Energy Policy 106 (2017) 111–121

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

# The response of the Beijing carbon emissions allowance price (BJC) to macroeconomic and energy price indices

Shihong Zeng[a,b,*], Xin Nan[a,b,*], Chao Liu[a,b], Jiuying Chen[a,b]

[a] Applied Economics Department, College of Economics & Management, Beijing University of Technology, Beijing 100124, China

[b] Finance and Economics Development Research Center, College of Economics & Management, Beijing University of Technology, Beijing 100124, China

ARTICLE INFO

*JEL:*
Q21
Q41
Q43
Q56
Q59

*Keywords:*
Beijing
carbon emissions allowance price
SVAR approach

ABSTRACT

In 2013, China opened pilot carbon emission trading markets in seven provinces, where carbon emission allowances have now been traded for more than two years. In this paper, we employ a structural VAR model and the price of the Beijing carbon emission allowance to study the dynamic relationships among the price of the carbon emission allowance, economic development and the price of energy. This paper's data cover the period from April 2, 2014 to November 6, 2015. This paper provides information that will be helpful to both investors and governmental policy makers. The results show that (1) an increase of one standard deviation in the coal price leads to an initial increase of approximately 0.1% in the Beijing carbon price. After 2 days, there is a decrease of less than 0.1%, and the price gradually increases by approximately 0.1% after 30 days; (2) the price of the Beijing carbon emission allowance is mainly affected by its own historical price; (3) the Beijing carbon emission allowance price, crude oil price, natural gas price and economic development have positive – albeit non-significant – correlations.

## 1. Introduction

Climate change and carbon emissions are major problems that are attracting substantial worldwide attention (Li et al., 2014; Calel and Dechezleprêtre, 2016; Zeng and Chen, 2016; Zeng et al., 2016). Consequently, many scholars have analyzed both carbon intensity and energy savings (Su and Ang, 2015; Wang et al., 2014; Wu, 2012).

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to promote international negotiations on climate change and to set long-term goals to reduce greenhouse gas emissions (Schmalensee et al., 1998). Another international agreement, the Kyoto Protocol, sets emissions targets that restrict the carbon emissions of thirty-seven industrialized countries and the European Union. Additionally, the principle of common but differentiated responsibilities establishes different goals for these thirty-seven industrialized countries, excluding developing countries such as China and India (Aichele and Felbermayr, 2015). Although China has no obligation to meet these binding constraints, it has nevertheless been working to reduce its own greenhouse gas emissions to slow global climate change. According to Guo (2015), China is the world's largest energy consumer and CO2 emitter. Fossil fuel combustion is an important source of greenhouse gas emissions. The power sector uses fossil fuels to generate power, which produces very large emissions of greenhouse gases. China has become the world's largest producer of electricity. In 2015, its ratio of coal power generation to overall power generation was 75%, which was higher than the international average of 28% (Liu, 2015). China's coal consumption accounted for 64% of its total energy consumption in 2015, while hydroelectric generation, wind power generation, nuclear power generation, natural gas and other clean energy sources accounted for 17.9% of total energy consumption, according to the National Bureau of Statistics of the People's Republic of China.

In 2015, at the twenty-first session of the United Nations Climate Change Conference, China set an ambitious goal: it aims to reduce its carbon dioxide emissions in per unit GDP by 60–65% by 2030 relative to its 2005 levels. Moreover, China expects its carbon dioxide emissions to peak in 2030 and aims to achieve this goal as soon as possible, as it currently faces enormous pressure to reduce its emissions.

Implementing carbon trading systems has been recognized as one of the main instruments by which to control the world's air pollution and greenhouse gas emissions. China's thirteenth five-year plan proposed the establishment of a national carbon emissions trading market during the thirteenth five-year period. Thus, the establishment of this carbon emissions trading market has become an important component of China's sustainable development and international competitiveness.

* Corresponding authors at: Applied Economics Department, College of Economics & Management, Beijing University of Technology, Beijing 100124, China.
*E-mail addresses:* zengshihong@bjut.edu.cn (S. Zeng), 460182810@qq.com (X. Nan).

http://dx.doi.org/10.1016/j.enpol.2017.03.046
Received 5 September 2016; Received in revised form 29 January 2017; Accepted 20 March 2017
Available online 26 March 2017
0301-4215/

China's pilot carbon emissions trading programs began operating in the second half of 2013 in 7 provinces and cities. Compared to the international emissions trading market, China's is currently in its initial stage and, unsurprisingly, has some significant problems, including unreasonable carbon emissions pricing and an imperfect carbon emissions trading mechanism. Price is the weather vane of the market: a change in the price of carbon emissions is a response to the supply of and demand for carbon emissions allowances in the carbon trading market, which influences the volume of carbon emissions. Therefore, it is essential to study the factors that influence the price of carbon emissions.

This paper is structured as follows. In Section 2, we present a review of the literature. In Section 3, we present the research framework and the SVAR model for carbon emission prices. In Section 4, we introduce the variables and data sources and estimate the SVAR model. Section 5 presents our empirical results and analyses. Section 6 provides a brief conclusion.

## 2. Literature review

### 2.1. Review of factors influencing carbon emissions trading and prices

As the international carbon market has developed and many countries have become active participants in carbon trading, a growing number of studies have examined the influential and determining factors affecting carbon emissions trading and prices.

From a macro perspective, some studies have analyzed how economic activities and energy policy affect carbon emissions trading. Guðbrandsdóttir and Haraldsson (2011) analyze the effects of the UK energy market and global equity indices on the price of carbon credits in the EU emissions trading system (EU ETS) and find an insignificant relationship between European Union Allowances (EUAs) and the UK power market; the switching price has little impact on the price of carbon credits. Based on a study at the firm level, Brauneis et al. (2013) argue that uncertainty in long-range climate policy is the main factor driving changes in carbon prices. Koch et al. (2014) investigate whether the economic recession, renewable energy policies and the use of international credits caused the decline in the EUA price from mid-2008 to mid-2013 and find that economic activity and solar electricity production can reflect the EUA price. Li et al. (2016) estimate the impact of both the economy and climate on an emissions trading system (ETS) in China, focusing on the impact of a regulated electricity price regime on carbon emissions prices.

Many studies thus far have been devoted to investigating the impact of energy prices on carbon emissions prices at the micro level. Kim and Koo (2010) focus on the impact of energy prices on the carbon allowance market in the US and find that in the long-term, coal prices have the strongest effect on carbon allowance trading. In the short-term, the impacts of the prices of coal, crude oil and natural gas on the carbon allowance market are significant. Hammoudeh et al. (2014a) study the effects of the prices of crude oil, natural gas, coal and electricity on the distribution of carbon emissions allowance prices in the US and find that the prices of crude oil, natural gas and coal have negative impacts on the carbon price; the electricity price, however, has a positive effect in the right tail of the distribution of carbon prices. Sousa et al. (2014) analyze the lead-lag relationship at different frequencies among $CO_2$ prices, energy prices and economic activity using multivariate wavelet analysis. Hammoudeh et al. (2015) study the asymmetric and nonlinear effects of price changes for crude oil, natural gas, coal and electricity on the $CO_2$ emissions allowance price in the US.

China's carbon emissions market is still in its initial stage; therefore, little research has studied the factors influencing prices in this very new market. Instead, most scholars have studied China's $CO_2$ marginal abatement cost and shadow prices. Some studies have calculated the shadow prices of China's carbon emissions at the provincial level by using a directional distance function approach and found that the shadow price is linked to regional economic development levels (Wang et al., 2016; Zhang et al., 2014).

Many studies of China's carbon emissions market have been published in recent years (Xia and Tang, 2017; Fan et al., 2016; Zhao and Hu, 2016; Zhang, 2016; Lv and Shao, 2015; Guo, 2015). Xia and Tang (2017) investigated the influence of different emissions accounting methods on carbon markets. China's unified carbon emissions trading market is conducive to reducing carbon emissions (Fan et al., 2016). Zhao and Hu (2016) showed that the market environment is one main factor that influences the carbon trading price. Policy factors and climate change are other main factors that affect carbon trading prices; energy prices also have a certain influence on carbon trading prices, but the effect is not obvious. Zhang (2016) showed that Shenzhen carbon emissions affect the price and that the Chinese manufacturing purchasing managers' index has at least one long-term co-integration relationship in China. Lv and Shao (2015) found that the price of carbon emissions shows regional differences in China. Guo (2015) found that the domestic carbon price is affected by the euro and secondly by the domestic oil price; the domestic economy and the European economy both have a positive effect on the domestic regional carbon price.

### 2.2. Review of methods of studying carbon emissions

The factors affecting price fluctuations in carbon emissions are extensive and include policy factors, domestic and international energy prices, macroeconomic indicators, etc. Many scholars have used the VAR model to study this complex problem.

The use of the VAR model to study and predict the dynamic impact of disturbances to this system involves several related variables. Notably, there have been many studies of the factors that influence stock returns and asset prices (Brana et al., 2012; Carvallo and Pagliacci, 2016; Fayyad and Daly, 2011; Jayasuriya, 2011; Ülkü and İkizlerli, 2012).

As a carbon emissions allowance is a type of scarce asset, some scholars use the VAR model and variations of the VAR model to analyze the interactive relationship among carbon emissions trading and other factors. The details of these studies are presented in Table 1. Hammoudeh et al. (2014b) use a Bayesian Structural VAR to examine the effect of energy price on the prices of $CO_2$ emissions in the short-run. da Silva et al. (2016) use a VECM model and find that the EU ETS has a positive long-term effect on the aggregated power sector stock market return in Phase II. Chevallier (2011a) applies two-regime Markov-switching VAR models to establish the relationship between carbon price returns and industrial production and finds that macroeconomic activity may influence carbon prices with a lag. Xu and Lin (2015) study the factors influencing carbon dioxide emissions in China's transport sector using a VAR model.

Chevallier (2011b) analyzed the impact of economic activities and energy prices on the EU's carbon emissions prices using the Markov-switching VAR model and found that economic activities influence carbon prices; the Brent oil price is a leading factor affecting carbon prices on the energy market. Piroli et al. (2015) use a structural vector autoregression (SVAR) model and investigate the effects of rising bioenergy production on global $CO_2$ emissions.

Compared with the VAR model, the SVAR model better captures instantaneous structural relationships among the variables in the model system, and it introduces the structural relationship between economic variables and financial theory into the VAR model.

Large studies have used the SVAR model to study factors influencing price. Clark (1999) studies the effect of monetary policy on production prices at different stages. Yu and Mallory (2014) analyze the impact of exchange rates on carbon prices in the EU ETS and find that a change in the exchange rate can affect the substitution between