                          | Standard errors in parentheses |
|                          | *** p<0.01, ** p<0.05, * p<0.1 |

3.3. Empirical study and result of Hubei carbon trading pilot

The time interval of current empirical study of Hubei carbon trading pilot is from June 2014 to December 2016, and we use the ARCH (3) as the variance equation to make OLS estimates for the equation(1). The empirical results are shown in Table 2.

On the whole, the variables are very significant except for the two variables of temperature and rainfall, which means that the weather factor does not significantly affect the carbon trading price. The study results also show that the economic development of the secondary industry, energy prices have impact on the carbon trading price, and the government intervention and the number of enterprises involved in the allocation of carbon quotas have significant impact on carbon trading prices at the
same time. Comparing the coefficients, we can find that the energy price is the biggest influencing factor, and its impact on carbon trading price is on the rise over time. Second, government intervention has a stable impact on carbon trading price. Also, we can see the macroeconomic development, energy prices, policy factors are still carbon trading price factors, but the energy prices become the biggest influencing factors, followed by government intervention.

Through in-depth analysis of the empirical results we can see that the secondary industry development, energy prices and government intervention affect the formation of carbon trading prices, of which energy prices is the biggest influencing factor. Possible reasons are as follows: coal prices and rising oil prices will push up the price of carbon, the mechanism for the industrial structure constraints and the price of electricity is not market conditions, the rigid demand for coal and other energy products led to rising carbon prices; the effect of weather changes for the current energy consumption is not significant, so the impact on the carbon price is not significant, which is consistent with China's carbon trading market carbon trading price factors empirical results by Chen Xin et al. (2016). For natural gas prices, the biggest feature of China's natural gas industry is the strong monopoly, and the raising of the price of natural gas rises the consumer price index (CPI) and reduces the carbon dioxide emissions, the carbon dioxide emissions per unit of GDP as well, and with carbon dioxide emissions gets slightly higher, the price of carbon transactions increases, in which Zhang Xidong et al. (2016) put forward the same point of view. As the carbon trading system has just been established, the relevant policies and systems are not perfect, the change is relatively large, causing a direct impact on the market quota supply and demand situation. As a commodity, quota supply and demand determine the price, triggering price fluctuations.

4. Conclusion & suggestions
Our study makes a theoretical analysis and empirical study on the influencing factors of the carbon trading price in Hubei Pilot. The theoretical analysis of the carbon trading pilot data in Hubei Province is consistent with the empirical results.

Under the background of carbon trading market in Hubei Province, the carbon trading price is mainly affected by the energy prices, other factors like industrial income, government intervention also have certain impact on carbon trading price. Moreover, we also found the impact of energy prices is the greatest, followed by the degree of government intervention, indicating that in China's emerging market of carbon trading, the government still adjusts the market through the policy means. In addition, the number of enterprises involved in the management of allocation of carbon quota also has a certain impact on carbon trading prices, indicating that the degree of participation affects the activity of the entire carbon emission, thus affecting the carbon trading price. It is worth noting that although the impact of industrial enterprises on the carbon trading price is significant, but from the impact coefficient perspective, the basic approach of industrial income is limited to zero, indicating that during current Hubei carbon trading process, the macroeconomic factors on the price mechanism are not effective, and the current carbon trading prices can’t effectively reflect the basic state of social macroeconomic. And from the view of foreign research, the weather factors have significant impact on the carbon trading price, but in the empirical study of carbon trading pilot in Hubei Province, the results are the opposite, indicating that the weather factor on the impact of energy consumption is small, has not yet reached the impact on energy prices, thus it can’t affect the extent of carbon trading prices, but for other carbon trading market, whether such impact exists remains to be studied.

4.1. Strict regulatory system and implementation
Compared with the carbon pilot markets, there will emerge the future expansion of the national carbon market, and the increase in the main types of the market, the rich trading products and the interests of the diversification. At the same time, the possibility of manipulation of the market, insider trading and other malicious market phenomenon will increase. The impact of government intervention on carbon trading price is significant recommends that the government should set an example by itself, and improve the construction of the supervision system, enhance the supervision and implementation of
the carbon market. The government should also introduce the relevant normative documents with guidance and operation, and establish cross-sectoral supervision on the emerging carbon trading products. At the same time, we should strengthen the management of the verification agencies, clear the scope of business and improve the access threshold, to change the supervision of the whole society to a better way through the authority of the information disclosure system.

4.2. Cultivate a good market environment
Pilot experience has shown that the highly centralized, unified feature, policy stability, predictability and transparency of the trading market is critical to build a fair, open and sustainable carbon market. The government should optimize the carbon market management model, clarify its responsibilities and roles in carbon trading, reduce the government's direct intervention in the market, maintain policy continuity and stability, and avoid policy risks. The government should promte the construction of carbon trading system information disclosure, credit platform and other supporting mechanisms to build an open, fair and transparent carbon market trading environment. The government should rationalize the development of carbon trading price mechanism for creating a reasonable and orderly and efficient carbon trading market and do policy work, based on real-time energy prices, carbon trading quota allocation, the number of participating enterprises and other factors.

Above all, in the process of establishing a carbon trading market in the pilot area, first of all, it is necessary to introduce and establish a good trading system and policies to ensure the scientific allocation of quotas and guide the reasonable price of carbon trading. Second, we should rationalize the energy price mechanism, with the quota supply and demand factors, and jointly promote the formation of a reasonable market price.

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