# An Analysis of the Interactions between Electricity, Fossil Fuel and Carbon Market Prices in Guangdong, China

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## 1. Introduction

The formation of substantial carbon market prices and the pass-through of price signals to the end users of electricity are essential for achieving the goals of a greenhouse gases emissions trading scheme (GHG ETS). There remains a long way for the true carbon costs of China's power companies to flow through electricity prices since the establishment of a nationwide carbon market and the new round reform of power sector are still under advancement in parallel. Within such a process, it is necessary to clarify the unique institutions of power sector in China for understanding the reform complex. Giving an analysis of the interactions between the pilot carbon market and electricity forward market, which have been operated, i.e., in Guangdong province for several years, is meaningful to seek the opportunity for promoting the effectiveness of national GHG ETS in the future.

## 2. Research method

Various methods were applied for this analysis. The related information was gathered to figure out the latest progress of the pilot ETS and the reform of electricity market in Guangdong. The historical data of price series were collected as much as possible from the accessible sources. After the information collection and data compilation, Stata was applied for the statistical tests and regressions with a standard procedure for the analysis of time-series data. Different with the previous researches in the regions of EU-ETS and the U.S., the forward electricity prices were confirmed to be stationary in this study. The multivariate OLS was thus applied by converting all the non-stationary input price series into the stationary variables. Since all the input prices are non-stationary and their first differences are stationary, the co-integrated vector error correlation model (VECM) was performed to analyze the linkage between carbon price and fossil fuel prices.

## 3. Analysis results

- Statistics of various prices

Statistics of the five price series, available from the beginning of 2016 to April, 2019, indicates that distribution of electricity and coal prices is skewed to the left with a negative skewness, while distribution of carbon and diesel prices is skewed to the right with a positive skewness and LNG prices are distributed symmetrically with a skewness of nearly 0. The kurtosis value of electricity and carbon prices is greater than 3.00, confirming their heavy tailed distribution. The distribution of the other prices are light tailed with a kurtosis less than 3.00.

- The relationships between carbon and fossil fuel prices

With the co-integration rank and optimum number of lags determined, the VECM was run and the estimation results are reported in the table below. The co-integrated vector shows that coal and diesel prices have a positive

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impact, while LNG price indicates a negative impact on carbon prices from the long run in Guangdong. If looking at the short term parameters, the lagged carbon and coal prices indicate significant impacts on their own current market prices. This implies that the prices of carbon and coal are essentially exogenous in the short run. Nevertheless, the lagged coal, diesel and LNG prices have no effect on the short term dynamics of carbon prices. Therefore, the carbon market investors can't use the historical information of fossil fuel prices to improve their short run forecast of the spot carbon prices in Guangdong pilot market.

Table: The result of VECM model analysis of carbon and fossil fuel prices

| A) Co-integration relationship | | | | |
|---|---|---|---|---|
| Endogenous variables | $P_{-Carbon}$ | $P_{-Coal}$ | $P_{-LNG}$ | $P_{-Diesel}$ |
| Coefficients | 1.00 | -0.1696*** | 58.7006*** | -31.2394*** |
| B) Short run dynamics | | | | |
| | $\Delta P_{-Carbon}$ | $\Delta P_{-Coal}$ | $\Delta P_{-LNG}$ | $\Delta P_{-Diesel}$ |
| Error correction | -0.1026** | 1.8629*** | 0.0008 | -0.0008 |
| $\Delta P_{-Carbon}$ (-1) | -0.5816*** | -0.0538 | -0.0061 | -0.0326 |
| $\Delta P_{-Carbon}$ (-2) | -0.4267** | -0.8089 | -0.0106 | -0.0249 |
| $\Delta P_{-Coal}$ (-1) | 0.0176 | 0.7481*** | 0.0011 | 0.0015 |
| $\Delta P_{-Coal}$ (-2) | 0.0272 | -0.4602*** | -0.0008 | 0.0007 |
| $\Delta P_{-LNG}$ (-1) | -1.7428 | -42.6142 | 0.3464 | 0.7758 |
| $\Delta P_{-LNG}$ (-2) | -8.3444 | -115.0822** | -0.1037 | 0.0028 |
| $\Delta P_{-Diesel}$ (-1) | 2.2893 | 57.1524** | -0.0018 | -0.0228 |
| $\Delta P_{-Diesel}$ (-2) | 5.0628 | 83.3590*** | 0.1015 | -0.0001 |
| Constant | -0.1941 | -0.0107 | 0.0079 | 0.0113 |
| R-squared | 0.5118 | 0.8050 | 0.2907 | 0.2696 |
| Log likelihood: -95.16; AIC: 9.87; HQIC: 10.49; SIC: 11.91 | | | | |
| Note: *** Significant at 1% level; ** Significant at 5% level. | | | | |

- Regression result with electricity forward price as the dependent

Using electricity forward price as the dependent, multivariate OLS regressions were carried out with the first differences of other prices as the independents. The result indicates that electricity price in Guangdong is significantly and positively associated with the first difference of coal price, but has no significant relationship with the first difference of the other two fuels, including diesel and LNG. There reveals no significant relationship between the electricity price and the first difference of carbon prices. This implies that the change in carbon prices of Guangdong is still not a factor influencing power company's bidding strategy in the monthly forward market.

**4. Conclusions**

This analysis provides some implications for the synergy of power sector reform and nationwide carbon market development in China. The liberalization of power industry shall be further advanced to create the conditions for carbon cost pass-through in the electricity markets. The national ETS shall apply simpler and stricter benchmarks, and auctioning to allocate the emissions allowances of power sector for the formation of substantial carbon market prices and the shift to a low carbon power supply portfolio.