NCCR Conference on the International Dimensions of Climate Policies

21 – 23 January 2009, University of Bern, Bern, Switzerland

Does Carbon Affect European Oil Companies' Equity Values?

Mohamed Amine Boutaba[†]

Centre for Analysis and Research in Economics (CARE), University of Rouen, France

Abstract

This paper empirically investigates the impact of European Emissions Trading Scheme (ETS) on oil stock companies. Our results reveal that European carbon allowance (EUA) price has a significant positive effect on equity returns. We also find evidence of an asymmetry in the EUA price sensitivities. In addition, we examine the EUA price risk across three other sectors namely cement, chemicals and steel chosen on the basis of their dependence on oil prices, in order to investigate if the EUA price affects other industries in the same ways or not. We find that the EUA price impact is only significant for the steel industry and appears symmetric. Our findings suggest that investors should hedge EUA price risk for portfolios including European steel and oil equities.

Keywords: European carbon allowance prices, equity returns, inter-sectoral comparison, panel data analysis.

JEL Classification : Q43, Q49, G12, C23.

[†] Corresponding author: CARE, UFR Droit-Économie-Gestion, 3, avenue Pasteur, 76186 Rouen cedex, France. Tel: +33 (0)2 32 76 96 64. Fax : +33 (0)2 32 76 96 63
mohamedamine.boutaba@univ-rouen.fr

1. Introduction

The European Union (EU) has created the largest Emissions Trading Scheme (ETS) in the world in order to reduce dioxide carbon (CO2) emissions by combustion installations with a rated thermal input capacity exceeding 20 megawatts, refineries, coke ovens, steel plants, and installations producing cement clinker, lime, bricks, glass, pulp and paper. These installations are responsible for roughly 50% of Europe's CO2 emissions and 40% of its total greenhouse gas emissions. The EU ETS is being introduced in three phases. The first phase which ran from 2005 to December 2007 is considered as a pilot phase; the second phase which ranges from 2008 to 2012, coincides with the period when the EU must meet the 8% decrease in emissions from 1990 levels under the Kyoto Protocol. As proposed recently by the European Commission, the third phase will ran from 2013 to 2020.

Since the approbation of the directive implementing the EU ETS in 2003, some studies have investigated its consequences and impacts on the refinery sector[1]. Barbusiaux (2003) and Pierru (2007) develop methods to compute the marginal contribution of each finished product to the CO2 emissions of the refinery. Reinaud (2005) suggests that the EU ETS could affect the competitiveness of refining companies, especially if indirect effects are realised when European carbon allowance (EUA) prices are passed-through to power prices. Reinaud (2008) and Lacombe (2008) conclude that the EU ETS have a very modest effect on the competitiveness of the refinery sector. However, this literature does not assess the impacts of EU ETS on the profitability of the oil refinery companies. This is unfortunate given its importance to the investor community. Indeed, modelling the determinants of oil market returns has attracted a growing interest in the literature over the last two decades. For examples, Al-Mudhaf and Goodwin (1993) find that oil price shocks affect positively the returns from 29 US oil companies during the 1973 oil shock period. Rajgopal and Venkatachalam (1998) find a strong correlation between earnings-sensitivity to oil price risk and equity return-sensitivity to oil price risk for a sample of 25 petroleum refiner companies. Sadorsky (2001) find that exchange rates, crude oil prices and interest rates each affect significantly stock returns of Canadian oil and gas companies. Likewise, El-Sharif et al. (2005) show a significant impact of crude oil price in equity values in the oil and gas returns using data relating to the United Kingdom. Lanza et al. (2005) argue that there is a significant relationship between the stock prices of six major oil companies and the spread between spot and future oil price, the relevant stock market index and the exchange rate. Boyer and Filion (2007) discover that the Canadian oil and gas companies' stock returns are sensitive to the Canadian stock market return, crude oil and natural gas prices, growth in internal cash flows and proven reserves, interest rates, production volume and exchange rates. Using a two-step regression analysis under two different arbitrage pricing models, Scholtens and Wang (2008) find that NYSE listed oil and gas firms' returns is positively associated with the return of the market, the increase of the spot crude oil price, and negatively with the firm's book-to-market ratio.

A major limitation of this literature explaining the behaviour of oil stock markets is that it does not take into account the effects of environmental regulations. Further, the findings of Oberdnorfer (2008) and Veith et al. (2009) indicate that EUA prices affect significantly stock

[1] Towards the end of the first phase of the EU ETS, a number of studies have assessed the ex-post economic impacts of the EU ETS. For examples, Hoffman (2007) investigates the impact of the EU ETS on the technology investment decisions that reduce CO2 emissions for the German electricity industry. He finds that the effect of the EU ETS is much stronger in low carbon investments with limited risks than in large-scale investments with long amortization times. Using an error correction and autoregressive distributed lag model, Zachmann and Hirshhausen (2008) find that EUA prices are passed through asymmetrically to electricity futures prices in Germany. Anger and Oberndorfer (2008) cannot detect any significant impact on firm performance and employment of regulated German firms.

returns of electricity companies. In this paper, we address this limitation by investigating whether and to what extent EUA price affects stock returns of European oil companies. In addition, we examine the carbon price risk across three other sectors namely cement, chemicals and steel chosen on the basis of their dependence on oil prices, in order to investigate if the EUA price affects other industries in the same ways or not. Our empirical results reveal that the relationship between EUA prices and equity values in the oil sector is significantly positive. There is evidence that EUA price shocks have asymmetric impacts on the oil stock market. Likewise, we discover that EUA price changes have significant positive effects on steel stock market, but this effect is symmetric. In contrast, there is no evidence of a significant impact of EUA price movements on chemicals and cement stock returns. Our findings suggest that investors should hedge EUA price risk for portfolio including European steel and oil stock.

The remainder of the paper is organized as follows. Section 2 describes the empirical methodology. Section 3 describes the data used in the study. Section 4 contains the empirical results. Section 5 concludes.

2. Methodology

The model presented in this paper has at its core the multifactor models developed by Jorion (1990), Faff and Chan (1998), Faff and Brailsford (1999) and Sadorsky (2001). The model used as a benchmark for our econometric estimation is a generalized least squared cross-sectional time series linear model incorporating five common factors and takes the following form:

$$R_{it} = \alpha + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t \quad (1)$$

where α is the constant term, and ε_t is the residual not explained by the four factors. $R_{i,t}$ is the excess equity return on each company's stock. $R_{oil,t}$ is the return on oil prices. $R_{m,t}$ is the market portfolio excess return; the market return is a proxy for changes in the return on the portfolio of all invested wealth that move risk premia and expected returns (Fama and French, 1989; Ferson and Harvey, 1991). $R_{e,t}$ is the exchange rate return, which is a proxy for unexpected movements in exchange rates. As found by Jorion (1990), the value of multinational firms should react to fluctuations in exchange rates. $R_{tc,t}$ is the interest rate factor, which is an indicator that gives an insight into the health state of the economy and therefore captures the default risk (Chen et al. 1986).

The main drawback of this specification is that it does not take into account environmental regulations. Indeed, the change in EUA prices directly moves revenues, profits and investments since oil companies covered by the ETS monitor the cost of their emissions in their production processes. Thus, we propose to estimate an extended model that evaluates the climate change impacts on the European oil stock prices by taking into account EUA price factor. Therefore, Model 1 becomes:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t \quad (2)$$

where $R_{co_2,t}$ is the return on the EUA and represents unanticipated change in the EUA price. All the remaining items have the same meaning as described under Eq. (1)

Some empirical studies demonstrate the asymmetric response of aggregate economic activity to oil price changes, suggesting that oil prices increases slowdown economic activity more faster than oil prices decreases boost it (see for e.g. Mork, 1989; Mory, 1993; Mork and Oslen ,1994, Federer, 1996; Brown and Yücel, 2002; Hamilton, 2003; Lardic and Mignon, 2008). Using an unrestricted vector autoregression model, Sadorsky (1999) investigates the interaction between oil prices, stock returns and economic activity over the period January, 1947 –April, 1996. He finds that positive oil price changes have a more important impact on aggregate stock returns than are negative price changes. Sadorsky (1999) concludes that the relationship between oil price shocks and stock returns is asymmetric. Guidi et al. (2006) consider the international events impacts on the price and availability of oil, with an explicit focus on the efficiency of the US and UK oil stock markets response during conflict and non-conflict times over the period 1986-2004. They discover that markets react efficiently to OPEC during non conflict periods but they react not immediately in conflict periods, suggesting that there are asymmetric reactions to OPEC policy decisions for the US and UK stock markets. Sadorsky (2008) finds that changes in oil prices have an asymmetric effect on stock return of firms listed in the S&P 1500. Oberdnorfer (2008) shows that the impact of EUA prices on stock returns of electricity corporations is symmetric, while Zachmann and Hirschhausen (2008) find evidence that rising prices of emission allowances have a stronger impact on wholesale electricity prices than falling prices for the German market. Oberdnorfer (2008) explains his finding by suggesting that the stock market agents ignore the asymmetric pricing in the relationship between EUA and wholesale electricity prices. Therefore, it is interesting to test whether the impact of EUA price changes is symmetric or asymmetric. To this end, we develop the following model:

$$R_{it} = \alpha + \beta_u D \times R_{co_2,t} + \beta_d (1-D) \times R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t \qquad (3)$$

where D is a dummy variable taking a value of 1 if unanticipated change in the EUA price is positive (i.e. $R_{co_2,t} > 0$) and D = 0 otherwise; β_u and β_d are indicative coefficients corresponding to up and down movements in the EUA price factor. All the remaining items have the same meaning as described under Eq. (1) and Eq. (2). The null hypothesis is the absence of asymmetry and is reflected by the equalisation between the two coefficients:

$$H_{01} : \beta_u = \beta_d$$

The absence of asymmetry as well as the significance of the EUA price factor can also be tested by assuming the sensitivity for both cases is jointly equal to zero:

$$H_{02} : \beta_u = \beta_d = 0$$

In addition, we use interaction terms to test for country-specific effects for the relation between EUA prices and companies' stock prices.

3. Data

In this paper, we examine the relationship between EUA price and European oil stock returns using multifactor incorporating the excess equity return on several oil companies, the EUA price return, the oil price return, the market return, and exchange and interest rates factors. The panel data used in this study consists of 15 European oil companies namely British Petroleum (BP, UK), Compania Espanola de Petroleo (CEPSA, ES), Dragon Oil PLC (IE), Ente Nazionale Idrocarburi (ENI, IT), ERG SpA (IT), Esso (FR), Hellenic Petroleum (GR), Lundin Petroleum (SE), Motor Oil (HELLAS) (GR), Neste Oil (FI), Osterreichischen

Mineraloleverwaltung (OMV, AT), Repsol YPF (ES), Royal Deutsh Schell A (NL), StatoilHydro (NO) and Total (FR). The reasons we use a sample of companies instead of aggregate index is two fold. First, an aggregate index could incorporate oil-related industries non operating in refining and therefore are not affected in the ETS. Second, as suggested by Boyer and Filion (2007), companies included in an aggregate index are restricted on the liquidity of their equities.

Given most of the companies are from countries belonging to the European Monetary Union, the excess equity return is measured as the return on each company stock[2] minus the yield on 3-month German Treasury Bills (the risk free interest rate) and we consider the exchange rate of the dollar against the euro. The interest rate variable is measured as the premium between the annual yield on 10-years German government bonds and the annual yield on 3-month German Treasury Bills and represents the risk free long term discount rate. The choice of German government bonds is explained by its perception by international rating agencies as the main benchmark for euro-denominated bonds because of their high quality (credibility), their liquidity, their size in the market and their degree of standardization (European central bank, 2007). Since most of the companies are included in the Dow Jones Stoxx 600 index, the market portfolio excess return is the return on the Dow Jones Euro Stoxx 600 index in excess of the 3-month Germany Treasury Bills rate. The EUA price is the spot European allowance settlement price and is sourced from Bluenext which is the Europe's leading spot exchange for European Union allowances. The oil price used in this study is the Europe Brent spot price which is the price of the oil produced in the North Sea oil fields. The data span from November 1, 2005 to December 31, 2007 and the frequency of observations is daily. The sample period was determined primarily by covering the first phase of the Emissions Trading Scheme (ETS) and by the availability of the data. Table 1 provides measure and source of the variables used in this study.

Table 1. Definition and source of the variables

Variable	Measure (%)	Source
$R_{i,t}$	Return of each company stock – 3-month German T-bill rate	Datastream/Reuters (author calculation)
$R_{co_2,t}$	((Price of the EUA in €)$_t$/(Price of the EUA in €)$_{t-1}$) – 1	Bluenext (author calculation)
$R_{oil,t}$	((Price of the Europe Brent in \$US)$_t$ / (Price of the Europe Brent in \$US)$_{t-1}$) – 1	Energy Information Administration (author calculation)
$R_{m,t}$	DJS 600 EUR return – 3-month German T-bill rate	Stoxx Limited/Reuters (author calculation)
$R_{e,t}$	((Exchange rate €/\$US)$_t$ / (Exchange rate €/\$US)$_{t-1}$) – 1	European Central Bank (author calculation)
$R_{tc,t}$	((10 years German government bond rate – 3-month German T-bill rate)$_t$ / (10 years German government bond rate – 3-month German T-bill rate)$_{t-1}$) – 1	Reuters (author calculation)

[2] The stock price of each company in the sample data is a closing price quoted in the stock market of the country of origin of each company except for companies from countries not belonging to the European Monetary Union (British Petroleum, Lundin Petroleum and StatoilHydro) which their stock prices are quoted in Berlin Stock Exchange (Germany).

As shown in figure.1 (Appendix A), the EUA spot price crashed by 65% between April 24 and May 12, 2006. Several reasons are advanced like the improvement of the air quality, the weakness in economic activity or the more important diffusion of clean technologies but the main reason is the announcement by some countries of their 2005 emissions data, before the official deadline of May 15 fixed by the European Commission, indicating a generous attribution of quotas in their national allocation plans. On May 15, 2006, the European commission, indeed, confirmed that states covered by the ETS had emitted 44 millions tons of carbon less than proposed in their national allocation plan. Furthermore, Ellerman and Buchner (2008) and Kettner et al. (2008) find evidence that the market of EUA is long for the first years of trading. Accordingly, for all specifications (Eqs. (2) and (3)), we include an interaction term between the EUA factor variable and a dummy variable taking the value of 1 in the period ranges from April 24, 2006 to May 12, 2006 and zero otherwise as well as another interaction term between the EUA factor variable and a dummy variable taking the value of 1 until April 23, 2006 and zero otherwise in order to take into account the EUA price shock.

In addition, we have created interaction terms between the EUA price change and a dummy variable taking the value of one for the country that the company belonged to and zero otherwise in order to investigate country-specific effects. These interaction terms are created for companies belonged to France, Italy, Greece, Ireland, Netherlands, Norway, Sweden, UK, Austria and Finland. Accordingly, oil companies from Spain are used as a benchmark for determining the EUA impact.

The descriptive statistics for the series are given in table 2. The t-statistics indicate that all series have significant means at the 1% confidence level. All the return series have non-symmetric distribution as shown by their positive skeweness statistics with the exception of market return and interest rate variables. These positive statistics indicate that the return series have a thicker upper tail than lower tail. All series exhibit an excessive Kurtosis suggesting that the rejection of the null hypothesis of normality for all return series. The Jarque-Bera statistics confirm the non-normal distribution of all return series.

Table 2. Descriptive statistics for all return series

	$R_{i,t}$ (%)	$R_{co_2,t}$ (%)	$R_{oil,t}$ (%)	$R_{m,t}$ (%)	$R_{e,t}$ (%)	$R_{tc,t}$ (%)
Mean	-3.2597***	-0.8714***	0.1001***	-3.2322***	0.0368***	-0.3459***
Std dev	1.9325	8.5050	1.8250	1.1141	0.4483	11.2308
t-statistic	-155.284	-9.4322	5.0495	-267.0816	7.5651	-2.8352
Skewness	0.2471***	0.9291***	0.0076	-0.3863***	0.3225***	-22.6001***
	(0.000)	(0.000)	(0.774)	(0.000)	(0.000)	(0.000)
Kurtosis	6.9873***	14.0335***	3.2162***	3.4157***	3.8198***	531.8775***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jarque-Bera	5700.463***	44208.45***	16.5862***	271.775***	384.2444***	99494550***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: the sample of daily returns is from 1 November 2005 to 31 December 2005. The number of observations is 8475. The t-statistics relate to a set of the hypothesis that the mean daily return is equal zero. Numbers into parenthesis are p-values. *** indicates significance at 1% level.

As shown in table 3, oil firms' stock returns, EUA returns, market returns and exchange rate returns are positively correlated. However, interest rate returns are negatively correlated with oil firms share returns. In general, the correlation values between the series are not too high to cause perfect multicollinearity.

Table 3. Correlation matrix

	$R_{i,t}$	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$
$R_{i,t}$	1					
$R_{co_2,t}$	0.0371*** (0.001)	1				
$R_{oil,t}$	0.1848*** (0.000)	-0.0054 (0.619)	1			
$R_{m,t}$	0.4350*** (0.000)	0.0291*** (0.008)	0.0565*** (0.000)	1		
$R_{e,t}$	0.0551*** (0.000)	-0.0824*** (0.000)	0.1217*** (0.000)	0.0379*** (0.001)	1	
$R_{tc,t}$	-0.0114 (0.293)	-0.0220** (0.043)	0.0242** (0.026)	-0.052*** (0.000)	-0.0257** (0.018)	1

Notes: Numbers into parenthesis are p-values. *** (**) indicate significance at 1% (5%), respectively.

4. Results

4.1 Results for oil companies

In order to well capture the evolution of the link between EUA prices and equity prices, we divided the sample period into 26 months. Table 4 presents the regression results for the multifactor model presented in Eq. (2) for the whole sample period and for each sub-period. As can be seen, the sign, strength and significance of the relationship between EUA returns and stock returns vary over the sub-period (Panel A). Indeed, the relationship is significantly negative on two occasions, while it is significantly positive in five occasions. This finding lets us predict that, in general, the impact of EUA prices on the value of oil companies' stocks is positive. Indeed, the EUA price has a positive effect on oil firm stock price and is statistically significant in the regression result for the whole sample period (Panlel B), suggesting that an increase (decrease) in EUA prices is reflected in positive (negative) returns being earned by European oil companies equities. This result is comparable to those found by Sijm et al. (2006) and Oberndorfer (2008) for electricity corporations and it is explained by the free allocation of emissions allowances. Indeed, under full grandfathering, the profitability of companies covered by the ETS is positively affected by EUA prices. We observe that the strength of the relation is especially strong in June 2006. This can be explained by the significant increase of EUA prices in this month due mainly to the dissipation of uncertainties about the shortage of allowances following the release of 2005 emissions data in April/May 2006 indicating a significant oversupply of EUAs. We find also that the crude oil price, the market return and the exchange rate affect positively oil firm returns. With the exception of exchange rate, our results are comparable to those found by Sadorsky (2001) and Boyer and Filion (2007) for Canadian oil companies and to those found by El-Sharif et al. (2005) for Britain oil firms. The positive sign of the exchange rate suggest that an appreciation of the Euro against the US dollar leads to positive returns for European oil stocks. Indeed, European oil companies benefit from the appreciation of the Euro since they export crude and refined oil to the United-States of America. The estimated coefficient for the market return is less than unity suggesting that the oil companies are less risky than the European market. The estimated coefficient for the interest rate is positive and insignificant in the whole sample period.

Table 4. Model results for oil companies

Panel A sub-period data

Sub-period	α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	Adj.R^2	DW
2005-11	-0.655	0.022	0.349***	0.649**	0.096	-5.852	-	0.058	2.082
	(0.217)	(0.708)	(0.000)	(0.010)	(0.720)	(0.188)			
2005-12	-1.801***	0.110**	0.246***	0.278	-0.417*	-8.329**	-	0.087	2.200
	(0.003)	(0.046)	(0.000)	(0.311)	(0.066)	(0.021)			
2006-01	-1.376***	-0.050	0.108*	0.237	-0.088	-0.924	-	-0.0002	2.556
	(0.000)	(0.181)	(0.059)	(0.128)	(0.532)	(0.742)			
2006-02	-1.806	0.118*	0.222***	0.377**	-0.349	-2.202	-	0.064	2.170
	(0.000)	(0.075)	(0.000)	(0.049)	(0.303)	(0.655)			
2006-03	-1.267***	0.043	0.149***	0.509	0.291	0.699	-	0.065	2.246
	(0.001)	(0.685)	(0.002)	(0.001)	(0.109)	(0.865)			
2006-04	-2.453***	0.0466***	0.262***	-0.040	0.125	-3.541*	-	0.106	2.309
	(0.000)	(0.000)	(0.008)	(0.861)	(0.489)	(0.085)			
2006-05	-0.712*	0.004	0.261***	0.781***	0.632*	3.675	-	0.194	2.326
	(0.058)	(0.795)	(0.002)	(0.000)	(0.069)	(0.271)			
2006-06	-1.837***	0.145***	0.320	0.351**	0.229	6.616	-	0.178	2.011
	(0.000)	(0.000)	(0.001)	(0.014)	(0.260)	(0.236)			
2006-07	-1.111	-0.131**	0.214***	0.567***	-0.094	2.808	-	0.068	2.194
	(0.001)	(0.018)	(0.002)	(0.000)	(0.628)	(0.397)			
2006-08	-2.456***	0.024	0.173***	0.233	0.039	1.806	-	0.038	2.116
	(0.000)	(0.537)	(0.000)	(0.113)	(0.831)	(0.484)			
2006-09	-1.164**	0.003	0.102***	0.679***	0.194	2.972	-	0.072	2.012
	(0.018)	(0.937)	(0.005)	(0.000)	(0.446)	(0.184)			
2006-10	-1.491**	0.126***	0.160***	0.471**	0.163	-0.423	-	0.067	2.220
	(0.035)	(0.001)	(0.000)	(0.038)	(0.624)	(0.758)			
2006-11	-0.907*	-0.007	0.207***	0.784***	0.111	-3.129**	-	0.137	2.106
	(0.058)	(0.748)	(0.000)	(0.000)	(0.633)	(0.021)			
2006-12	-2.401***	-0.044	0.104*	0.361***	-0.040	2.269***	-	0.043	2.113
	(0.000)	(0.151)	(0.122)	(0.009)	(0.856)	(0.001)			
2007-01	-1.557**	0.002	0.151***	0.579***	-0.051	0.420	0.136	0.068	2.012
	(0.011)	(0.859)	(0.005)	(0.000)	(0.813)	(0.389)	(0.204)		
2007-02	-0.696	0.012	0.116**	0.794***	-0.057	1.706***	-	0.255	2.328
	(0.129)	(0.195)	(0.022)	(0.000)	(0.837)	(0.000)			
2007-03	-1.261***	-0.016	0.237***	0.647***	-0.053	0.0004	-	0.179	2.296
	(0.000)	(0.144)	(0.000)	(0.000)	(0.858)	(0.786)			
2007-04	-1.698***	0.007	0.116*	0.576***	0.298	-0.005	-	0.051	2.515
	(0.000)	(0.472)	(0.060)	(0.000)	(0.347)	(0.404)			
2007-05	-0.960*	0.012	0.038	0.752***	-0.196	0.781***	-	0.087	2.029
	(0.080)	(0.138)	(0.443)	(0.000)	(0.454)	(0.006)			
2007-06	-1.400***	-0.006	0.055	0.607***	-0.263	0.463	-	0.163	2.204
	(0.000)	(0.325)	(0.410)	(0.000)	(0.237)	(0.297)			
2007-07	-1.946***	0.002	0.077	0.556***	0.924**	0.813*	-	0.196	2.177
	(0.000)	(0.862)	(0.304)	(0.000)	(0.012)	(0.087)			
2007-08	-1.046***	0.043***	0.098	0.788***	0.163	0.326***	-	0.273	2.455
	(0.003)	(0.001)	(0.158)	(0.000)	(0.581)	(0.003)			
2007-09	-1.846***	0.016	0.049	0.502***	0.105	0.087	-	0.152	2.405
	(0.000)	(0.15)	(0.463)	(0.000)	(0.727)	(0.594)			
2007-10	-1.924***	-0.0128*	0.194***	0.522***	0.066	-0.507*	-	0.101	2.155
	(0.002)	(0.099)	(0.000)	(0.001)	(0.752)	(0.096)			
2007-11	-2.357***	0.002	0.023	0.464***	0.683**	0.325	-	0.033	2.091
	(0.000)	(0.792)	(0.795)	(0.000)	(0.034)	(0.271)			
2007-12	-1.397***	0.002	0.136**	0.595***	0.023	-1.602*	-	0.089	2.467
	(0.001)	(0.770)	(0.048)	(0.000)	(0.904)	(0.075)			

Continued on the next page

Table 4 (continued)

Panel B-whole period data

α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	λ	ω
-0.892***	0.006**	0.167***	0.737***	0.095**	0.001	-	0.068***	-0.006
(0.000)	(0.012)	(0.000)	(0.000)	(0.034)	(0.251)		(0.0003)	(0.483)

Observations = 8475 Panels = 15 Adj.R^2=0.216 DW=2.157 F-statistic= 112.213 Prob(F-statistic)=0.000

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. All regressions were performed on the basis of White's (1980) correction for heteroskedasticity. Period"*yyyy-m*" refers to month *m* in year *yyyy*. The coefficient δ is an estimate of the first-order autoregressive coefficient produced by the Cochrane Orcutt procedure for those cases in which significant autocorrelation is detected by the Durbin-Watson test in the original regression. The DW statistics are compared to critical values sourced from Bhargava and Narendranathan (1982). For the panel B, the regression includes the two interaction terms: pre-market shock (λ) and market shock (ω).*, ** and*** indicate significance at the 10%, 5% and 1%, respectively. P-values are into parentheses.

Results for Wald tests for the model 2 are reported in Table 5. The null Hypothesis $H_{02}: \beta_u = \beta_d = 0$ is rejected, implying the significance of the EUA price factor. This result is consistent with that of model 1. As shown in table 5, the null hypothesis $H_{01}: \beta_u = \beta_d$ is rejected. This finding shows that the impact of EUA price changes on the stock returns of oil firms is asymmetric, suggesting that negative EUA price movements have a greater impact on stock returns than positive EUA price movements. This result is entirely opposite to that found by Oberndorfer (2008) for electricity companies.

Table 5. Asymmetric model results

β_u	β_d	$H_{02}: \beta_u = \beta_d = 0$	$H_{01}: \beta_u = \beta_d$	Adj.R^2	DW	F-statistic
-0.006	0.019***	16.703	14.995	0.218	2.161	108.335
(0.230)	(0.000)	(0.000)	(0.000)			(0.000)

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_u D \times R_{co_2,t} + \beta_d (1 - D) \times R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, *D* is a dummy variable taking a value of 1 if $R_{oil,t} > 0$, and 0 otherwise, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. The regression includes the two interaction terms: pre-market shock and market shock. P-values are into parentheses.

As indicated by F-statistic (Table 6), the null hypothesis of the absence of country effects is accepted significantly at 1%. However, the EUA impact appears only significant for Spanish and Dutch companies. One explanation for this finding may be the short position of these companies. Indeed, Spain and Netherlands rank amongst the few countries to have a National Allocation Plan (NAP) that is below their baseline emissions.

Table 6. Country-Specific model results

$R_{i,t}$	Coefficients
α	-0.900***
	(0.000)
$R_{co_2,t}$	0.008**
	(0.035)
$R_{oil,t}$	0.165***
	(0.000)
$R_{m,t}$	0.736***
	(0.000)
$R_{e,t}$	0.092**
	(0.044)
$R_{tc,t}$	0.001
	(0.255)
Market shock	-0.006
	(0.481)
Pre-market shock	0.067**
	(0.003)
France	0.001
	(0.774)
Italy	0.007
	(0.171)
Greece	0.002
	(0.727)
Ireland	0.014
	(0.544)
Netherlands	0.014***
	(0.000)
Norway	0.007
	(0.371)
Sweden	0.004
	(0.717)
UK	0.006
	(0.203)
Austria	0.010
	(0.230)
Finland	0.0002
	(0.987)

Observations = 8475 Panels = 15 Adj.R^2= 0.215 DW = 2.157 F-statistic = 76.076 Prob (F-statistic) = 0.000

F-test on country-interaction specific terms = 0.77 Prob (F-test on country-interaction specific terms) = 0.629

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. All regressions were performed on the basis of White's (1980) correction for heteroskedasticity. The regression includes the two interaction terms (pre-market shock and market shock) as well as country interaction terms (France, Italy, Greece, Ireland, Netherlands, Norway, Sweden, UK, Austria and Finland). P-values are into parentheses.

4.2. Inter-sectoral comparison of results

We examine the carbon price risk across three other industries namely steel, cement and chemicals chosen on the basis of their affectation to the ETS and their consumption of oil, in order to investigate if the EUA price affects other industries in the same ways or not. Faff and Brailsford (1999, 2000) and Nandha and Faff (2008) find a significant oil and market sensitivity for chemicals, construction and building materials and steel industries, among others[3]. Accordingly, we use the same model in the analysis of these industries[4]. Table 7 reports the EUA price coefficient estimates using daily data for the three non-oil industries. We observe significant differences between estimation results. Indeed, the EUA price coefficient values for the steel companies range from -0.004 to 0.158 across the 26 months and are significant in five cases. For the whole sample period regression, the effect of the EUA price on industry steel equities is significantly positive. This result is similar to that found for oil industry. The coefficient estimates of EUA price for cement industry vary between -0.016 and 0.234 across the 26 sub-period, taking a significant positive values on four cases. However, the EUA price coefficient estimate appears negative and insignificant in regression result for the whole sample period implying that the EUA price effect on cement industry returns is weak. The EUA price coefficient is also negative and insignificant for chemicals companies for the whole sample period implying a feeble relationship between EUA prices and equity values. However, the EUA price effect appears significant on 4 occasions across the 26 sub-period. In summary, the results indicate that the EUA price effect is significant for steel company returns but it is insignificant for returns of cement and chemicals companies' equity values.

.

Table 7. Model results for non-oil companies

Panel A sub-period data			
Sub-period	Dependent variable		
	$R_{co_2,t}$ (steel)	$R_{co_2,t}$ (cement)	$R_{co_2,t}$ (chemicals)
2005-11	0.025	-0.009	0.059
	(0.646)	(0.881)	(0.190)
2005-12	0.158**	0.125**	0.038
	(0.011)	(0.011)	(0.366)
2006-01	-0.118	0.005	-0.011
	(0.131)	(0.895)	(0.745)
2006-02	0.084	0.234***	0.048
	(0.421)	(0.002)	(0.480)
2006-03	-0.042	0.011	-0.121
	(0.801)	(0.943)	(0.200)
2006-04	0.070***	-0.003	0.030**
	(0.003)	(0.829)	(0.024)
2006-05	-0.031	-0.008	0.018*
	(0.179)	(0.685)	(0.058)
2006-06	0.073	0.160***	0.092***
	(0.210)	(0.002)	(0.001)
2006-07	0.125	0.047	-0.016
	(0.114)	(0.453)	(0.739)
2006-08	0.075	0.016	0.0321
	(0.159)	(0.779)	(0.501)
2006-09	0.053	0.050	0.058**
	(0.235)	(0.113)	(0.046)

Continued on the next page

[3] In the steel industry, oil is used as reductant in the blast furnace as well as in heating ovens. For the cement industry, oil is used during the calcination of raw materials in the kiln. Moreover, oil is an important fuel used in the production of most bulk chemicals.

[4] The descriptive statistics and the sample data of each industry analysis are available in Appendix B.

Table 7 (continued)

Sub_period	Dependent variable		
	$R_{co_2,t}$ (steel)	$R_{co_2,t}$ (cement)	$R_{co_2,t}$ (chemicals)
2006-10	0.080	-0.006	-0.037
	(0.106)	(0.852)	(0.231)
2006-11	0.005	-0.016	-0.003
	(0.887)	(0.545)	(0.862)
2006-12	0.023	0.075*	-0.027
	(0.901)	(0.085)	(0.352)
2007-01	-0.021	-0.015	0.020**
	(0.473)	(0.204)	(0.031)
2007-02	0.041***	-0.011	-0.005
	(0.002)	(0.254)	(0.613)
2007-03	0.007	0.004	0.016
	(0.725)	(0.730)	(0.123)
2007-04	0.026**	-0.001	-0.015
	(0.043)	(0.969)	(0.114)
2007-05	0.020	0.011	-0.023*
	(0.110)	(0.252)	(0.060)
2007-06	-0.004	0.017**	-0.001
	(0.608)	(0.022)	(0.848)
2007-07	0.0008	-0.004	-0.002
	(0.962)	(0.753)	(0.819)
2007-08	-0.009	-0.012	0.001
	(0.650)	(0.457)	(0.912)
2007-09	0.060***	0.015	0.014
	(0.000)	(0.310)	(0.259)
2007-10	0.013	-0.002	-0.005
	(0.302)	(0.839)	(0.545)
2007-11	0.013	-0.008	-0.002
	(0.203)	(0.323)	(0.735)
2007-12	0.026	-0.008	0.012
	(0.535)	(0.363)	(0.122)

Panel B-whole period data

	Dependent variable		
	$R_{co_2,t}$ (steel)	$R_{co_2,t}$ (cement)	$R_{co_2,t}$ (chemicals)
	0.014**	0.0001	-0.001
	(0.024)	(0.744)	(0.664)

Notes: this table reports the EUA return coefficient estimates in model 1 for steel, cement and chemicals companies. All regressions for each industry analysis are available in the Appendix C. *, ** and*** indicate significance at the 10%, 5% and 1%, respectively. P-values are into parentheses.

Results for EUA exposure estimates and Wald tests for the model 2 equations for the non-oil industries are reported in Table 8. $H_{02}:\beta_u=\beta_d=0$ is rejected for cement and chemicals companies. In contrast, it is accepted for steel companies. These results are consistent with the results of model 1. The null hypothesis $H_{01}:\beta_u=\beta_d$ is accepted for the steel industry suggesting that EUA price increases and decreases affect symmetrically stock returns.

Considering the four industries as a whole, the EUA price movements appear an important factor in modelling steel and oil companies' equity values. Given the importance part of steel and especially oil equities in international portfolios, our findings suggest that traders and investors should consider EUA price risk in their forecast of European oil and steel companies' equity values.

Table 8. Asymmetric model results for non oil-companies

Companies	β_u	β_d	$H_{02}:\beta_u=\beta_d=0$	$H_{01}:\beta_u=\beta_d$	Adj.R^2	DW	F-statistic
Steel	0.013	0.016*	2.867	0.038	0.202	2.360	81.658
	(0.215)	(0.055)	(0.057)	(0.845)			(0.000)
Cement	-0.001	0.003	0.158	0.247	0.378	2.075	127.887
	(0.848)	(0.577)	(0.854)	(0.619)			(0.000)
Chemicals	-	-0.002	0.151	0.106	0.314	2.202	180.828
	0.0002	(0.590)	(0.860)	(0.745)			(0.000)
	(0.964)						

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_u D \times R_{co_2,t} + \beta_d (1 - D) \times R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, D is a dummy variable taking a value of 1 if $R_{oil,t} > 0$, and 0 otherwise, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. The regression includes the two interaction terms: pre-market shock and market shock. P-values are into parentheses.

5. Summary and Conclusion

There is a sizable literature investigating the determinants of oil stock market with an explicit focus on the impact of changes in oil prices. This literature however ignores the impact of environmental regulations. This paper extends the existing literature by examining the impact of EUA price on the oil stock market. Our analysis was undertaken using a sample of 15 European oil companies over the period November 2005-December 2007. Empirical results reveal that European carbon allowance (EUA) price has a significant positive effect on oil equity returns. Moreover, we find evidence of an asymmetry in the EUA price sensitivities. In addition, we examine the EUA price risk across three other sectors namely cement, chemicals and steel chosen on the basis of their dependence on oil prices, in order to investigate if the carbon price affect other industries in the same ways or not. We find that the EUA price impact is only significant for the steel industry and appear symmetric for the three non-oil industries. Our findings suggest that investors should hedge EUA price risk for portfolio including European steel and oil equities.

References

Al-Mudhaf, A., Goodwin, T.H., 1993. Oil shocks and oil stocks: evidence from the 1970s. Applied Economics 25,181–190.

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 58 (6), 685–692.

Bhargava, A., Narendranathan, W., 1982. Serial correlation and the fixed effects model. Review of Economic Studies 49 (4), 533–549.

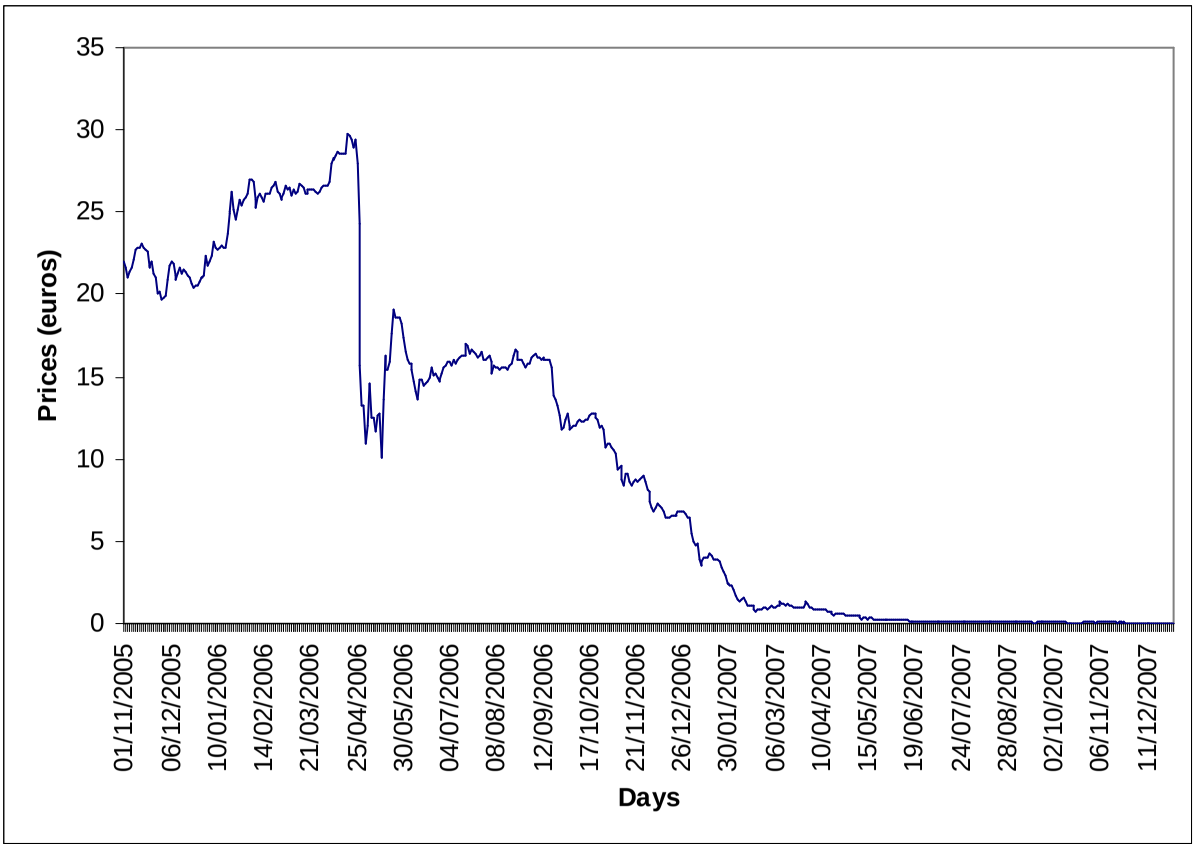
Boyer, M.M., Filion, D., 2007. Common and fundamental factors in stock returns of Canadian oil and gas companies. Energy Economics 29 (3), 428–453.

Brown, S.P.A., Yücel, M.K., 1999. Oil prices and U.S. aggregate economic activity. Federal Reserve Bank of Dallas Economic Review 16–53.
Chen, N.F., Roll, R., Ross, S.A., 1986. Economic forces and the stock market. Journal of Business 59, 383–403.
Ellerman, D., Buchner, B.K., 2008. Over-allocation or abatement? A preliminary analysis of the EU ETS based on the 2005-06 emissions data. Environmental and Resource Economics, in press.
El-Sharif, I., Brown, D., Burton, B., Nixon, B., Russell, A., 2005. Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. Energy Economics 27 (6), 819–830.
European Central Bank, 2007. The Euro bonds and derivatives markets.
Faff, R., Brailsford, T., 1999. Oil price risk and the Australian stock market. Journal of Energy Finance & Development 4, 69–87.
Faff, R., Brailsford, T., 2000. A test of a two-factor 'market and oil' pricing model. Pacific Accounting Review 12 (1),61–77.
Faff, R., Chan, H., 1998. A multifactor model of gold industry stock returns: evidence from the Australian equity market. Applied Financial Economics 8, 21–28.
Fama, E., French, K., 1989. Business conditions and expected returns on stocks and bonds. Journal of Financial Economics 25, 23– 49.
Ferderer, J.P., 1996. Oil price volatility and the macroeconomy: a solution to the asymmetry puzzle. Journal of Macroeconomics 18, 1–16.
Ferson, W., Harvey, C., 1991. The variation of economic risk premiums. Journal of Political Economy 99, 385–415.
Guidi, M., Russell, A., Tarbert, H., 2006. The effect of OPEC policy decisions on oil and stock prices. OPEC Review 30, 1–18.
Hamilton, J.D., 2003. What is an oil shock? Journal of Econometrics 113, 363–398.
Hoffman, V.H., 2007. EU ETS and investment decisions: The case of the German Electricity Industry. European Management Journal 25 (6), 464–474.
Jorion, P., 1990. The exchange-rate exposure of US multinationals. Journal of Business 63, 331– 345.
Kettner, K., Köppl, A., Schleicher, S.P., Themius, G., 2008. Stringency and distribution in the EU Emissions Trading Scheme—the 2005 evidence. Climate Policy 8, 41–61.
Lacombe R, 2008, Economic Impact of the European Union Emission Trading Scheme: Evidence from the Refining Sector, MIT Masters Thesis
Lanza, A., M. Manera, M. Grasso, and M. Giovannini, 2003. Long-run Models of Oil Stock Prices. Environmental Modelling and Software 20, 1423–1430.
Lardic, S., Mignon, V., 2008. Oil prices and economic activity: An asymmetric cointegration approach. Energy Economics 30 (3), 847–885.
Mork, K.A., 1989. Oil and the macroeconomy when prices go up and down: an extension of Hamilton's results. Journal of Political Economy 97, 740–744.
Mork, K.A., Olsen, O., Mysen, H.T., 1994. Macroeconomic responses to oil price increases and decreases in seven OECD countries. Energy Journal 15 (4), 19–35.
Mory, J.F., 1993. Oil prices and economic activity: is the relationship symmetric? Energy Journal 14 (4), 151–161.
Nandha, M., Faff, R., 2008. Does oil move equity prices? A global view. Energy Economics 30, 986–997.
Oberndorfer, U., 2008. EU Emission Allowances and the stock market: Evidence from the electricity industry. Ecological Economics. In press.
Pierru, A., 2007. Allocating the CO2 emissions of an oil refinery with Auman-Shapeley prices. Energy Economics 29, 563–577.

Rajgopal, S., and M. Venkatachalam, 1998. Are Earning Sensitivity Measures Risk-relevant? The Case of Oil Price Risk for the Petroleum Refining Industry, Working Papers, Stanford Graduate School of Business.
Reinaud, J., 2008. Issues behind Competitiveness and Carbon Leakage under Uneven Climate Polices – Focus on Heavy Industry, IEA Information Paper.
Reinaud, J., 2005. The European Refinery under the EU Emissions Trading Scheme - Competitiveness, Trade flows and Investment Implications, IEA Information Paper, IEA/OECD, Paris.
Sadorsky, P., 2008. Assessing the impact of oil prices of firms of different sizes: Its tough being in the middle. Energy Policy 36, 3854–3861.
Sadorsky, P., 2001. Risk factors in stock returns of Canadian oil and gas companies. Energy Economics 23, 17–28.
Sadorsky, P., 1999. Oil price shocks and stock market activity. Energy Economics 21, 449–469.
Sijm, J., Neuhoff, K., and Chen, Y., 2006. CO2 Cost Pass-Through and Windfall Profits in the Power Sector. Climate Policy 6, 49–72.
Scholtens, B., Wang, L., 2008. Oil risk in oil stocks. The Energy Journal 29 (1), 89–112.
Veith, S., Werner, J.R., Zimmermann, J., 2009. Capital Market Response to Emission Rights Returns: Evidence from the European Power Sector. Energy Economics, In press.
White, H., 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica 48, 817– 838.
Zachman, G., von Hirschhausen, C., 2008. First evidence of asymmetric cost pass-through of EU emissions allowances: Examining wholesale electricity prices in Germany. Economics Letter 99, 465– 469

Appendix A

Fig.1 The evolution of EUA prices (November 2005- December 2007)



Source: Bluenext

Appendix B

Table B1. Descriptive statistics for steel companies' analysis

	$R_{i,t}$ (%)	$R_{co_2,t}$ (%)	$R_{oil,t}$ (%)	$R_{m,t}$ (%)	$R_{e,t}$ (%)	$R_{tc,t}$ (%)
Mean	-3.12090***	-0.8714***	0.1001***	-3.2322***	0.0368***	-0.3459**
Std dev	2.8368	8.5050	1.8250	1.1141	0.4483	11.2308
t-statistic	-78.4506	-7.3059	3.9112	-162.9783	5.8597	-2.1961
Skewness	0.8934***	0.9291***	0.0076	-0.3863***	0.3225***	-22.6001***
	(0.000)	(0.000)	(0.824)	(0.000)	(0.000)	(0.000)
Kurtosis	38.1974***	14.0335***	3.2162***	3.4157***	3.8198***	531.8775***
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)
Jarque-Bera	263159.2***	26525.07***	9.9517***	163.065***	230.547***	59696730***
	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)

Notes: The panel data consists of 9 European steel companies: Acerinox (ES), Arcelor Mittal (LU), Outokumpu (FI), Rautaruukki K (FI), Salzgitter (DE), Saint Gobain (FR), Tenaris (IT), ThyssenKrupp (DE) and Voestalpine (AT). The sample of daily returns is from 1 November 2005 to 31 December 2005. The number of observations is 5085. The t-statistics relate to a set of the hypothesis that the mean daily return is equal zero. Numbers into parenthesis are p-values. ***, **indicate significance at 1%, 5%, respectively.

Table B2. Descriptive statistics for cement companies' analysis

	$R_{i,t}$ (%)	$R_{co_2,t}$ (%)	$R_{oil,t}$ (%)	$R_{m,t}$ (%)	$R_{e,t}$ (%)	$R_{tc,t}$ (%)
Mean	-3.1979***	-0.8714***	0.1001***	-3.2322***	0.0368***	-0.3459*
Std dev	1.7697	8.5050	1.8250	1.1141	0.4483	11.2308
t-statistic	-113.6450	-6.4430	3.4493	-182.4382	5.1676	-1.9367
Skewness	0.0627	0.9291***	0.0076	-0.3863***	0.3225***	-22.6001***
	(0.108)	(0.000)	(0.852)	(0.000)	(0.000)	(0.000)
Kurtosis	5.2096***	14.0335***	3.2162**	3.4157***	3.8198***	531.8775***
	(0.000)	(0.000)	(0.01)	(0.000)	(0.000)	(0.000)
Jarque-Bera	807.186***	20630.61***	7.7402**	126.8282***	179.314***	46430790***
	(0.000)	(0.000)	(0.021)	(0.000)	(0.000)	(0.000)

Notes: The panel data consists of 7 European cement companies: Cimpor Cementos de Portugal (PT), CRH PLC (IE), FLSMIDTH & Company (DK), Heidelbergcement (DE), Holcim (CH), Laffarge (FR), Titan Cement Company (GR). The stock firm price of each companies in the sample data is a closing price quoted in the stock market of the country of origin of each company except for companies from countries not belonging in the European Monetary Union which their stock price are quoted in Berlin Stock Exchange (Germany). The sample of daily returns is from 1 November 2005 to 31 December 2005. The number of observations is 3955. The t-statistics relate to a set of the hypothesis that the mean daily return is equal zero. Numbers into parenthesis are p-values. *, ** and*** indicate significance at the 10%, 5% and 1%, respectively.

Table B3. Descriptive statistics for chemicals companies' analysis

	$R_{i,t}$ (%)	$R_{co_2,t}$ (%)	$R_{oil,t}$ (%)	$R_{m,t}$ (%)	$R_{e,t}$ (%)	$R_{tc,t}$ (%)
Mean	-3.2117***	-0.8714***	0.1001***	-3.2322***	0.0368***	-0.3459*
Std dev	1.8827	8.5050	1.8250	1.1141	0.4483	11.2308
t-statistic	-162.1906	-9.7416	5.2152	-275.8402	7.8132	-2.9282
Skewness	0.1048***	0.9291***	0.0076	-0.3863***	0.3225***	-22.6001***
	(0.000)	(0.000)	(0.766)	(0.000)	(0.000)	(0.000)
Kurtosis	7.3176***	14.0335***	3.2162***	3.4157***	3.8198***	531.8775***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jarque-Bera	7038.312***	47155.68***	17.6920***	289.893***	409.8607***	1.06E+08***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: The panel data consists of 16 European chemicals companies: Aksonobel (NL), Basf (DE), Bayer (DE), Ciba HLDG (CH), Clariant (CH), Givaudan (CH), Johnson Matthey (UK), K+S (DE), Koninklijke DSM (NL), Lanxess (DE), Linde (DE), Rhodia (FR), Solvay (BE), Syngenta (CH), Umicore (BE), Yara (NO). The stock firm price of each companies in the sample data is a closing price quoted in the stock market of the country of origin of each company except for companies from countries not belonging in the European Monetary Union which their stock price are quoted in Berlin Stock Exchange (Germany). The sample of daily returns is from 1 November 2005 to 31 December 2005. The number of observations is 9040. The t-statistics relate to a set of the hypothesis that the mean daily return is equal zero. Numbers into parenthesis are p-values. ***, **indicate significance at 1%, 5%, respectively.

Appendix C

Table C1. Model results for steel companies

Panel A daily data

Sub-period	α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	Adj.R^2	DW
2005-11	0.133	0.025	0.107*	0.976***	0.186	-9.312**	-	0.071	2.022
	(0.813)	(0.646)	(0.075)	(0.000)	(0.331)	(0.017)			
2005-12	-1.071***	0.158**	0.004	0.444	-0.292	4.383	-	0.073	2.280
	(0.007)	(0.011)	(0.938)	(0.016)	(0.150)	(0.223)			
2006-01	2.388**	-0.118	0.277**	1.709***	-0.978**	-8.402	-	0.184	2.019
	(0.026)	(0.131)	(0.022)	(0.000)	(0.022)	(0.169)			
2006-02	-0.658	0.084	0.098	0.694**	0.092	-8.915	-	0.025	2.736
	(0.348)	(0.421)	(0.312)	(0.019)	(0.850)	(0.160)			
2006-03	-0.576	-0.042	0.062	0.653**	-0.044	-1.391	-	-0.004	1.946
	(0.378)	(0.801)	(0.398)	(0.014)	(0.889)	(0.805)			
2006-04	0.390	0.070***	-0.027	0.984***	0.149	-0.360	-	0.161	2.322
	(0.577)	(0.003)	(0.837)	(0.000)	(0.503)	(0.915)			
2006-05	1.123**	-0.031	0.129	1.378***	1.049**	9.856**	-	0.364	2.697
	(0.042)	(0.179)	(0.313)	(0.000)	(0.037)	(0.032)			
2006-06	0.517	0.073	0.188	1.182***	0.198	1.939	-	0.210	2.308
	(0.578)	(0.210)	(0.367)	(0.001)	(0.555)	(0.801)			
2006-07	-0.206	0.125	0.036	0.915***	0.416	9.346**	-	0.243	2.470
	(0.635)	(0.114)	(0.741)	(0.000)	(0.136)	(0.029)			
2006-08	-1.292***	0.075	-0.082	0.609***	0.212	-4.232	-	0.074	2.242
	(0.008)	(0.159)	(0.131)	(0.000)	(0.342)	(0.230)			
2006-09	-0.429	0.053	0.122**	0.798***	0.360	2.835	-	0.110	2.242
	(0.475)	(0.235)	(0.011)	(0.000)	(0.294)	(0.284)			
2006-10	0.147	0.080	0.188***	0.874***	-0.097	1.006	-	0.143	2.321
	(0.859)	(0.106)	(0.000)	(0.001)	(0.798)	(0.583)			
2006-11	0.493	0.005	0.074	1.116***	0.818**	1.574	-	0.162	2.179
	(0.507)	(0.887)	(0.247)	(0.000)	(0.042)	(0.29)			
2006-12	4.428	0.023	0.143	2.251**	1.520	3.031	-	-0.024	2.269
	(0.186)	(0.901)	(0.757)	(0.020)	(0.296)	(0.557)			
2007-01	0.476	-0.021	0.188	1.088***	1.316**	-0.417	-	0.162	2.159
	(0.660)	(0.473)	(0.024)	(0.000)	0.036	(0.637)			
2007-02	3.391***	0.041***	-0.219***	1.798***	-0.577	-0.940	-	0.315	2.165
	(0.007)	(0.002)	(0.007)	(0.000)	(0.349)	(0.239)			
2007-03	0.140	0.007	0.159*	1.057***	-0.173	9.80E-06	-	0.296	2.089
	(0.766)	(0.725)	(0.077)	(0.000)	(0.652)	(0.995)			
2007-04	-1.478**	0.026**	-0.045	0.590***	-0.399	0.012	-	0.157	2.167
	(0.013)	(0.043)	(0.586)	(0.000)	(0.278)	(0.241)			
2007-05	0.870	0.020	-0.075	1.150***	0.200	0.477	-	0.134	2.429
	(0.386)	(0.110)	(0.301)	(0.000)	(0.556)	(0.273)			
2007-06	1.623***	-0.004	0.117	1.370***	0.356	0.337	-	0.481	2.312
	(0.000)	(0.608)	(0.180)	(0.000)	(0.298)	(0.510)			
2007-07	0.045	0.0008	0.140	0.988***	0.163	0.183	-	0.289	2.411
	(0.941)	(0.962)	(0.224)	(0.000)	(0.6881)	(0.785)			
2007-08	0.207	-0.009	0.141	1.034***	0.089	-0.071	-	0.353	2.184
	(0.700)	(0.650)	(0.143)	(0.000)	(0.807)	(0.551)			
2007-09	0.123	0.060***	-0.021	1.017***	0.422	0.087	-	0.275	2.050
	(0.872)	(0.000)	(0.855)	(0.000)	(0.571)	(0.690)			
2007-10	-0.166	0.013	0.043	1.023***	1.021***	-0.705*	-	0.166	2.128
	(0.849)	(0.302)	(0.500)	(0.000)	(0.000)	(0.092)			
2007-11	-1.169	0.013	0.077	0.904***	1.479***	1.577***	-	0.221	2.463
	(0.109)	(0.203)	(0.544)	(0.000)	(0.003)	(0.003)			
2007-12	-0.526	0.026	-0.099	0.858	-0.682	4.000*	-	-0.018	2.808
	(0.834)	(0.535)	(0.528)	(0.216)	(0.506)	(0.063)			

Panel B-monthly cumulative data

α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	λ	ω
0.476***	0.010*	0.102***	1.115***	0.198**	0.002	-	0.011	-0.034**
(0.000)	(0.079)	(0.000)	(0.000)	(0.034)	(0.189)		(0.725)	(0.019)

Observations = 5085 Panels = 9 Adj.R^2 = 0.202 DW = 2.361 F-statistic = 87.113 Prob (F-statistic) = 0.000

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. All regressions were performed on the basis of White's (1980) correction for heteroskedasticity. Period"*yyyy-m*" refers to month *m* in year *yyyy*. The coefficient δ is an estimate of the first-order autoregressive coefficient produced by the Cochrane Orcutt procedure for those cases in which significant autocorrelation is detected by the Durbin-Watson test in the original regression. The DW statistics are compared to critical values sourced from Bhargava and Narendranathan (1982). For the panel B, the regression includes the two interaction terms: pre-market shock (λ) and market shock (ω).*, ** and*** indicate significance at the 10%, 5% and 1%, respectively.

Table C2. Model results for cement companies

Panel A daily data

Sub-period	α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	Adj.R^2	DW
2005-11	-1.515***	-0.009	-0.030	0.164	-0.128	4.175	-	-0.034	2.430
	(0.004)	(0.881)	(0.588)	(0.518)	(0.574)	(0.278)			
2005-12	-2.613***	0.125**	-0.042	-0.250	-0.443	-5.105	-	0.034	2.440
	(0.000)	(0.011)	(0.536)	(0.332)	(0.033)	(0.102)			
2006-01	-0.900**	0.005	0.106*	0.574***	-0.051	5.416*	-0.035	0.112	1.920
	(0.046)	(0.895)	(0.055)	(0.002)	(0.755)	(0.073)	(0.711)		
2006-02	-1.000*	0.234***	0.032	0.463*	-0.009	5.224	0.080	0.045	1.983
	(0.085)	(0.002)	(0.645)	(0.063)	(0.984)	(0.278)	(0.456)		
2006-03	-0.601	0.011	-0.085	0.671***	0.211	0.821	-	0.069	2.189
	(0.160)	(0.943)	(0.248)	(0.000)	(0.286)	(0.859)			
2006-04	0.382	-0.003	-0.093	1.083***	0.113	-2.404	-	0.155	2.267
	(0.471)	(0.829)	(0.358)	(0.000)	(0.638)	(0.348)			
2006-05	0.650	-0.008	0.038	1.235***	0.482	-0.678	-	0.437	2.444
	(0.058)	(0.685)	(0.659)	(0.000)	(0.149)	(0.876)			
2006-06	-1.387***	0.160***	0.341***	0.583***	0.103	11.652	-	0.393	2.344
	(0.005)	(0.002)	(0.000)	(0.000)	(0.658)	(0.025)			
2006-07	-0.640	0.047	0.073	0.754***	0.924***	2.968	-	0.285	2.187
	(0.116)	(0.453)	(0.435)	(0.000)	(0.000)	(0.443)			
2006-08	-1.417***	0.016	-0.017	0.540***	-0.139	-9.795	-	0.148	2.495
	(0.000)	(0.779)	(0.738)	(0.000)	(0.529)	(0.001)			
2006-09	-0.492	0.050	-0.014	0.837***	-0.076	-1.800	-	0.181	2.170
	(0.251)	(0.113)	(0.751)	(0.000)	(0.767)	(0.370)			
2006-10	0.086	-0.006	0.120**	0.996***	0.314	-0.719	-	0.132	2.023
	(0.905)	(0.852)	(0.017)	(0.000)	(0.369)	(0.576)			
2006-11	-0.898	-0.016	0.022	0.681***	-0.271	1.970	-	0.157	2.141
	(0.134)	(0.545)	(0.690)	(0.000)	(0.437)	(0.215)			
2006-12	-1.400**	0.075*	0.062	0.513***	-0.474*	-0.949	-	0.201	2.258
	(0.016)	(0.085)	(0.444)	(0.003)	(0.054)	(0.506)			
2007-01	-2.153***	-0.015	0.021	0.388***	0.168	0.766*	-	0.089	2.477
	(0.000)	(0.204)	(0.595)	(0.006)	(0.417)	(0.086)			
2007-02	1.170*	-0.011	-0.125**	1.308***	-0.120	-0.864	-	0.403	1.873
	(0.051)	(0.254)	(0.050)	(0.000)	(0.748)	(0.110)			
2007-03	-0.190	0.004	0.107	0.976***	-0.332	0.004**	-	0.401	2.526
	(0.581)	(0.730)	(0.173)	(0.000)	(0.273)	(0.023)			
2007-04	0.486	-0.001	0.117	1.117***	-0.419	0.016	-	0.287	2.270
	(0.565)	(0.969)	(0.137)	(0.000)	(0.218)	(0.202)			
2007-05	-1.785***	0.011	-0.022	0.493***	0.405	0.768	0.095	0.069	2.045
	(0.005)	(0.252)	(0.741)	(0.003)	(0.189)	(0.118)	(0.884)		
2007-06	0.303	0.017**	-0.100	1.066***	0.689**	0.062	-	0.417	2.548
	(0.546)	(0.022)	(0.244)	(0.000)	(0.029)	(0.914)			
2007-07	-2.227***	-0.004	-0.036	0.478***	0.689*	0.252	0.066	0.195	1.979
	(0.000)	(0.753)	(0.671)	(0.000)	(0.053)	(0.596)	(0.429)		
2007-08	0.098	-0.012	-0.032	1.033***	-0.346	0.037	-	0.466	2.073
	(0.828)	(0.457)	(0.701)	(0.000)	(0.395)	(0.771)			
2007-09	-0.555	0.015	0.0342	0.944***	0.335	-0.298	-	0.365	2.349
	(0.343)	(0.310)	(0.743)	(0.000)	(0.441)	(0.145)			
2007-10	0.030	-0.002	-0.032	1.038***	0.448*	0.093	-	0.212	1.947
	(0.971)	(0.839)	(0.612)	(0.000)	(0.055)	(0.812)			
2007-11	0.492	-0.008	-0.066	1.149***	0.875	0.083	-	0.270	2.230
	(0.490)	(0.323)	(0.562)	(0.000)	(0.055)	(0.828)			
2007-12	0.496	-0.008	-0.116*	1.132***	-0.063	1.370*	-	0.299	2.179
	(0.382)	(0.363)	(0.091)	(0.000)	(0.778)	(0.077)			

Panel B-monthly cumulative data

α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	λ	ω
-0.0447	-0.0003	0.0294**	0.977	0.093*	0.006***	-	0.079***	-0.010
(0.555)	(0.907)	(0.020)	(0.000)	(0.077)	(0.000)		(0.005)	(0.464)

Observations = 3955 Panels = 7 Adj.R^2 = 0.382 DW = 2.157 F-statistic = 139.516 Prob (F-statistic) = 0.000

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. All regressions were performed on the basis of White's (1980) correction for heteroskedasticity. Period"*yyyy-m*" refers to month *m* in year *yyyy*. The coefficient δ is an estimate of the first-order autoregressive coefficient produced by the Cochrane Orcutt procedure for those cases in which significant autocorrelation is detected by the Durbin-Watson test in the original regression. The DW statistics are compared to critical values sourced from Bhargava and Narendranathan (1982). For the panel B, the regression includes the two interaction terms: pre-market shock (λ) and market shock (ω).*, ** and*** indicate significance at the 10%, 5% and 1%, respectively.

Table C3. Model results for chemicals companies

Panel A Sub-period data

Sub-period	α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	Adj.R^2	DW
2005-11	-0.693	0.059	-0.041	0.642**	-0.085	2.312	-	-0.009	2.000
	(0.175)	(0.190)	(0.287)	(0.018)	(0.592)	(0.585)			
2005-12	-0.460	0.038	0.0217	0.783***	-0.321	-5.568*	-	0.119	2.508
	(0.158)	(0.366)	(0.582)	(0.000)	(0.020)	(0.079)			
2006-01	-0.671**	-0.011	0.176***	0.755***	0.098	3.787	-	0.168	2.517
	(0.022)	(0.745)	(0.001)	(0.000)	(0.524)	(0.135)			
2006-02	-0.799*	0.048	0.072	0.653***	-0.615**	3.251	-	0.060	2.446
	(0.073)	(0.480)	(0.215)	(0.000)	(0.025)	(0.411)			
2006-03	-0.759**	-0.121	0.100**	0.699	-0.0180	-1.945	-	0.070	1.977
	(0.0182)	(0.200)	(0.022)	(0.000)	(0.910)	(0.602)			
2006-04*	-1.257***	0.030**	-0.039	0.422**	-0.273	-1.923	0.050	0.051	2.022
	(0.005)	(0.024)	(0.640)	(0.0102)	(0.126)	(0.008)	(0.519)		
2006-05	0.089	0.018*	0.191***	1.074***	0.588***	2.814	-	0.517	2.515
	(0.665)	(0.058)	(0.000)	(0.000)	(0.003)	(0.163)			
2006-06	-1.092***	0.092***	0.110*	0.649***	0.288**	10.732***	-	0.358	2.271
	(0.000)	(0.001)	(0.086)	(0.000)	(0.018)	(0.002)			
2006-07	-0.403	-0.016	0.016	0.832***	0.389*	6.898***	-	0.255	2.538
	(0.235)	(0.739)	(0.824)	(0.000)	(0.080)	(0.009)			
2006-08	-1.154	0.0321	-0.122**	0.624***	-0.194	-1.269	-	0.078	2.066
	(0.019)	(0.501)	(0.029)	(0.000)	(0.306)	(0.667)			
2006-09	-0.237	0.058**	0.012	0.880	-0.090	-4.031**	-	0.122	2.332
	(0.513)	(0.046)	(0.708)	(0.000)	(0.690)	(0.020)			
2006-10	-0.621	-0.037	0.045	0.773***	-0.127	-0.113	-	0.075	2.419
	(0.315)	(0.231)	(0.178)	(0.000)	(0.597)	(0.917)			
2006-11	-0.123	-0.003	0.039	0.952***	0.217	0.574	-	0.171	2.516
	(0.800)	(0.862)	(0.343)	(0.000)	(0.387)	(0.623)			
2006-12	-0.218	-0.027	0.140**	0.873***	0.047	-1.596*	-	0.174	2.351
	(0.596)	(0.352)	(0.031)	(0.000)	(0.838)	(0.090)			
2007-01	0.306	0.020**	0.034	1.042***	-0.342*	-0.112	-	0.151	2.178
	(0.497)	(0.031)	(0.441)	(0.000)	(0.090)	(0.854)			
2007-02	0.270	-0.005	0.064	1.106***	-0.395	-0.158	-	0.243	2.372
	(0.623)	(0.613)	(0.231)	(0.000)	(0.170)	(0.719)			
2007-03	-0.469	0.016	0.093*	0.867***	-0.127	-0.001	-	0.264	2.246
	(0.122)	(0.123)	(0.064)	(0.000)	(0.538)	(0.514)			
2007-04	-0.274	-0.015	0.037	0.940***	-0.036	-0.002	-	0.144	2.016
	(0.554)	(0.114)	(0.530)	(0.000)	(0.913)	(0.792)			
2007-05	-1.066*	-0.023*	0.062	0.742***	-0.030	0.590	-	0.054	2.340
	(0.063)	(0.060)	(0.142)	(0.000)	(0.886)	(0.154)			
2007-06	0.504	-0.001	-0.100	1.086***	0.893***	0.087	-	0.386	2.424
	(0.224)	(0.848)	(0.110)	(0.000)	(0.003)	(0.829)			
2007-07	-1.253***	-0.002	-0.047	0.695	-0.089	0.516	-	0.181	2.546
	(0.006)	(0.819)	(0.565)	(0.000)	(0.757)	(0.227)			
2007-08	-0.509	0.001	0.097	0.898***	0.377	0.120	-	0.350	2.258
	(0.163)	(0.912)	(0.136)	(0.000)	(0.199)	(0.184)			
2007-09	-1.303***	0.014	0.070	0.697***	0.055	-0.176	-	0.250	2.600
	(0.000)	(0.259)	(0.350)	(0.000)	(0.839)	(0.132)			
2007-10	-0.253	-0.005	-0.072	0.914***	0.427*	-0.147	-	0.094	2.178
	(0.738)	(0.545)	(0.115)	(0.000)	(0.058)	(0.609)			
2007-11	0.303	-0.002	0.033	1.139***	0.660*	0.695**	-	0.265	2.000
	(0.536)	(0.735)	(0.692)	(0.000)	(0.068)	(0.017)			
2007-12	-0.057	0.012	0.089	0.900***	0.038	-0.444	-	0.167	2.369
	(0.920)	(0.122)	(0.175)	(0.000)	(0.805)	(0.392)			

Panel B-whole period data

α	$R_{co_2,t}$	$R_{oil,t}$	$R_{m,t}$	$R_{e,t}$	$R_{tc,t}$	δ_t	λ	ω
-0.182***	-0.0004	0.046***	0.939***	0.011	-0.0002	-	0.018	0.004
(0.001)	(0.870)	(0.000)	(0.000)	(0.785)	(0.868)		(0.335)	(0.572)

Observations = 9040 Panels = 16 Adj.R^2 = 0.314 DW = 2.203 F-statistic = 189.059 Prob (F-statistic) = 0.000

Notes: This table reports the estimates for:

$$R_{it} = \alpha + \beta_{co_2} R_{co_2,t} + \beta_{oil} R_{oil,t} + \beta_m R_{m,t} + \beta_e R_{e,t} + \beta_{tc} R_{tc,t} + \varepsilon_t$$

Where $R_{i,t}$ is the excess equity returns of each stock, α is the constant, $R_{co_2,t}$ is the EUA return, $R_{oil,t}$ is the Brent oil return, $R_{m,t}$ is the market portfolio excess return, $R_{e,t}$ is the US$/EU€ exchange rate return, $R_{tc,t}$ is the interest rate return and ε_t is the residual. According to the Hausman test, the econometric model is the fixed effects model. All regressions were performed on the basis of White's (1980) correction for heteroskedasticity. Period"*yyyy-m*" refers to month *m* in year *yyyy*. The coefficient δ is an estimate of the first-order autoregressive coefficient produced by the Cochrane Orcutt procedure for those cases in which significant autocorrelation is detected by the Durbin-Watson test in the original regression. The DW statistics are compared to critical values sourced from Bhargava and Narendranathan (1982). For the panel B, the regression includes the two interaction terms: pre-market shock (λ) and market shock (ω).*, ** and*** indicate significance at the 10%, 5% and 1%, respectively.