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European Union emissions trading scheme impact on the Spanish electricity price during phase II and phase III implementation

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ABSTRACT

The European Union Emissions Trading Scheme (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. The purpose of the present work is to evaluate the influence of CO_2 opportunity cost on the Spanish wholesale electricity price. Our sample includes all Phase II of the EU ETS and the first year of Phase III implementation, from January 2008 to December 2013. A vector error correction model (VECM) is applied to estimate not only long-run equilibrium relations, but also short-run interactions between the electricity price and the fuel (natural gas and coal) and carbon prices. The four commodities prices are modeled as joint endogenous variables with air temperature and renewable energy as exogenous variables. We found a long-run relationship (cointegration) between electricity price, carbon price, and fuel prices. By estimating the dynamic pass-through of carbon price into electricity price for different periods of our sample, it is possible to observe the weakening of the link between carbon and electricity prices as a result from the collapse on CO_2 prices, therefore compromising the efficacy of the system to reach proposed environmental goals. This conclusion is in line with the need to shape new policies within the framework of the EU ETS that prevent excessive low prices for carbon over extended periods of time.

1. Introduction

The European Union Emissions Trading Scheme (EU ETS) is the first international system for trading greenhouse gas emission allowances. The EU ETS works based on the 'cap-and-trade' principle. Among the several industries covered by the scheme, the electricity sector is the largest one. Launched in 2005, implementation of the EU ETS was set to run in three phases: the first (pilot phase) ranging from 2005 to 2007, the second from 2008 to 2012 and now in its third phase, running from 2013 to 2020. Economic theory explains why under a 'cap-and-trade' system, the price of emissions ought to be treated as a marginal cost. As a producer holds allowances, the electricity production and CO_2 emission compete with the possibility of selling those allowances in the market. Therefore, according to the economic theory, energy producers are expected to add this new cost to their marginal production cost whether or not CO_2 allowances are granted for free. This so-called CO_2 opportunity cost equals the CO_2 market price. Adding the opportunity cost of carbon to the other costs of energy generation and passing these costs through to the electricity price is a necessary condition for achieving the environmental targets in a cost-efficient way (that is, guaranteeing that the emission cuts would be made by those firms that could achieve the most efficient abatement costs).

Thus, the efficiency of the EU ETS in providing incentives both to the energy producers (to reduce their emissions by switching to or investing in technologies with lower emissions) and energy consumers (to reduce their demand of electricity by increasing their energy efficiency) depends on whether or not CO_2 costs may be passed through to electricity prices. We therefore investigate as our research problem the interaction between the electricity markets and carbon markets trying to find out how the EU ETS impacts the price of electricity. Our specific research questions are: Does the carbon price have an impact on the Spanish electricity price? Do the

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prices of electricity and carbon (and other fuels used in electricity generation) share a common trend?

The theoretical foundation of the CO_2 cost pass-through to electricity prices is well established in the scientific literature, as presented by Sijm et al. (2006) in the context of perfect competition, and by Bonacina and Gulli (2007) for markets under imperfect competition. While electricity producers may fully recognize the opportunity costs of CO_2 allowances in their marginal production costs, these costs might not be fully passed through to electricity prices. Sijm et al. (2005) and Gullì (2008) offer a set of explanations for the pass-through rate of CO_2 costs into electricity prices that may differ by 100%, including among other reasons demand response (price elasticity), level of energy demand (peak-load vs. off-peak-load), market structure (degree of market concentration), technology mix (fuel used in production), and available generation capacity.

This paper builds on previous work by the authors for the Portuguese Electricity Market (Freitas and Silva, 2013, 2012) on the complementary division of Iberian Electricity Market (MIBEL). According to our knowledge, we believe this study is an innovative contribution to the state of the art due to the fact that our research embodies the first empirical study of the Spanish market for the complete Phase II of the EU ETS, as well as the first empirical study on the European market to include results from the Phase III of the system. Moreover, the econometric treatment given to renewable energy within the model alongside carbon and fuel prices represents an important contribution considering the growing significance of these technologies in the Spanish energy mix. This paper is structured as follows. Section 2 presents a brief literature review. Section 3 describes the functioning of the Spanish electricity market and presents the data set. Section 4 describes the methodological approach. Section 5 presents the empirical findings. Section 6 concludes.

2. Literature review

Previous authors began to assess the interaction between carbon prices and electricity prices. A more extensive literature review regarding the EU ETS impact in the European power sector can be found in Freitas and Silva (2013). Initial published analyses conducted in order to estimate the pass-through rate of CO_2 cost into electricity prices have not considered the mutual interactions between electricity price, fuel prices (natural gas, coal, fuel, oil), and carbon prices. The first studies taking those interdependencies into account through multivariate analysis, where all prices are modeled as a joint system, were provided by Honkatukia et al. (2006) and Fezzi and Bunn (2009). Developing a Vector Error Correction Model (VECM), with the electricity, gas and carbon prices modeled jointly as endogenous variables, and temperature as an exogenous regressor, Fezzi and Bunn (2009) estimated the dynamic pass-through of CO_2 price into electricity price for Germany and the UK. Honkatukia et al. (2006) developed a similar model for the NordPool market considering the electricity, gas, coal, and carbon prices as endogenous variables. Other studies, including this one, have followed that econometric approach. Fell (2010), also for the NordPool and with the same prices variables, added to the VECM the temperature and the reservoir water level as exogenous regressor. Thoenes (2011) analyzed the relationship among electricity, fuels, and carbon prices for the German market, also with a VECM. Honkatukia et al. (2006), Fezzi and Bunn (2009), Fell (2010), Thoenes (2011), and Freitas and Silva (2013) found a long-run cointegrating equilibrium among electricity, fuels, and carbon prices. Chemarin et al. (2008) estimated a VECM to the French energy market considering electricity, gas, oil, and carbon prices as endogenous and two different weather variables: temperature (affecting the demand side of electricity market) and rainfall (influencing the electricity production of a country concerning its energy mix). The authors found that there is no short-run relationship between electricity returns and carbon returns, while there is a long-run relationship. Pinho and Madaleno (2011) examine the interactions between carbon, electricity, and fossil fuel (coal, oil, and natural gas) returns for Germany, France, and Nordic countries. They analyzed the effect of nuclear power generation using a VECM and found it could limit increases in electricity prices as a result of increased carbon prices.

Mohammadi (2009) analyzes the relation between the electricity prices and coal, natural gas, and crude oil prices for the United States (US) market finding, a long-run relationship between electricity and coal prices. Also for the US market, Mjelde and Bessler (2009) added the uranium price to the analysis and controlled for weather effects with temperature variables similar to those used in our model. They concluded that in the long run the price of electricity is influenced by the fuels market as these prices are weakly exogenous, except for uranium. Ferkingstad et al. (2011), for the Northern European electricity markets, studied the dynamics between electricity and fuel prices (oil, natural gas, and coal) with wind power and water reservoir level as exogenous variables. Using a VECM and a Linear non-Gaussian Acyclic Model (LinGAM), they concluded that in the long run, electricity and natural gas prices are interlinked. Moutinho et al. (2011) focused the Spanish power market, same as our study, but for an earlier period (2002–2005). Based on a cointegration approach, they concluded that electricity price is explained by the evolution of natural gas prices.

Cotton and Mello (2014) analyzed the efficiency of the Australian Emission Trading Scheme using a long-run structural modeling technique. They applied a generalized forecast error variance decomposition, finding that emissions prices have little effect on electricity prices.

Jouvet and Solier (2013) used a first order autoregressive model to assess the cost pass-through of CO_2 into electricity prices. Their results indicated that while energy producers pass through the carbon cost during Phase I, the relationship between CO_2 costs and marginal costs of electricity seems to be less evident over the second phase due to the global financial crises. Aatola et al. (2013), for a set of European countries, concluded that the carbon price has a positive but uneven impact on electricity prices. Boersen and Scholtens (2014), employing a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model concluded, for the NordPool market, that the price of electricity is partly determined by the cost of the fuel inputs (natural gas and oil prices) and these costs are affected by EUA prices.

With respect to the recent behavior of the carbon market and impacts on the electricity sector the recent works of Van den Bergh et al. (2013), Fagiani et al. (2014) and Koch et al. (2014) identified a set of reasons that might explain the CO_2 price fall observed in recent years. These factors include economic recession, renewable policies and the use of international green certificates. Also, the impact of new developments in energy commodities markets on the price of CO_2, namely the availability of cheap gas (shale gas), has been emphasized by some authors (Glachant and Ruester, 2014).

3. Spanish electricity market and data

The Spanish energy sector was liberalized in the late 1990s and the Spanish electricity wholesale market was established in 1998. An important reform implemented in the Iberian wholesale electricity markets was the launch of MIBEL in July 2007. The joint Portuguese-Spanish electricity market allows participants to trade power on either side of the border. The daily spot market (the drive