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ENERGY, MOBILITY AND OTHER REAL WORLD APPLICATION

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Towards an Auction System in the Allocation of EU Emission Rights: Its Effect on Firms' Stock Market Returns

Patrícia Pereira da Silva[1], Blanca Moreno[2] and Ana Rosa Fonseca[2]

Abstract

The impact of the European Union Emission Trading System (EU ETS) on firms' stock market returns relies on the system employed to allocate emission allowances. This impact has been analysed in the literature for the EU ETS Phase I and II periods under which allowances were given for free. However, the effect during the current phase, Phase III, where the allocation of emission permits is based on an auction system has not yet been analysed and discussed.

In this framework, this paper discloses the results of a research aimed at investigating the interactions between the stock market returns of Spanish industry sectors under EU ETS and emission rights prices during the first year and half of Phase III. A cointegrated Vector Error Correction analysis is employed for the period covering January 1st 2013 until July 31st 2014.

The analysis presents statistically significant positive long-run impact of EU ETS on power sector, cement and petroleum and negative impact on iron and steel sectors. No short-run interactions were found for the sectors analysed.

Keywords: European Union Emission trading system; Energy costs; Vector error correction analysis

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1. Introduction

The European Union Emission Trading System (EU ETS) has been implemented in three phases with different systems to give out emission allowances: Phase I, from January 2005 to December 2007, where emission rights were allocated for free; Phase II, from January 2008 to December 2012, where over 90 percent of the allowances were given out for free (usually referred as 'grandfathering'); and the current phase, Phase III, from January 2013 to December 2019, during which the allocation of emission permits are given out predominantly through auctions. As stated by Ellerman et al. (2014), the EU ETS is possibly the principal market-based application of economic principles in the climate domain and the largest cap-and-trade program yet implemented.

The introduction of an EU ETS instrument can produce impacts on the stock market returns, profitability and international competitiveness of companies covered by the EU ETS, such as: power plants; oil refineries; ferrous metallurgy; cement clinker or lime; glass including glass fibre; ceramic products by firing and pulp, paper and board.

In that sense, European Union carbon emissions allowances (EUA) price fluctuations can disturb companies' stock market value through cash flows and expected returns. Firstly, carbon dioxide prices could influence cash flows of companies as they can incorporate their carbon emission allowance costs in their sale offers. Therefore, a variation in pollution prices would be reflected in output prices as well as in costs. Secondly, Litterman (2013) and Pindyck (2013) indicate that carbon emissions generate "carbon risk" as they could lead to a climate disaster impacting the prosperity of next generations. Since polluting firms are exposed to carbon risk, they will require higher expected returns relative to non-polluting firms.

Therefore, the final effect of carbon emissions allowances prices on firms' profitability is ambiguous, as it depends on the ability of firms to pass to consumers the increase in marginal cost through higher output prices and the uncertainty about carbon risk. For instance, Sijm et al. (2006) indicate that pass through rates of German and Netherland power companies vary between 60 and 100 percent of carbon costs depending on the carbon intensity of the marginal production unit. In the same way, Ostreich and Tsiakas (2014) show that the initial two phases of EU ETS generated a carbon premium in stock returns of German firms explained by the higher cash flows due to the free allocation of carbon emission allowances and the carbon risk factor of firms with high carbon emissions.

The existing empirical studies do not converge to a shared position as many of the studies are country-region specific and results also rely on the modelling method, the period studied, the system used to give out the emission allowances, the market structure, the used econometric tool and scenarios analysis adopted impeding the generalization of their findings.

Some scholars have concluded that the EU ETS has had a positive effect on companies: Smale et al. (2006), Demailly and Quirion (2009), Goulder et al. (2010), among others suggest that, in many sectors, firms make net profits due to the impact on product prices combined with the free allocation of allowances during Phase I and II.

There is another view that the EU ETS has had little or no effect on companies: Anger and Oberndorfer (2008) indicate that the initial allocation of allowances did not affect revenue and the employment of German firms over the period of 2005–2006.

Moreover, the effect of the EUA prices on companies also depends on the economic sector studied but also considering the same sector results can be ambiguous: Bushnell et al. (2013) found that the decline in the price of carbon allowances had the highest negative impact on the stock returns of carbon-intensive industries; Smale et al. (2006) applying the Cournot representation of an oligopoly market to five sectors for UK (steel, aluminium, cement, newsprint, and petroleum) concluded that most participating sectors would be expected to profit; Demailly and Quirion (2009) discovered that profitability of EU steel makers raised under a 20 euro per ton CO_2 price and the amount of allowances allocated for free during Phase I, but Chan et al. (2013) concluded that EU ETS had no impact on the revenue performance of cement and iron and steel industries.

For the case of electricity sector, Oberndorfer (2009), Veith et al. (2009), Keppler and Cruciani (2010), Mo et al. (2013) and Chan et al.

(2013) found that EUA price changes and stock returns or revenue of the European electricity corporations are shown to be positively correlated. However, the particular effect of EUA price changes on electricity corporations´ stock returns varies across countries (Oberndorfer 2009 found a significantly small negative relationship for Spain), EU ETS phase (Mo et al. 2013 found a positive and negative correlation during phase I and II respectively) or power generation technology (Bode, 2006).

It has been showed that several studies have investigated this impact under EU ETS Phase I and II when the allowances were allocated for free. However, the effect during current Phase III, when the allocation of emission permits is given out predominantly in auctions, is still unknown. In 2013, EU ETS began its ninth year of operations after having progressed from a system with 25 national caps and decentralized allocation based on national allocation plans and dealing with CO_2 emissions alone towards a centralized system including several greenhouse gases (GHGs) and presenting an EU-wide cap indefinitely declining at an annual rate of 1.74%. Having entered Phase III a prevalence of free allocation has given way to a mixture of auctioning and free allocation based on benchmarking for sectors believed to be at risk of carbon leakage, with full auctioning for all sectors as the medium-term goal (Ellerman et al. 2014).

In the context of this debate, this study analyses whether and to what extent the EUA prices may be linked with polluting sectors' stock market returns in Spain during current Phase III. We use a cointegrated Vector Error Correction (VECM) model. Multifactor market models are widely used to study the effect of EU emission allowance prices (and others variables such as fuel prices and electricity prices) on corporate value change (Mo et al. 2013, Veith et al. 2009, Oberndorfer 2009). However, dynamic interactions among variables may play a fundamental role (see Paolella and Taschini 2008 and Keppler and Mansanet-Bataller 2010) so a multivariate analysis of simultaneous equations would avoid the endogeneity problems by treating all variables to be endogenous. Specifically, we use a cointegrated Vector Error Correction analysis, which allows the estimation of long-run equilibrium relations and short-run interactions between stock market returns and carbon emission prices.

The daily sample period used in our analysis ranges from the 1^{st} of January 2013 to the 31^{st} of July 2014.

The present study contributes to the literature on this topic in five ways: (*i*) to enrich the body of empirical literature on this matter, (ii) to offer a comprehensive empirical investigation of the effect of the EU ETS on stock returns during the current Phase III, (*iii*) to provide useful information to policy makers on which sectors show additional impacts on their competitiveness due to the European Emission Trading Scheme, (*iv*) to contribute with practical lessons for countries who are contemplating "cap and trade" systems; and (*v*) to provide findings that may be important for market investors.

The remainder of the paper is organized as follows. Section 2 presents a brief description of the methodology used including the multifactor model specification and the cointegrated Vector Error Correction analysis. Section 3 describes the data used. Section 4 presents the empirical results and VECM estimation. Finally, Section 5 concludes and discusses policy implications.

2. Methodology: A cointegrated Vector Error Correction Model

Multifactor market models are widely used to study the effect of any possible factor on corporate value change. In fact, Veith et al. (2009), Oberndorfer (2009) or Mo et al. (2013) have used a multifactor market model to investigate the impact of EUA price changes on firms' stock returns.

The basic model employed takes the following form:

$$R_{it}= \beta_0 + \beta_1 R_{mt} + \beta_2 P_t^{EUA} + u_{it} \quad (1)$$

R_{it} represents the return on the stock index of the i^{th} sector or firm, R_{mt} the return of the market portfolio, P_t^{EUA} the price of EU emission allowances changes and u_{it} a disturbance term with $E(u_{it})$=0, $var(u_{it})$=σ^2.

Moreover other authors as Lee et al. (2012) or Moya-Martínez et al. (2014) include the long-term interest rate to incorporate market expectations.

Many empirical analyses indicate that stock returns are closely related to the price of oil (Lee et al. 2012, Moya-Martínez et al. 2014 for Spanish case) and gas (Acaravci et al. 2012) so other influencing factors such as fuel prices are included in the basic model. For example, Veith et al. (2009) include oil and natural gas prices as control variables and Oberndorfer (2009) also includes the electricity price in the regression equation.

We notice that electricity prices are very important for the Spanish industry, as electricity usually represents a significant proportion of the total energy cost for the industry (51.7% of the total energy consumption, according to The Energy Consumption Survey of the Spanish Statistical Institute, 2013).

The Energy Consumption[3] Survey offers data broken down for 96 activity sectors, (excluding power activity) which enables a detailed study of the industrial reality, as it provides information regarding which of the different types of fuel are the most significant in consumption.

The following Table 1 presents the 10 sectors with the highest energy consumption, representing more than 50% of the total consumption in the extractive and manufacturing industry. As it is showed, all the sectors included in the EU ETS belong to the sectors with the highest energy consumption.

Table 1: The 10 sectors with the most energy consumption (2013, thousands of euros).

Activity sectors	Consumption	% of the total
Manufacture of basic chemical products	1.390.747	12.5
Manufacture of basic products in iron, steel and ferroalloys	811.478	7.3
Production of precious metals and other non-ferrous metals	680.329	6.1
Manufacture of pulp, paper and cardboard	574.848	5.2
Petroleum and natural gas industries	533.319	4.8
Manufacture of ceramic products for construction	410.838	3.7
Manufacture of plastic products	403.323	3.6
Meat industry	377.215	3.4
Manufacture of glass and glass products	329.063	3.0
Manufacture of cement, lime and plaster	277.861	2.5
TOTAL	11.086.198	100.0

[3] Energy consumption is measured in monetary terms, at current prices. Therefore, its evolution considers both the evolution of the amounts consumed and the evolution of the prices of the different energy products.

Figure 1 represents the distribution of energy consumption, with electricity representing a very significant percentage of the total consumption for a large number of industrial sectors.

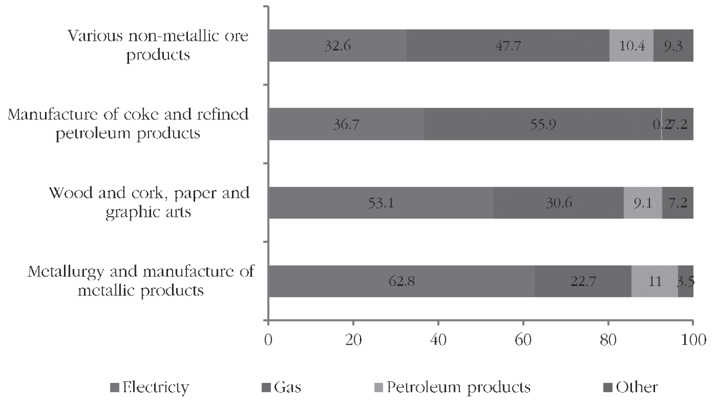

Figure 1: Percentage distribution, by type of energy and activity grouping (2013)

Moreover, gas it is also one of the most used fuels in industrial activity. In fact, belonging to the 10 sectors with the highest percentage of use of gas are those covered by EU ETS as it is shown in Table 2: manufacture of ceramic products for construction (75.0% of the total), manufacture of glass and glass products (58.7%) sectors, manufacture of ceramic products, except those used for construction (58.7%), petroleum and natural gas industries (55.6%).

Table 2: The 10 sectors with the highest percentage of use of gas year (2013)

Activity group	% use of gas
Manufacture of ceramic products for construction	75.0
Textile finishing's	61.7
Sugar, coffee, tea and infusions and confectionery	60.8
Manufacture of artificial and synthetic fibres	60.0
Manufacture of ceramic products, except those used for construction	58.7
Manufacture of glass and glass products	58.7
Manufacture of abrasive products and non-metallic mineral products n.e.c.	56.9
Petroleum and natural gas industries	55.6
Paints, varnishes, printing ink and mastics	52.6
Treatment and coating of metals	43.1

Regarding coal, a very residual use of it as a source of energy was observed, with the exception of the manufacture of cement, lime and plaster sector, where it represented 31.5% of the total energy consumption by companies practising that activity in 2013. Moreover, among the 10 sectors with the highest percentage of use of petroleum products is manufacture of elements made of concrete, cement and plaster (where petroleum represent the 42.5 % of the total energy consumption of this activity).

Regarding the energy used by power sector (which is not included in the Spanish Energy Consumption Survey), the last Spanish Energy Balance information published by International Energy Agency (2014), shows that electricity power station consumed 53 Mtoe of primary energy fuels. The percentage distribution of primary energy used by power stations is shown in Figure 2.

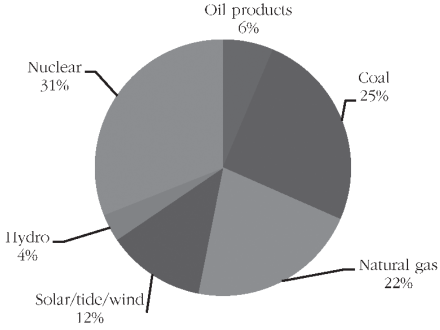

Figure 2: Distribution of primary energy used by power stations (2012).

Thus, the initial model can be specified as follows

$$R_{it} = \beta_0 + \beta_1 R_{mt} + \beta_2 P_t^{EUA} + \beta_3 P_t^{Oil} + \beta_4 P_t^{Gas} + \beta_5 P_t^{Coal} + \beta_6 P_t^{Elect} + \beta_7 r_t + u_{it} \quad (2)$$

P_t^{Oil}, P_t^{Gas}, P_t^{Coal} and P_t^{Elect} being the oil, gas, coal and electricity prices, respectively, and r_t the long-term interest rate.

The above multifactor model presumes the direction of causality, however dynamic interactions among variables may play a fundamental role thereby making estimation erroneous.

For instance, Paolella and Taschini (2008) have shown that oil and gas prices drive emission allowance costs: if, for example, the price of coal rises compared to gas, gas will be preferred by electricity producers, resulting in lower CO_2 emissions. Consequently, it follows a reduction of EUA demand and its price.

Moreover, the practice of marginal cost pricing in power generation implies that fuel and EUA prices play a fundamental role in the electricity price formation process through wholesale markets (see Freitas and Silva 2013, 2015 for the Iberian case) and consequently the final electricity prices for consumers (see Moreno et al. 2014 and Moreno and García-Álvarez 2013 for the Spanish case).

In the same way, Mansanet-Bataller et al. (2007) and Keppler and Mansanet-Bataller (2010) have analysed the interplay between daily carbon, electricity and gas price data with EU ETS concluding that fuel prices changes may be drivers of the EUA price itself.

Moreover, fuel and carbon emissions and fuel price fluctuations may also affect the interest rate. Rising energy prices are often indicative of inflationary pressures that central banks typically control by raising interest rates.

Therefore, when dynamic interactions among variables exist, multivariate analysis of simultaneous equations is the only technique that avoids the endogeneity problems by treating all variables (electricity price, fuel prices, EUA prices,…) as endogenous.

Multivariate analysis has been developed using either vector autoregressive models (VAR) or cointegrated models, which are also named Vector Error Correction models (VECM). These models offer a system of equations that expresses each variable in the system as a fraction of the lagged values of all the variables of the system- including its own lagged values.

As noted by Engle and Granger (1987), there are strong beliefs that economic data are non-stationary, meaning that any particular price measure over time will not be tied to its historical mean. So, modelling that kind of data by a levels VAR model appears to be inadequate, because of spurious regression risk, thus requiring one of two solutions: *i*) modelling a VAR in first differences which may impose the risk of losing relevant information about long-term relationships; *ii*) specifying a VECM, if the variables show a very interesting property, namely the cointegration. The latter alternative, if possible, has the advantage of allowing the simultaneous analysis of the long-run interactions and the short-term adjustments to the equilibrium relationship.

The cointegration concept, introduced by Engle and Granger (1987), means that individual economic variables may be non stationary and wander through time, but they are expected not to be completely independent of each other. That is, similar economic forces influence each variable and it is expected that the different variables will be tied together. In a more formal way, it is possible that two or more variables are non-stationary and wander through time, but a linear combination of them may, over time, converge to a stationary process. Such a process, if present, may reflect the long-run equilibrium relationship, and is referred to as the cointegration equation. According to Engle and Granger (1987), cointegrated variables must have an error correction representation in which an error correction term (ECT) must be incorporated into the model. Accordingly, a VECM is formulated to reintroduce the information lost in the differencing process, thereby allowing for long-run equilibrium as well as short-run dynamics.

Since the influential work of Engle and Granger (1987) several procedures have been proposed for testing the null hypothesis that two or more non-stationary time series are not cointegrated, meaning that there exist no linear combinations of the series that are stationary. One approach is to use likelihood ratio tests based on estimating a VAR. This approach was first proposed by Johansen (1988) and refined further by Johansen and Juselius (1990), Johansen (1991), Johansen (1992) and Johansen (1994). Johansen`s approach provides a unified framework for estimation and testing in the context of a multivariate VECM.

The cointegration test procedure specifies a VAR of order k, without imposing any restriction a priori, in the form of error correction model (ECM). Assuming the existence of cointegration, the data generating process P_t can be appropriately modelled as a VECM with k-1 lags (which is derived from a levels VAR with k lags). Consider a VAR of order k with a deterministic part given by μ_t. One can write the p-variate process as $P_t = \mu_t + A_1 P_{t-1} + A_2 P_{t-2} + \cdots + A_k P_{t-k} + \varepsilon_t$. Taking the variables in first differences, with Δ as the difference operator ($\Delta P = P_t - P_{t-1}$) than $P_{t-i} \equiv P_{t-1} - (\Delta P_{t-1} + \Delta P_{t-2} + \cdots + \Delta P_{t-i+1})$ and one can re-write the process as:

$$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \mu_t + \varepsilon_t \ (3)$$

Where: $\Pi = \sum_{i=1}^{k} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{k} A_j$ and $\varepsilon_t \sim Niid(0, \Sigma)$

In Eq. (3) P_t represents a vector of p non-stationary endogenous variables and the matrix Π contains information about the long-run relationship among endogenous variables and can be decomposed as $\Pi = \alpha\beta'$, whereas β represents the cointegration vectors and α the matrix with the estimations on the speed of adjustment to the equilibrium. The matrix α is called an error correction term, which compensates for the long-run information lost through differencing. The rank of matrix $\Pi(r)$ determines the long-run relationship. If the rank of the matrix Π is zero ($r = 0$), there is no long-run relationship and the model above is equal to a VAR in differences. If the matrix Π has the full rank ($r = p$), then it is invertible, meaning that the processes P_t are stationary I(0) and a normal VAR in levels can be used. The cointegration relationship occurs when the order of the matrix is between 0 and p ($0 < r < p$) and there are (p x r) matrixes α and β such that equation $\Pi = \alpha\beta'$ holds. In this case, P_t is I(1) but the linear combination $X_t = \beta' P_t$ is I(0). If, for example, $r = 1$ and the first element of β was $\beta = -1$, then one could write the linear combination as $X_t = -P_{1,t} + \beta_2 P_{2,t} + \cdots + \beta_p P_{p,t}$ which is the equivalent to saying that long-run equilibrium relationship among variables of vector P_t is expressed as $P_{1,t} = \beta_2 P_{2,t} + \cdots + \beta_p P_{p,t} - X_t$. This long-run relationship may not hold all the time, however the deviation X_t is stationary I(0). In this case, Eq. (4) can be written as follows:

$$\Delta P_t = \alpha\beta' P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-1} + \mu_t + \varepsilon_t \ (4)$$

If β is known, then X_t would be observable and all the remaining parameters could be estimated by OLS. In practice, the procedure estimates β first and then the rest.

An error correction model provides two alternative channels of the interaction among variables: *i*) short-run effects of the variables are captured similar to the VAR of differences, whose parameters are estimated in the matrix Γ_i; *ii*) the long-run effects enter the model with the term $\Pi\, P_{t-1}$ or $\alpha\beta\,'\, P_{t-1}$. μ_t is a vector of deterministic terms (constant and trend) and ε_t is a vector of innovations reflecting new information emanating from each of the variables.

Estimation typically proceeds in two stages: first, a sequence of tests is run to determine r, the cointegration rank. Then, for a given rank the parameters of Eq. (4) are estimated. The rank of Π (row rank of β) determines the number of cointegration vectors. Usually two tests on the eigenvalues are used to determine r: Trace Test and λmax Statistics.

3. Data and variables

The daily sample period herein used covers the first year and a half of the second year of the third phase of the EU ETS: 1st January 2013 to 31st July 2014.

We are aware of the fact that low frequency data (monthly or weekly) is often preferred to daily data which may induce errors-in-variables problems. However, the sample period of our analysis is relatively short (one year and a half), so by using weekly or monthly data were used our sample size would be too small to perform traditional time series analysis. We use daily data for working days.

Information on daily stock prices during 2013-2014 comes from the Datastream Database. We used the adjusted close price corrected by capital increases and splits. Data about the capitalization of the companies have been obtained in Bolsas y Mercados Españoles (www.bolsasymercados.es). We take the daily stock market price of companies affected by EU ETS for which financial market data is available for the whole sample.

We eliminated those companies that state as their main or core activity an activity related to renewable energy. The final sample consisted of 27 firms which have been clustered by sectors (as it is shown in Table 3): oil refineries; ferrous metallurgy; cement clinker or lime; glass including glass fibre; ceramic products by firing and pulp, paper and board.

The daily return weighted sector has been calculated using as a weighting factor the market capitalization of each company at year-end compared to the market capitalization of all companies in the same sector.

This process allows us to obtain an aggregate daily stock market return for each sector: R_{ccg}, R_{power}, R_{paper}, R_{petrol}, R_{metal}.

As cement, ceramic and glass only account for one of the companies listed on the Spanish Stock Market, we have grouped them into a unique series, which we have named R_{ccg} (weighted aggregate of the daily stock market return for cement, ceramic and glass sectors).

The proxy for the Rm market portfolio used is the *Índice General de la Bolsa de Madrid*, the biggest Spanish market index.

The yield on 10-year Spanish Treasury bonds is used to assess the interest rate r.

The electricity series P^{elect}, from OMEL, is the day-ahead price (€/MWh) for the peak load regime. The peak price is the hourly average of spot prices quoted from 8:00 h to 20:00h.

The natural gas price P^{gas} (€/MWh gas) is the spot price from the Zeebrugge Hub (European virtual trading point, Belgium).

The coal price P^{coal} (€/ton.) is the spot index API#2 (CIF ARA Delivered to the Amsterdam/Rotterdam/Antwerp region).

The EUA price series P^{EUA} (€/ton.) is the spot price quoted at EEX – European Energy Exchange (Leipzig, Germany).

The oil Crude price P^{oil} is the Oil Dated Brent (€//BBL).

Table 4 summarizes the main descriptive statistics of the variables.

Table 3: Companies* traded on the Madrid Stock Exchange that belong to sectors affected by EU ETS.

Company	Economic sector
Cementos Portland Valderrivas, S.A.	Cement
Uralita, S.A.	Ceramic
Vidrala S.A.	Glass
Centrais Ele. Brasileira S.A. Electrobas Enersis S.A. Empresa Nacional de Electricidad SA Endesa S.A. Iberdrola S.A.	Power
Grupo Empresarial Ence S.A. Iberpapel Gestion S.A. Miquel y Costas & Miquel S.A.	Paper
Petroleo Brasileiro S.A. Petrobras Repsol YPF S.A.	Petroleum refineries
ArcelorMittal S.A. Vale S.A.	Ferrous Metallurgy

*Companies representing 85% of the total market capitalization of each sector.

Table 4: Summary descriptive statistics

Variable	Units	Phase III				
		Mean	Median	Min.	Max.	Stnd.Dv
r	%	4.12	4.22	2.58	5.43	0.73
p^{EUA}	€/ton	4.84	4.78	2.68	7.11	0.85
p^{elect}	€/MWh	43.29	46.20	0.79	91.89	16.34
p^{gas}	€/MWh gas	3.05	3.03	2.33	5.85	0.51
p^{oil}	€//BBL	81.68	81.10	75.12	90.52	3.24
p^{coal}	€/ton	59.74	59.23	53.03	69.30	4.18
R_m		940.29	945.42	760.72	1143.30	105.47
R_{CCG}	€	22.18	21.39	14.22	29.68	4.52
R_{power}	€	11.38	10.33	8.74	16.48	2.35
R_{paper}	€	11.10	11.00	8.39	14.09	1.73
R_{petro}	€	9.49	9.55	8.09	11.00	0.68
R_{metal}	€	13.38	13.52	9.824	16.49	2.017

We transformed the variables into their natural logarithms, except for the interest rate.

4. Empirical results

The estimation method proceeds as follows: i) unit root tests are conducted to test for the order of integration in individual price series, *ii*) assuming the tests conclude that the series are I(1), the cointegration rank is determined, and *iii*) a VECM is estimated.

4.1. Preliminary tests: Unit-root-testing

Before deciding on applying either a VAR or VEC model, we need to test for the presence of a unit root. The series in the current study are tested for the presence of unit root by the Augmented Dickey-Fuller unit root prior test. The null hypothesis for this test is the presence of a unit root in the time series; the alternative hypothesis is the time series being generated by a stationary process. The results of the testing are presented in Table 5.

Table 5: Unit root testing of variables using the Augmented Dickey-Fuller test (variables - except r - in natural logarithms)

	Level		diff.	
	Statist.	p value	Statist.	p value
r	-0.111	0.947	-4.363	0.000
p^{EUA}	-2.818	0.056	-6.172	0.000
p^{elect}	-2.782	0.061	-7.957	0.000
p^{gas}	-1.913	0.327	-5.570	0.000
p^{oil}	-2.240	0.192	-6.636	0.000
p^{coal}	-1.571	0.497	-20.083	0.000
R_m	-0.287	0.925	-5.032	0.000
R_{CCG}	-3.149	0.024	-6.717	0.000
R_{power}	-0.450	0.898	-5.135	0.000
R_{paper}	-1.504	0.532	-8.576	0.000
R_{petro}	-2.591	0.095	-4.391	0.000
R_{metal}	-1.671	0.445	-4.216	0.000

The test indicates that, at 1% of significance, all the series contain a unit root (integrated of order 1) and therefore must be differentiated for the purpose of the current research.

Then, we obtain the growth rate of the relevant variables by their differenced logarithms.

4.2. Econometric model

Given the order of integration of the variables used, a general VECM specification can be formulated for each sector j as:

$$\Delta P_t = \alpha\beta' P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-1} + \mu_t + \varepsilon_t \quad (5)$$

P_t is a (7x1) vector of prices (endogenous variables) measured at time *t*: $P_t = [r_t, R_{mt}, R_{jt}, P_{telec}, P_{toil}, P_{tgas}, P_{tcoal}]$. R_{mt}, R_{jt}, P_{telec}, P_{toil} and P_{tcoal} are in natural logarithms, α and β are (7xr)[4] matrix, whereas β and α represent the cointegrating vectors and the matrix with the estimations on the speed of adjustments to the equilibrium, respectively. Γ_i is a (7x7) matrix with the estimations of short-run parameters relating price changes lagged *i* periods. μ_t is a (7x1) vector of constant and ε_t is a (7x1) vector of innovations.

4.3. Cointegration testing

The first step of the modelling procedure is to determine the lag relationship among the price series in levels VAR (used to generate Eq. (5)). Both the AIC (Akaike Info Criterion) and HQC (Hannan and Quinn Criterion) loss metrics suggest the appropriate VAR lag length is two[5] *K*=2 (Table 6).

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[4] Where r is the number of cointegrating vectors.

[5] As the VAR is specified in first differences, the number of lags lag in the VECM should be one (k-1).

Since the unit root tests reveal that the series are integrated of order one, a need arises to check whether these time series contain a common stochastic trend. Performing the Johansen cointegration test does this. If the I(1) variables do not exhibit cointegration relations, we opt for a VAR model analysis.

The existence of cointegration relations is shown in Table 7. The null hypothesis states that the amount of cointegrating vectors is equal to r; the alternative hypothesis is that the number of cointegrating vectors is greater than r.

The tests of cointegration were implemented with the technique based on the reduced rank regression introduced in Johansen (1991). Since the VAR model contains exogenous variables, the Osterwald-Lenum (1992) and Johansen (1995) asymptotic critical values are no longer valid, and we therefore use the asymptotic critical values provided in Mackinnon et al. (1999).

Table 6: Lag length in endogenous variables

Sector j	Lags	AIC	SC	HQ
	0	-12.541	-12.460	-12.509
	1	-32.429	-31.698*	-32.139*
Cement	2	-32.464	-31.083	-31.917
	3	-32.495*	-30.465	-31.691
	0	-13.305	-13.224	-13.273
	1	-33.162	-32.431*	-32.872*
Power	2	-33.233	-31.852	-32.685
	3	-33.256*	-31.226	-32.452
	0	-12.942	-12.861	-12.910
	1	-32.743	-32.012*	-32.454*
Paper	2	-32.7872	-31.406	-32.240
	3	-32.819*	-30.789	-32.014
	0	-12.915	-12.834	-12.883
	1	-32.874	-32.143*	-32.585*
Petro	2	-32.954	-31.574	-32.407
	3	-32.989*	-30.959	-32.184
	0	-12.378	-12.297	-12.346
	1	-32.160	-31.429*	-31.870*
Metal	2	-32.181	-30.800	-31.633
	3	-32.196*	-30.166	-31.392

Note: Model with constant and a maximum of 20 lags

Table 7: Cointegration tests Phase III

Sector	H_0: r=	Trace test Statistics	Critical Value	p-values	λmax -max eigen value test Statistics	Critical Value	p-values
Cement	1	0.161	125.615	0.000	0.161	46.231	0.000
	2	0.137	95.754	0.005	0.137	40.078	0.000
	3	0.052	69.819	0.583	0.052	33.877	0.700
Power	1	0.137	125.615	0.000	0.137	46.231	0.002
	2	0.128	95.754	0.000	0.128	40.078	0.001
	3	0.072	69.819	0.004	0.072	33.877	0.164
Paper	1	0.168	125.615	0.000	0.168	46.231	0.000
	2	0.091	95.754	0.092	0.091	40.078	0.104
	3	0.056	69.819	0.436	0.056	33.877	0.567
Petro	1	0.197	125.615	0.000	0.197	46.231	0.000
	2	0.108	95.754	0.053	0.108	40.078	0.015
	3	0.052	69.819	0.603	0.052	33.877	0.690
Metal	1	0.157	125.615	0.000	0.226	52.363	0.000
	2	0.087	95.754	0.057	0.157	46.231	0.000
	3	0.073	69.819	0.259	0.087	40.078	0.144

4.4. Sectorial VECM estimation

With the cointegrated rank and optimum number of lags determined, the parameters of model (5) for each sector can be estimated.

Following, the VECM estimations for each EU ETS affected sector are presented. We only report the estimation of the coefficients that are significant at 1% (***), 5% (**) or 10% (*) significant levels - with the exception of the coefficients related to EUA prices that are always shown. The interpretation of the results is focused in the effect of EUA change prices on stock prices changes.

4.4.1 VECM estimations for cement, ceramic and glass sector

The results reported in Table 8 for the cointegrated vector β, which is normalized on R_{CGt-1}, r_{t-1} and R_{mt-1} show that the long-run relationships between EUA price change and stock market price change for cement, ceramic and glass sector are important (but small) during phase III. Since the coefficients can be interpreted as price elasticities, therefore, a EUA price rise of 1%, would, in equilibrium, be associated with a stock price for the sector increase of 0.0187%.

Table 8: VECM parameter estimates for cement, ceramic and glass sector

Cointegration relationships

$R_{CG\ t-1}$	r_{t-1}	$R_{m\ t-1}$	P^{EUA}_{t-1}	P^{ELECT}_{t-1}	P^{COAL}_{t-1}	P^{OIL}_{t-1}	P^{GAS}_{t-1}	Const.
1.000	0.000	0.000	-0.923***	-0.369***	-0.887**	2.014***	-0.982***	-
0.000	1.000	0.000	-	2.382***	-	-	7.138***	-
0.000	0.000	1.000	-0.598***	-0.442***	-1.085***	1.222**	-0.853***	-

Short run dynamics

	$\Delta R_{CG\ t}$	Δr_t	$\Delta R_{m\ t}$	ΔP^{EUA}_t	ΔP^{ELECT}_t	ΔP^{COAL}_t	ΔP^{OIL}_t	ΔP^{GAS}_t
$EC1_{t-1}$	-0.052***	-	-	-	-	-	-	0.161***
$EC2_{t-1}$	-	-	-	0.033***	-	-	-	-0.050***
$EC3_{t-1}$	0.049**	-	-	0.128**	1.403**	-	-	-0.387***
$\Delta R_{CG\ t-1}$	-	-0.408**	-	0.351**	-	-	-	-
Δr_{t-1}	-	-0.139***	0.027***	-	-	-	-	-
$\Delta R_{m\ t-1}$	-	-1.526***	0.094*	-0.533**	-	-	-	-
ΔP^{EUA}_{t-1}	-0.026	-	-	0.085*	-	-	-	-
ΔP^{ELECT}_{t-1}	-	-	0.002*	-0.008	0.105**	-0.002**	-	-0.012**
ΔP^{COAL}_{t-1}	-	-	-	-	-	-	-	-0.872***
ΔP^{OIL}_{t-1}	-	-	-	-	-	-	-	-
ΔP^{GAS}_{t-1}	-	-	0.024*	-	-	-	-	0.180***
Const.	0.002***	-0.005**	-	-	-	-	-	-

*stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 1% level.

The short-run parameters in the VECM indicate that the EUA price change does not have an effect on stock market returns of the cement, ceramic and glass companies. The short run parameter corresponding to EUA price for Phase III is -0.026 but it is not significant.

The results are similar to those found by Chan et al. (2013) who examine the impact of EU ETS on firms' unit material costs, employment and revenue during 2005–2009. They concluded that EU ETS had no impact on the performance of cement and iron or steel industries.

4.4.2. VECM estimations for power sector

The results reported in Table 9 for the cointegrated vector β , which is normalized on R_{CGt-1}, r_{t-1} and R_{mt-1} show that the long-run relationships between EUA price change and stock market price change for the power sector are important (but small) during Phase III. Since the coefficients can be interpreted as price elasticities, therefore, a EUA price rise of 1%, would, in equilibrium, be associated with a stock price for the sector increase of 0.03% during phase III.

Table 9: VECM parameter estimates for power sector

Cointegration relationships								
$R_{power\ t-1}$	r_{t-1}	$R_{m\ t-1}$	P^{EUA}_{t-1}	P^{ELECT}_{t-1}	P^{COAL}_{t-1}	P^{OIL}_{t-1}	P^{GAS}_{t-1}	Const.
1.000	0.000	0.000	-0.809***	-0.386***	-0.702**	0.202***	-1.719***	-
0.000	1.000	0.000	-	1.758***	-	-	6.955***	-
0.000	0.000	1.000	-0.677***	-0.419***	-1.109***	1.514**	-0.878***	-

Short run dynamics								
	$\Delta R_{power\ t}$	Δr_t	$\Delta R_{m\ t}$	ΔP^{EUA}_t	ΔP^{ELECT}_t	ΔP^{COAL}_t	ΔP^{OIL}_t	ΔP^{GAS}_t
$EC1_{t-1}$	-0.040***	-	-	0.105***	-	-	-	0.031***
$EC2_{t-1}$	-	-	-	0.053***	-	-	-	-0.029***
$EC3_{t-1}$	-0.020**	-	-	0.122**	0.873**	-	-	-0.131***
$\Delta R_{power\ t-1}$	-	-0.736**	-	-	-	-	-	-
Δr_{t-1}	-	-0.145***	0.030***	-	-	-	-	-
$\Delta R_{m\ t-1}$	-	-1.130***	0.045*	-0.605**	-	-	-	-
ΔP^{EUA}_{t-1}	-0.015	-	-	0.097*	-	-	-	-
ΔP^{ELECT}_{t-1}	-	-	0.002*	-	0.109**	-0.002**	-	-0.013**
ΔP^{COAL}_{t-1}	-	-	-	-	-	-	-	-0.741***
ΔP^{OIL}_{t-1}	-	-	-	-	-	-	-	-
ΔP^{GAS}_{t-1}	-	-	0.022*	-	-	-	-	0.173***
Const.	0.002***	-0.005**	-	-	-	-	-	

*stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 1% level.

The results are similar to those found by empirical literature. Oberndorfer et al. (2006) examined the impacts of the EU ETS on competitiveness in Europe and concluded that for the power sector the impacts were modest. In the same way, Chan et al. (2013) concluded that EU ETS was associated with increased material costs and revenue of the power industry during 2005–2009. Also by using a Cournot representation, Bonenti et al. (2013)

evaluated the impact of EU ETS on the Italian electricity market profits under different allocation scenarios of allowances (free and auctions), concluding that the generators would be expected to profit in an oligopolistic market as they are able to transfer almost all their emission costs to the final price paid by consumers. In addition, Veith et al. (2009) by using a modified multifactor market similar to Eq. 2 and 2005-2007 data of 22 electricity companies estimated a coefficient β_2 equal to 0.006.

However, the existing empirical studies do not converge with our research findings, as some scholars have concluded that the EU ETS has a negative effect on power companies. For instance, Mo et al. (2013) indicate that positive EUA prices generated corporate value depreciation during phase II. By using a modified multifactor market similar to Eq. 2 and 2008 and 2009 data of 48 electricity companies, they estimate a coefficient β_2 equal to -0.0334. Moreover, Oberndorfer (2009) found that although EUA price changes and stock returns of the most important European electricity corporations were positively related, Spanish electricity corporations exhibit a significant (but small as far as the size of the estimated coefficient is concerned) negative relationship.

Jaraitė and Kažukauska (2013) found that the first years of the EU ETS (2002-2010) couldn't be associated with excess profits for electricity producers.

Regarding the short-run parameters in the VECM, these indicate that the EUA price changes do not have an effect on stock market returns of power sector in the EU ETS Phase III.

We would like to point out that, in the long-run, the electricity sector as a whole has modest gains from the introduction of the EU ETS instrument, but these results could change if the electricity sector was grouped by companies according to its main generation technology (Bode 2006).

4.4.3. VECM estimation for paper sector

The results reported in Table 10 for the cointegrated vector β , which is normalized on R_{CGt-1}, r_{t-1} and R_{mt-1} show that there are not significant long-run relationships between EUA price change and stock market price change for paper sector during the current phase. Moreover, the short-

-run parameters in the VAR indicate that the EUA price changes do not have an effect on stock market returns of the sector.

Meleo (2014) discusses the main factors affecting competitiveness coming from the EU-ETS, considering the case of the Italian paper industry. He points out that paper firms cannot easily move prices to cover environmental costs because paper demand is price-elastic and paper products have several substitutes such as plastic goods.

Table 10: VECM parameter estimates for paper sector

Cointegration relationships								
$R_{paper\ t-1}$	r_{t-1}	$R_{m\ t-1}$	p^{EUA}_{t-1}	p^{ELECT}_{t-1}	p^{COAL}_{t-1}	p^{OIL}_{t-1}	p^{GAS}_{t-1}	Const.
1.000	0.000	-1.696***	-	0.384***	0.803***	-	0.662***	-
0.000	1.000	2.095**	-	1.320***	-2.113*	-	5.004***	-

Short run dynamics								
	$\Delta R_{paper\ t}$	Δr_t	$\Delta\ R_{m\ t}$	ΔP^{EUA}_t	ΔP^{ELECT}_t	ΔP^{COAL}_t	ΔP^{OIL}_t	ΔP^{GAS}_t
$EC1_{t-1}$	-0.024**	-	0.009**	-0.073**	-1.216***	0.014*	-	0.180***
$EC2_{t-1}$	0.007***	-	-0.004*	0.026***	-	-	-	-0.057***
$\Delta R_{paper\ t-1}$	-0.101**	-	-	-	3.124*	-0.065*	-	-
Δr_{t-1}	-	-0.146***	0.028***	-	-	-	-	-
$\Delta R_{m\ t-1}$	-	-1.597***	0.118**	-0.523**	-	0.084*	-	-
ΔP^{EUA}_{t-1}	-	-	-	-	-		-	-
ΔP^{ELECT}_{t-1}	-	-	-	-	0.115**	-0.003*	-	-0.014***
ΔP^{COAL}_{t-1}	-	-	-	-	-	-	-	-0.908***
ΔP^{OIL}_{t-1}	-	-	-	-	-	-	-	-
ΔP^{GAS}_{t-1}	-	-	0.025**	-	-	-	-	0.171***
Const.	0.002**	-0.006**	-	-	-	-	-	-

*stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 1% level.

4.4.4. VECM estimations for petroleum refineries sector

The results reported in Table 11 for the cointegrated vector β, which is normalized on R_{CGt-1}, r_{t-1} and R_{mt-1}, show that the long-run relationships between EUA price change and stock market price change for oil refineries sector are important (but small) during phase III. A EUA price rise of 1%, would, in equilibrium, be associated with a stock price for the sector increase of 0.0261%.

The short-run parameters in the VAR indicate that the EUA price changes do not have an effect on stock market returns for this sector.

Table 11: VECM parameter estimates for oil refineries sector

Cointegration relationships								
$R_{petro\ t-1}$	r_{t-1}	$R_{m\ t-1}$	P^{EUA}_{t-1}	P^{ELECT}_{t-1}	P^{COAL}_{t-1}	P^{OIL}_{t-1}	P^{GAS}_{t-1}	Const.
1.000	0.000	0.000	0.231***	-0.186***	-0.363*	-	-	-
0.000	1.000	0.000	-	2.236***	-	-	7.182***	-
0.000	0.000	1.000	-0.493***	-0.397***	-0.896***	-	-1.054***	-
Short run dynamics								
	$\Delta R_{petro\ t}$	Δr_t	$\Delta R_{m\ t}$	ΔP^{EUA}_t	ΔP^{ELECT}_t	ΔP^{COAL}_t	ΔP^{OIL}_t	ΔP^{GAS}_t
$EC1_{t-1}$	-0.032***	-	-	-	0.755**	-0.023***	-0.031***	-0.215***
$EC2_{t-1}$	-0.015***	-	-	0.044***	-	-	-	-0.050***
$EC3_{t-1}$	-0.068***	-	-	0.257***	0.794*	-	-	-0.161***
$\Delta R_{petro\ t-1}$	0.117*	-0.637***	0.173***	-	-	-	-	-
Δr_{t-1}	0.026**	-0.148***	0.029***	-	-	-	-	-
$\Delta R_{m\ t-1}$	-	-1.205***		-0.688**	-	-	-	-
ΔP^{EUA}_{t-1}	-0.011	-	-	0.101**	-	-	0.020*	-
ΔP^{ELECT}_{t-1}	-	-	-	-0.009*	0.111**	-0.002**	-	-0.013**
ΔP^{COAL}_{t-1}	-	-	-	-	-	-	-	-0.927***
ΔP^{OIL}_{t-1}	-	0.535*	-	-	-	-	-	-
ΔP^{GAS}_{t-1}	-	-	-	-	-	-	-	0.175***
Const.	-	-0.006**	0.001*	-	-	-	-	-

*stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 1% level.

Although the petroleum refineries sector´s stock market returns are positive related to EUA price changes as a whole according to Reinaud (2005) the results for each refinery may depend of the way they obtain electricity. The refinery produces its own electricity, it purchases its electricity from the grid or it produces its energy needs from an Integrated Gasification Combined Cycle. Reinaud concludes that refinery margins in the Mediterranean area are lower if power is purchased from the grid.

Moreover, results could also change according to the main product of the refinery: Babusiaux (2003) reveals higher emission contents for diesel than for gasoline for large number of scenarios. In certain cases, negative gasoline marginal contents are even obtained.

4.4.5. VECM parameter estimates for ferrous metallurgy sector

The results reported in Table 12 for the cointegrated vector β, which is normalized on R_{CGt-1}, r_{t-1} and R_{mt-1} show that the long-run relationships between EUA price change and stock market price change for ferrous metallurgy sector are important (but small) during phase III. In fact an EUA price rise of 1%, would, in equilibrium, be associated with a stock price decrease for the sector of -0.0174%.

The short run parameter corresponding to the EUA price is 0.0158 but it is not significant.

Demailly and Quirion (2009) examine the impact on iron and steel industry under a euro 20 per ton CO_2 price. They found that profitability depends on the amount of allowances allocated for free. As they point out, even though more allowances are going to be allocated for free in the future, the decrease in the profitability of the ferrous metallurgy sector would be modest.

Table 12: VECM parameter estimates for ferrous metallurgy sector- Phase III

Cointegration relationships								
$R_{metal\ t-1}$	r_{t-1}	$R_{m\ t-1}$	P^{EUA}_{t-1}	P^{ELECT}_{t-1}	P^{COAL}_{t-1}	P^{OIL}_{t-1}	P^{GAS}_{t-1}	Const.
1.000	0.000	-4.086***	1.241***	1.272***	1.995*	-3.724*	2.644***	-
0.000	1.000	1.918**	-	1.528***	-	-	5.422***	-

Short run dynamics								
	$\Delta R_{metal\ t}$	Δr_t	$\Delta R_{m\ t}$	ΔP^{EUA}_t	ΔP^{ELECT}_t	ΔP^{COAL}_t	ΔP^{OIL}_t	ΔP^{GAS}_t
$EC1_{t-1}$	-0.014***	-	-	-0.045***	-0.268***	-	0.004*	0.032***
$EC2_{t-1}$	0.010***	-	-	0.039***	-	-	-	-0.032***
$\Delta R_{metal\ t-1}$	-	0.370**	-0.079**	-	-	-	-	-
Δr_{t-1}	-	-0.144***	0.027***	-	-	-	-	-
$\Delta R_{m\ t-1}$	-	-1.882***	0.154***	-0.494**	-	-	-	-0.551**
ΔP^{EUA}_{t-1}	0.016	-	-	-	-	-	-	-
ΔP^{ELECT}_{t-1}	-	-	-	-	0.106**	-0.002**	-	-0.013**
ΔP^{COAL}_{t-1}	-	-	-	-	-	-	-	-0.693***
ΔP^{OIL}_{t-1}	-	-	-	-	-	-	-	-
ΔP^{GAS}_{t-1}	-	-	0.024**	-	-	-	-	0.143***
Const.	-	-0.006*	-	-	-	-	-	-

*stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 1% level

5. Conclusions and policy implications

Over the course of the EU ETS history, the system has been expanded in scope to include both additional countries and new sectors. Furthermore, links have been established with both the permit trade under the mechanisms of the Kyoto Protocol and non-EU national emission trading systems. The existence of 2 billion unused allowances at the end of Phase II of the EU ETS, approximately 20% of the five-year cap, is frequently quoted as the cause of the current low price of EUAs and an indication of some fundamental shortcoming in the design of the EU ETS.

It was in this set up that this study investigated the interactions between the stock market returns of Spanish industry sectors under EU ETS and emission rights prices during the on-going Phase III. The witnessed divergence amongst allowances distributed and allowances used has been the reason for the debate about "back-loading" that lead the examination concerning the EU ETS in 2013, as well as for the proposal made in January 2014 to establish a Market Stability Reserve. Together, these measures would diminish the amount of allowances available in the immediate period while placing the reserved allowances back into circulation at a later time (European Commission, 2012, 2014).

By using daily data from January 2013 to July 2014 and a cointegrated Vector Error Correction (VECM), the results obtained indicate that the EUA price change does not present short-run effects on stock market returns on the sector during the current phase. However, the long-run relationships between EUA price change and stock market price change depending on the considered sector- as it is showed in the second column of Table 13 (Long-run cointegration relationship Π).

A statistically significant positive long-run impact of EU ETS on power sector stock market return is found. In fact, an EUA price rise of 1%, would, in equilibrium, be associated with a stock price for the power sector increase of 0.03% for Phase III.

Moreover, statistically significant positive long-run impact of EU ETS on cement and petroleum and, on the other hand, negative impact on iron and steel sectors were found during phase III. Thus, an EUA price rise of 1%, would be associated with a stock price change of 0.0187%, 0.0261%, and -0.0174 % for cement, oil refineries and ferrous metallurgy sectors, respectively.

A long-run link between carbon prices and stock market on the paper sector is found no to be supported during the studied period.

The long-run cointegration relationship (Π) can be decomposed as $\Pi = \alpha \beta'$, whereas β represents the cointegration vectors and α the matrix with the estimations defining the speed of adjustment of the daily stock market return of each sector to the long-run equilibrium. The matrix α is called an error correction term (EC), which compensates for the long-run information lost through differencing. The presence of cointegration requires at least one of the coefficients of the error correction terms to be statistically significant. This condition is observed throughout the VECM model. As it is shown in Table 3 all the sectors have at least the estimation of two error correction terms statistically significant. High absolute values of the error correction terms indicate that a sector is largely able to correct the disequilibrium within one day. In that sense, the estimated values are very small for all the sectors, so we can conclude that no sectors are able to correct the disequilibrium within one day. In general, the correction terms are higher for Cement, ceramic and glass sector, i.e. the adjustment is faster. For example, the EC1 indicates that about 5.2% of the disequilibrium is corrected within one day in this sector.

Table 13: Long-run and Error correction terms from VECM estimations- Phase III

Economic sector	Long-run cointegration relationship	Error Correction terms*		
		EC1	EC2	EC3
Cement, ceramic and glass	0.0187	-0.052		0.049
Power	0.0300	-0.040	-0.013	-0.020
Paper	0.0000	-0.024	0.007	
Petroleum refineries	0.0261	-0.032	-0.015	-0.068
Ferrous Metallurgy	-0.0174	-0.014	0.010	

Estimated coefficients that are significant at 1%, 5% or 10% significant levels.

As it is shown, electricity sector is the one where EU allowances price changes has the highest long-run impact on stock market returns, following by petroleum refineries. An essential element of the effect of EUA price increase on each sector stock market returns is the capacity that companies belonging to each sector have to increase product prices. In general, the cost incurred to respond to the EUA constraint should reduce profit margins, all other things equal. However, companies can incorporate their carbon emission allowance costs in their sale offers. The market structure, the demand elasticity to price variations or the number of substitutes of the principal product of the firm, among others, influence the grade of the pass-through of environmental costs on prices. Regarding the electricity sector, although the Spanish electricity market liberalization compels to introduce competition into electricity generation, the old integrated monopolies continue with the control of the electricity production (Endesa e Iberdrola). Although the concentration of the electricity generation market decreased in 2010 and 2011 to a moderate level, below that of other European countries, it is still high. According to the last report on the development of competition in gas and electricity markets published by the Spanish Energy Commission (Comisión Nacional de la Energía, 2012), the Herfindahl and Hirschman index (HHI) associated to the domestic market is of 1400. Moreover, if we use a more conservative definition that uses only the group of technologies setting the price in the Spanish market (combined cycle gas, coal, reservoir hydro), the HHI stands at 1900. However, there continues to be a difference between new entrants and incumbents in terms of the degree of vertical integration (the former sell most of their energy on the spot market, while the latter enter into bilateral contracts –mainly between companies of the same group– that were primarily associated with nuclear and hydro power plants in 2011).

In addition, the demand elasticity to electricity price variations is very low because of the special characteristics of electricity output (such as no storability or the existence of capacity constraints in the short term offer) and the number of substitutes limited to gas.

As we mentioned before, the market structure, among others, influence the grade of the pass-through of environmental costs on prices. In that sense, when comparing results of the impact of EU allowances price on sectors' stock market returns from different countries they might differ as countries could have different market conditions for the same sector. For example, European countries with the highest market shares of the largest generator in the electricity market (as a percentage of the total generation) are Cyprus (100%), Malta (100%), Estonia (87%) or France (84%), and with the lowest market shares are Spain (24.5%) and Poland (17.3%) according to 2013 data (Eurostat).

Moreover, Ireland and United Kingdom have introduced a carbon floor price in April 2013. This means that polluter producers in Great Britain must pay a premium when the EU allowances prices become lower than the price floor. Thus, although sectors covered by EU ETS in Ireland and United Kingdom are the same than in other countries, the carbon price might differ, so we must be cautious when making sectoral comparison with other countries without this system.

It is important to note that these findings should be viewed in alignment with the specific period and EU ETS phase analysed. We would like to point out that during Phase III the allocation of emission allowances are given out predominantly through auctioning, starting from a proportion of the 20% in 2013 and reaching a 70% level in 2020 (European Commission, 2009). Thus, the results we obtain based on data from January 2013 to July 2014 could vary, following an increase in the proportion of allowances auctioning as we approach 2020. For instance, concerning the power sector, switching to a higher proportion auctioning would leave the electricity sector as a whole better off than before the introduction of the EU ETS (Keppler and Cruciani 2010).

In the future, we plan to extend the research herein presented in the following two directions. First, while the present paper focuses on the analyses at a global sectoral level, we have not examined the impact on stock market returns at firm level, thus a more detailed study by firms of each sector would be of added value.

Second, we plan to include updated data from July 2014 in our analysis so that we can acquire a more comprehensive depiction of the impacts of the third phase of the program.

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References

Acaravci, A. Ozturk, I., Kandir, S.Y. (2012): Natural gas prices and stock prices: Evidence from EU-15 countries, Economic Modelling 29(5), 1646–1654.

Anger, N., Oberndorfer, U. (2008): Firm Performance and Employment in the EU Emissions Trading Scheme: An Empirical Assessment for Germany. Energy Policy 36, 12-22

Babusiaux, D. (2003): Allocation of the CO2 and Pollutant Emissions of a Refinery to Petroleum Finished Products, Oil and Gas Science Technology, Vol 58, No. 6, 685-692

Bode S. (2006): Multi-period emissions trading in the electricity sector e winners and losers. Energy Policy 34(6), 680-91.

Bushnell, J.B., Chong H., Mansur E.T. (2013): Profiting from Regulation: Evidence from the European Carbon Market, American Economic Journal: Economic Policy, 5(4): 78-106.

Chan S.R, Li S.Zhang, F. (2013): Firm competitiveness and the European Union emissions trading scheme, Energy Policy 63, 1056–1064.

Comisión Nacional de la Energía (2012): Report on the development of competition in gas and electricity markets. Period 2008-2010 and Preview 2011. Madrid: Spain

Demailly, D., Quirion, P. (2008): European Emission Trading Scheme and Competitiveness: A Case Study on the Iron and Steel Industry, Energy Economics 30, 20-27.

Ellerman, D., Marcantonini, C. Zaklan, A. (2014): The EU ETS: Eight Years and Counting, Robert Schuman Centre for Advanced Studies Working Paper 2014-04, European University Institute.

Engle, R., Granger, C. (1987): Co-Integration and Error Correction: Representation, Estimation, and Testing, Econometrica 55, 251-276.

European Commision (2009): Directive 2009/29/EC of The European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community.

European Commission (2012), Report from the Commission to the European Parliament and the Council: The State of the European Carbon Market in 2012, COM(2012) 652 final, Brussels: 14.11.2012.

European Commission (2014), "A Policy Framework for Energy and Climate from 2020 to 2030: Communication from the Commission to the European Parliament the Council, the European Economic and Social Committee, and the Committee of the Regions,"COM(2014) 15 final, Brussels, January 22, 2014.

Freitas C.J., Silva P. P. (2013): Evaluation of dynamic pass through of carbon prices into electricity prices - a cointegrated VECM analysis, International Journal of Public Policy 9, 65-85

Freitas C.J., Silva, P. P. (2015): European Union Emissions Trading Scheme impact on the Spanish electricity price during Phase II and Phase, Utilities Policy, 33: 54 - 62.

Goulder, L., Hafstead, M., Dworsky, M. (2010): Impacts of Alternative Emissions Allowance Allocation Methods Under a Federal Cap-and-Trade Program, Journal of Environmental Economics and Management 60, 161-181.

International Energy Agency (2014): Energy Balances of OECD Countries.

Jaraitė, J., Kažukauskas, A. (2013): The profitability of electricity generating firms and policies promoting renewable energy, Energy Economics 40, 858–865.

Johansen, S. (1988): Statistical analysis of cointegrating vectors, Journal of Economic Dynamics and Control 12, 231–254.

Johansen, S. (1991): Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, Econometrica. 59, 1551–1580.

Johansen, S. (1992): Determination of cointegration rank in the presence of a linear trend, Oxford Bulletin of Economics and Statistics 54, 383–397.

Johansen, S. (1994): The role of the constant and linear terms in cointegration analysis of nonstationary variables, Econometric Reviews 13, 205–229.

Johansen, S. (1995): Likelihood-based Inference in Cointegrated Vector Autoregressive Models, Oxford University Press, New York.

Johansen, S. and Juselius, K. (1990): Maximum likelihood estimation and inference on cointegration – with applications to the demand for money, Oxford Bulletin of Economics and Statistics 52.169–210.

Keppler, J.H. and Mansanet-Bataller, M. (2010): Causalities between CO2, electricity, and other energy variables during phase I and phase II of the EU ETS, Energy Policy 38, 626–632.

Keppler, J.H., Cruciani, M. (2010): Rents in the European power sector due to carbon trading, Energy Policy 38, 4280–4290

Lee B-J, Yang C.W., Huang B-N. (2012): Oil price movements and stock markets revisited: A case of sector stock price indexes in the G-7 countries, Energy Economics 34, 1284–1300.

Litterman, B. (2013): What is the Right Price for Carbon Emissions? Regulation, Summer 2013, 38.43.

Mackinnon, J., Haug, A., Michelis, L. (1999): Numerical distribution functions of likelihood ratio tests for cointegration, Journal of Applied Econometrics, Vol. 14, No. 5, pp.563–577.

Mansanet-Bataller, M., Pardo, A., Valor, E. (2007): CO2 prices, energy and weather. The Energy Journal 28, 73–92.

Meleo, L. (2014). On the determinants of industrial competitiveness: The European Union emission trading scheme and the Italian paper industry, Energy Policy, in press

Mo J.L., Zhu, L., Fan Y. (2012): The impact of the EU ETS on the corporate value of European electricity, Energy 45, 3-11.

Moreno, B.; García-Álvarez, M.T. (2013): The role of renewable energy sources on electricity prices in Spain. A maximum entropy econometric model, Strojarstvo 55, 149-159.

Moreno, B.; García-Álvarez, M.T.; Ramos, C.; Fernández-Vázquez, E. (2014): A General Maximum Entropy Econometric approach to model industrial electricity prices in Spain: A challenge for the competitiveness, Applied Energy 135, 815-824.

Moya-Martínez P., Ferrer-Lapeña R., Escribano-Sotos F. (2014): Oil price risk in the Spanish stock market: An industry perspective, Economic Modelling 37, 280-290

Oberndorfer, U. (2009): EU Emission Allowances and the Stock Market: Evidence from the Electricity Industry, Ecological Economics 68, 1116.1129.

Oberndorfer, U., Rennings, K., Sahin, B. (2006): The impacts of the European emissions trading scheme on competitiveness in Europe. Zentrum für Europäische Wirtschaftsforschung/ Center for European Economic Research.

Oestreich, A.M., Tsiakas, I. (2014): Carbon Emissions and Stock Returns: Evidence from the EU Emissions Trading Scheme. Available at SSRN: http://ssrn.com/abstract=2189497

Osterwald-Lenum, M. (1992): A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics, Oxford Bulletin of Economics and Statistics 54, 461–471.

Paolella MS, Taschini L (2008): An econometric analysis of emission allowance prices, Journal of Banking & Finance 32, 2022-2032

Pindyck, R.S. (2013). Pricing Carbon When We Don't Know the Right Price.Regulation, Summer 2013, 43.46.

Reinaud, J. (2005): The European refinery industry under the EU Emissions Trading Scheme, International Energy Agency, IEA Information Paper.

Sijm, J.P.M., Neuhoff, K., Chen, Y. (2006): CO2 Cost Pass-Through and Windfall Profts in the Power Sector, Climate Policy 6, 49-72.

Smale, R., Hartley, M., Hepburn, C., Ward, J., Grubb, M. (2006): The impact of CO2 emissions trading on firm profits and market prices, Climate Policy 6, 31-48,

Spanish Statistical Institute (2013). Spanish Energy Consumption Survey 2011. INE: Madrid, Spain; 2013

Veith, S., Werner, J., Zimmermann, J. (2009): Capital Market Response to Emission Rights Returns: Evidence from the European Power Sector, Energy Economics 31, 605-613.

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