Testing the Efficiency of the European Carbon Futures Market using Event-Study Methodology

Paul G. Miclăuş, Radu Lupu, Sorin A. Dumitrescu, Ana Bobircă

Abstract**—**The European Emissions Trading Scheme (EU ETS) forms the centerpiece of EU climate change policy. Within the new trading system, the right to emit a particular amount of CO2 becomes a tradable commodity - called EU Allowances. We test the AR(1)-GARCH(1,1) model on these young markets and analyze the impact of National Allocation Plans announcements on carbon prices, by applying an event study methodology using daily carbon futures returns. We find that markets are not efficient as far as the correlation test is concerned; nonetheless, the event study proves that, even if past returns reacted to VER announcements, the expectation building has been functioning correctly since investors were able to predict the market dynamics.

Keywords**—**AR-GARCH, event study, CO2 emission allowances, EU ETS, National Allocation Plans

I. Introduction

The European Emissions Trading Scheme (EU ETS) forms the centerpiece of EU climate change policy. Launched in 2005 to cap CO2 emissions from heavy industry, it covers almost half the EU's CO2 emissions and more than a third of total greenhouse gas emissions. Within the new trading system, the right to emit a particular amount of CO2 becomes a tradable commodity - called EU Allowances (EUAs – one EUA gives the right to emit one metric tone of CO2), with affected companies, traders and investors facing new strategic challenges. Since failure to submit a sufficient amount of allowances results in sanction payments per missing ton of CO2 allowances, the new market forces companies to hold an adequate number of allowances according to their carbon dioxide output. In order to increase liquidity, the EU ETS allows non-emitting firms or individual investors to engage in EUA trading for speculation or diversification purposes. The only prerequisite is that the interested investors establish an account in the emission registry of an EU member state. As it is pointed out by Uhrig-Homburg and Wagner [11], regulated companies and investors face risks specific to the emissions trading scheme, mainly price risk of fluctuating allowance prices and volume risk, since due to unexpected fluctuations in energy demand the emitters do not know ex ante their exact demand for EUAs. Thus, the new market not only requires regulated emitters an adequate risk management, it also provides new business development opportunities for market intermediaries and service providers like brokers or traders.

Trade in these emission allowances gives value to reducing CO2 emissions and has formed a market with an asset value worth tens of billions of euros annually: two years after its initiation, the EU ETS accounted for almost 97% of the global exchange-based carbon trading with an annual turnover in 2007 exceeding $50 billion [12].

While trading of EUA started with a spot market in January 2005, on October 4, 2005 a futures market was also established at the European Energy Exchange. Thus, market participants also have the possibility to hedge against presumed increasing or decreasing demand or prices for CO2 allowances, transforming the price behavior and dynamics of this new asset class into an issue of major importance. Having a reliable pricing and forecast model would allow companies, investors and traders to realize efficient trading strategies, risk management and investment decisions in the carbon market.

However, the EU ETS is still very young and other emissions markets differ significantly in the regulatory framework, especially regarding banking and borrowing regulations. The relevant spot and futures price history is short and it is thus difficult to deduce essential properties of a potential CO2 price process from historical data. By studying the new market mechanism and analyzing empirical data we consider the appropriateness of price determination processes.

The general behavior of prices in emissions trading schemes has already attracted some interest in the literature. Central to most considerations is the assumption that prices of emission certificates must always be equal to marginal abatement costs in market equilibrium. If prices would be above, companies with lower abatement costs would try to profit on the price difference by abating more CO2 than they would need to comply with regulations. They would then sell the spare certificates for the higher certificate price and vice versa. Most literature focuses on environmental and policy

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issues, with very little research being undertaken from a financial market perspective. Specifically, an important question would be whether the chosen mechanics of the EU ETS have allowed the market to operate efficiently during the first two years of its life [4]. In other words, do emission allowance prices reflect all available information to the extent that no investor can systematically gain excess returns [5], [6], [7]. Investigating this issue is important, since the main goal of the EU ETS is to allow the participating countries to achieve environmental compliance in a cost effective and economically optimal manner, both of which implicitly require that the market itself is efficient.

There is also only little literature with an explicit focus on dynamic price behavior of emission certificates, exceptions including research examining the spot price dynamics of EUAs: see Benz and Trück [2], Fehr and Hinz [8], Paolella and Taschini [9], or Seifert, Uhrig-Homburg and Wagner [11]. As opposed to these papers, our focus is not on spot price dynamics but rather on the dynamics of futures markets for EUAs. To our knowledge, the first work to analyze both spot and futures prices of EUAs together was by Daskalakis, Psychoyios and Markellos [4]: they adopt an equilibrium pricing model for futures prices in the trading period 2008 - 2012 based on current spot prices. In a recent working paper, Borak et al. [3] analyze convenience yields for futures prices with maturities up to 2012.

Our analysis builds especially on the work of Benz and Truck [2], by advocating the use of a model allowing for heteroscedasticity, with a unique stochastic process but conditional variance, i.e. an AR-GARCH-type structure, but differs from theirs in that we suggest a model allowing for analyzing the dynamics of futures prices, assuming that futures prices lead the price discovery process on exchanges. Volume data show that CO2 futures trading is far more liquid than CO2 spot trading, which is common in many commodity markets. As opposed to spot certificates, transactions with EUA futures do not have to be accounted for in the emissions registers before maturity. Moreover, companies without their own EUA allocations can only achieve short positions in the futures and not in the spot market. Companies seeking reliable price signals in the EU ETS should therefore always start by looking at the futures market. We will show, however, that our results are consistent with their findings.

To test our model formally and to deepen our understanding of these young markets, we contribute to the growing field of study by further analyzing the impact of National Allocation Plans announcements on carbon prices, by applying an event study methodology using daily carbon futures returns. Our research extends the work of Bataller and Pardo [1], who proposed a truncated mean model; this approach is a modification of the constant mean return model in which the abnormal returns in the estimation period are obtained using a truncated mean.

II. Problem Formulation

Motivated by the aforementioned considerations, the paper attempts to examine the efficiency of the EU ETS during the first two years of its operation. In line with previous research on other assets and markets, we concentrate on the weak-form of market efficiency according to which all the information contained in historical prices should be reflected in today's price. This means that historical prices cannot be used to form superior forecasts or to accomplish trading profits above the level justified by the risk assumed. The empirical analysis focuses on the largest and most liquid futures regional exchange under the EU ETS, namely the European Climate Exchange (ECX, Netherlands).

We considered the examination of both spot and futures markets as superfluous since it can be assumed that these are related through a straightforward cost-of-carry relationship. In other words, efficiency of one market usually implies efficiency for the other, so the investigation can be limited to only one market if the futures contract is written and expires in the same phase of the EU ETS. Thus, our study analyses futures market data from contracts with inter-phase expirations.

From an econometric perspective, market efficiency is first evaluated using an AR-GARCH-type structure. Subsequently, we analyze the influence of the different types of announcements related to National Allocation Plans on both returns and volatility.

The NAP is the document in which Member States determine both the total quantity of CO2 allowances available in the Member State and the allocation made to each installation covered by the Scheme, which must subsequently be approved by the European Commission. The system regulates an annual allocation of the allowances while the emission rights may either be allocated free of charge, auctioned off or sold at a fixed price. Combinations of the different allocation systems are also possible. The pilot period lasts from 2005-2007. Participating companies have to indicate the amount of emitted CO2 of the previous calendar year by March 31, and by April 30 each year, a number of allowances that is equal to the total verified emissions from that installation during the preceding calendar year has to be surrendered to the member states. Additionally, around 15 May, the Members States must submit a report of the verified emission to the European Commission including all the companies in the country covered by the European Directive. When this information is published the agents in the market know whether the companies are long or short in respect of the allowances that they have received for free from their governments.

Generally, a company's stock of emission allowances determines the degree of allowed plant utilization. Thus, a lack of allowances requires a company either some plant-specific or process improvements, a cut- or shutdown of the emission producing plant or the purchase of additional allowances and emission credits respectively.

Benz and Trueck [2] point out the substantial differences between emission allowances and classical stocks. While the value of a stock is based on profit expectations of the firm that distributes the shares, the price for the allowances is determined directly by the expected market scarcity induced by the current demand and supply. Besides, firms by themselves are able to control market scarcity and hence the market price by their abatement decisions. It is important to note that the annual quantity of allocated emission allowances is limited and already exactly specified by the EU-Directive for all trading periods. Additionally, CO2 emission allowances have a limited duration of validity. The value of an individual allowance expires after each commitment period.

III. Data description

Trading of emission allowance futures contracts is primarily performed through the European Climate Exchange (ECX) in Netherlands. Due to no-arbitrage arguments, there should not be significant price differences for futures EUA prices with the same maturity among the different exchanges. Since the ECX does not allow spot EUA trading, it uses Powernext spot prices as a reference for the futures contracts. For the period under study, the ECX accounts for approximately 87% of the total exchange-based futures contract transactions in Europe. The underlying asset of the futures contract is 1,000 spot EUAs, with the most liquid contracts being those with annual (December) maturities. We used all futures contracts that expired in 2007. The data correspond to daily closing prices covering the period from the first available quote up to 7/12/2007.

The different types of announcements selected to have influenced the futures price dynamics of carbon certificates have been divided into two categories [1]: news strictly related to National Allocation Plans (NAPs) and news related to the Verification of Emissions (VER). In the first group there are 6 categories of events: Notification of Phase I NAPs (NAPs for Phase I of the EU ETS: 2005-2007) to the European Commission (NOT1), Notification of Additional Information related to the Phase I NAPs to the European Commission (NAI1), Approval of the Phase I NAPs (A1), Notification of Phase II NAPs (NAPs for Phase II of the EU ETS: 2008-2012) to the European Commission (NOT2), Notification of Additional Information related to the Phase II NAPs to the European Commission (NAI2), and Approval of the Phase II NAPs (A2). In the second type of events, the Verification of Emissions, there are 2 subcategories: verified emissions for the year 2005 (VER2005) and verified emissions for the year 2006 (VER2006).

IV. Description of the model

A. *Stylized facts of CO2 allowances logreturns*

The logreturns of CO2 emission allowances exhibit heteroskedasticity and volatility clustering for both the calibration period and the testing period. Table 1 comprises summary statistics for in-sample and out-of-sample observations series, which display similarities. Most notably, the logreturns are excessively leptokurtic and skewed.

TABLE 1. DESCRIPTIVE STATISTICS FOR THE EUAS LOGRETURNS FOR THE IN-SAMPLE (22 APRIL 2005 - 18 DECEMBER 2006) AND OUT-OF-SAMPLE (19 DECEMBER 2006 - 17 DECEMBER 2007) PERIODS.

Series	In-Sample	Out-of-Sample
N	425	258
Mean	-0.002	-0.025
Min	-0.313	-1.386
Max	0.474	1.099
Std Dev	0.046	0.164
Skew	0.673	-2.165
Kurt	39.994	36.235

The empirical distribution obtained by kernel estimator against the normal distribution with mean and standard deviation extracted from the logreturns series, depicted in Figure 1, indicates that a Gaussian fit of the data would be inappropriate. Hence, alternative models allowing for changes in the volatility structure, asymmetry and excess kurtosis should provide a better fit of the time series.

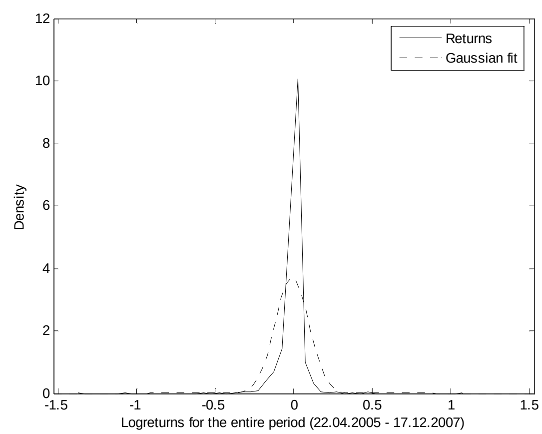


Fig. 1. Empirical distribution obtained by kernel estimator and Gaussian fit to daily EUA logreturns from 22.04.2005 to 17.12.2007.

B. *Model selection and benchmarking*

1) *Future and spot prices, evidence of inefficiency*

The convenience yield model is widely used to describe the behavior of spot and future prices for commodities. Under the assumptions of no transaction costs and banking permitted across all relevant periods, arbitrage between current and expected future compliance costs and between allowances of different maturities will cause the immediate settlement prices, i.e. the spot prices for allowances of different maturities, to be equal. In the real market, however, transaction costs cannot be ignored and prices are affected by a number of factors whose evolution is uncertain. The source of uncertainty lies primarily in the amount of greenhouse gases emitted, which is stochastic even when abatement costs are certain.

Because the amount of emissions cannot be determined in advance and the purchase and selling of certificates is expensive, the firm benefits from holding a stock of allowances at hand to buffer itself against unexpectedly high prices. The transaction cost saved from not having to make additional transactions and/or undo a transaction just done is called the convenience yield.

The convenience yield will cause future prices to be higher than spot prices, resulting in a price structure called backwardation. The relationship can be represented in the following form:

$$F_t(S,T) = Se^{(r-\delta)(T-t)} \quad (1)$$

where F is the futures price, t is the time at which the futures is evaluated, T is the maturity of the contract, S the spot price, r the risk-free rate and δ is the convenience yield. A commodity's future price described by model (1) should decrease as maturity increases.

Paolella and Taschini [9] find that the CO2 emission allowances convenience yield does not behave according to the theory. In other words, the futures market displays a contango term structure, leading to a cost-of-carry model that works best in pricing futures on commodities with large readily available inventories, and that have a stable supply and demand flow. Therefore, a price scenario based on the futures-spot parity would be irrelevant in a market where political uncertainty affects long futures maturity. Uhrig-Homburg and Wagner [11] reach a similar conclusion in a study that analyzes the relationship between spot and futures prices for CO2 emission certificates in the EU ETS. They discover that during the year 2005, obvious arbitrage opportunities existed in this market, opportunities that disappeared in part in subsequent years. However, temporary deviations from the theoretical relationship given by the cost-of-carry model indicate that valuation of such derivatives should not be based on the current spot price, because it does not reflect all the information necessary for building an expectation about future spot prices in the years 2008 and beyond. For this reason, our analysis assessing the efficiency of the carbon emission allowances market relies solely on futures prices series.

2) Model selection

Paolella and Taschini [9] investigate the behavior of emission allowance commodities using statistical models that rely on historical price information. Observing that forecast methods lead to unreliable conclusions because of the complexity of the market and particular behaviors of emission allowance commodities, they test econometric models that address the unconditional tail behavior and the inherent heteroskedastic dynamics in the returns on emissions allowances. They maintain that knowledge of the unconditional and conditional distribution of emission trading allowance prices is essential for constructing optimal hedging and purchasing strategies in the carbon market. Thus, on the one hand, they analyze asset risk by estimating tail thickness of the unconditional distribution; on the other hand, mixed-normal and mixed-stable GARCH models are proposed for the conditional distribution of the returns on the emission allowance spot prices.

Benz and Trueck [2] investigate the short-term spot price behavior of CO2 emission allowances, emphasizing price dynamics and changes in the volatility of the underlying stochastic price process. Accounting for the different regimes of price behavior, they propose AR-GARCH and Markov regime-switching models for stochastic modeling of the time series. We extend their work by analyzing futures prices in the AR-GARCH framework.

3) Markov regime-switching models

Regime-switching models are based on the separation of the time series into several phases (regimes), for which independent underlying price processes can be defined. There are two main classes of regime-switching models presented in the literature: one in which the regime can be determined by an observable variable, and another in which the regime is imposed by a latent variable. [2] argue it improbable that the regime-switching mechanism be simply governed by a fundamental variable or the price process itself, since spot prices of emission allowances are generated by many variables including fundamentals (e.g. weather), but also regulatory, policy and sociological factors that can cause an unexpected and irrational buyout or lead to price jumps and periods of extreme volatility. As a result, they propose regime-switching models determined by latent variables (i.e. Markov regime-switching models) to be used in the stochastic modeling of the returns on emission allowances. This class of models does not rely on the certain occurrence of a particular regime at one point in time, but it assigns probabilities to such events, making it more appropriate to the study of the price behavior of emission allowances. [2] show that the Markov regime-switching model they propose displays a systematic change between stable and unstable states, as required by existing fluctuations in demand and supply on the CO2 allowance market. In addition, the model also allows for several consecutive price jumps or extreme returns that are important when talking about risk management and pricing of derivative instruments.

4) Model calibration

There are several approaches in the literature for modeling asset returns. Among the most successful are the ARCH family and its extensions (Engle, 1982 and Bollerslev, 1986). In this class of models, the conditional volatility of the time series is represented by an autoregressive process (AR):

$$y_t = \varepsilon_t \sigma_t \quad (2)$$

$$\sigma_t^2 = a_0 + \sum_{i=1}^{q} a_i y_{t-i}^2 \quad (3)$$

where ε_t are i.i.d. with zero mean and finite variance.

Generalized ARCH (GARCH) models, in particular, have become the benchmark in volatility modeling. GARCH models do not focus directly on returns in the tails. Instead, by acknowledging the tendency of return volatilities to be time-dependent, GARCH models explicitly model conditional volatility as a function of past conditional volatilities and returns.

$$y_t = \varepsilon_t \sigma_t , \quad (4)$$

with $\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i y_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$ (5)

where the coefficients have to satisfy $\sum \alpha_i + \sum \beta_j < 1$, $\alpha_i, \beta_j \geq 0$ and $\alpha_0 > 0$ to ensure stationarity and a conditional variance that is strictly positive. Coupling the variance equation with an AR(1) model for the mean of the time series provides a more appropriate model for our data, as suggested in Paolella and Truek [9]. In this model,

$$y_t = c + \sum_{k=1}^{r} \phi_k y_{t-1} + \varepsilon_t \quad (6)$$

where $\phi_k < 1$ and c denote real constants.

By analyzing the behavior of futures prices with a CO2 allowances index as underlying asset, we investigate the application of an AR-GARCH model. To benchmark the estimated results, we also compare them to the results of a simple normal distribution for the logreturns, as well as to an AR(r). All models are tested by using maximum likelihood estimation, while parameter values are selected according to three model comparison criteria (LLF, AIC and BIC).

We have employed the Schwarz Bayesian Criterion (SBC) to determine the most appropriate value for the order of the autoregressive process, which was chosen as the minimizer of SBC. The lowest SBC value, i.e. -6.1354, corresponds to an AR(1) model, which is consequently the best fit for our in-sample dataset.

The Lagrange multiplier test statistics point out highly significant heteroskedastic effects, which impose the calibration of data with a GARCH(p,q) model. We start with a simple GARCH(1,1) model that seemingly fits the data well. As the log-likelihood tests indicate, there is insufficient statistical evidence in support for higher order GARCH models. Therefore, we advocate the use of an autoregressive model of order 1 with conditional variance modeled by a GARCH(1,1) process.

Estimation coefficients of the AR(1)-GARCH(1,1), as well as of the benchmark models, are provided in Table 2. Consistent with the results of other authors [2], we find all coefficients statistically significant.

TABLE 2. IN-SAMPLE PARAMETER ESTIMATES FOR THE MODELS UNDER CONSIDERATION, FOR THE PERIOD 22 APRIL 2005 – 18 DECEMBER 2006.

i.i.d Gaussian $r_t = \mu + \sigma \cdot \varepsilon_t$

	Coefficient	*Std Error*	*t-Stat*
	Mean equation		
μ	-0.0022	0.0022	-0.9744
k	0.0021	0.0000	63.9168

AR(1) $r_t = \mu + \varphi \cdot r_{t-1} + \varepsilon_t$

	Coefficient	*Std Error*	*t-Stat*
	Mean equation		
μ	-0.0019	0.0030	-0.6424
φ	0.1080	0.0223	4.8528
k	0.0021	0.0000	46.6466

AR(1)-GARCH(1,1) $\varepsilon_t = u_t \cdot \sigma_t$;
$\sigma_t^2 = k + \alpha \cdot \varepsilon_{t-1}^2 + \beta \cdot \sigma_{t-1}^2$

	Coefficient	*Std Error*	*t-Stat*
	Mean equation		
c	0.0012	0.0011	1.0413
φ	0.3554	0.0605	5.8730
	Variance Equation		
k	0.0001	0.0000	7.0016
α	0.5652	0.0249	22.7170
β	0.4348	0.0400	10.8599

The lowest values of the AIC and BIC in Table 3 show that the GARCH model specification seems more appropriate for the price dynamics of futures contracts with CO2 allowances as underlying assets.

TABLE 3. NUMBER OF PARAMETERS, K, LOG-LIKELIHOOD, AKAIKE INFORMATION CRITERION (AIC), BAYESIAN INFORMATION CRITERION FOR THE ESTIMATED MODELS.

	i.i.d Normal	**AR(1)**	**AR(1) GARCH(1,1)**
k	2	3	5
LLF	**703.96**	706.45	929.13
AIC	-1403.90	-1406.90	-**1848.30**
BIC	-1395.80	-1394.70	-**1828.00**

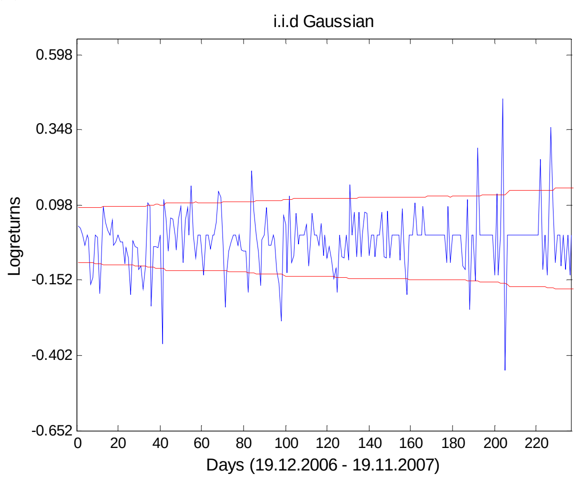
With the purpose of strengthening this assumption, we proceed to out-of-sample testing. The method implies the application of a recursive and rolling technique with re-estimation of the parameters on a daily basis. The length of the rolling window was chosen to be equal to the length of the in-sample logreturns series, which is 425 days. For point forecasts, we measure the average prediction errors by computing the mean absolute error (MAE) and mean squared error (MSE) of the one-day-ahead forecasts. The results are reported in Table 4. The AR-GARCH model outperforms the AR model, but both are outclassed by the random walk model. This surprising result might be attributed to the higher volatility associated with the approach of the settlement date, when prices converge to zero and even small absolute modifications generate extreme volatility.

TABLE 4. POINT FORECASTS OF THE MODELS UNDER CON-SIDERATION FOR MEAN ABSOLUTE ERROR (MAE) AND MEAN-SQUARED ERROR (MSE).

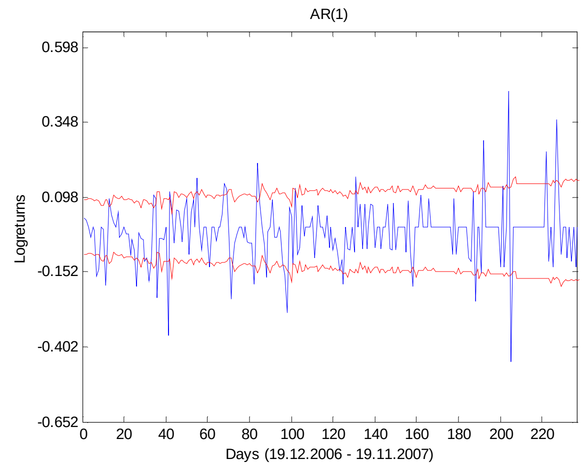
	MAE	*MSE*
i.i.d Normal	0.07729	0.02702
AR(1)	0.07920	0.02995
AR(1)-GARCH(1,1)	0.07921	0.02967

Figure 3 displays the observed logreturns and predicted 95%-confidence intervals for the period 19 December 2006 – 19 November 2006. We observe that the width of confidence intervals predicted by the Gaussian fit and the AR(1) models remains almost constant, while that of the confidence intervals predicted by the GARCH model varies with the conditional variance of the density forecast, such that during periods of higher volatility the intervals become wider.

(a)



(b)



(c)

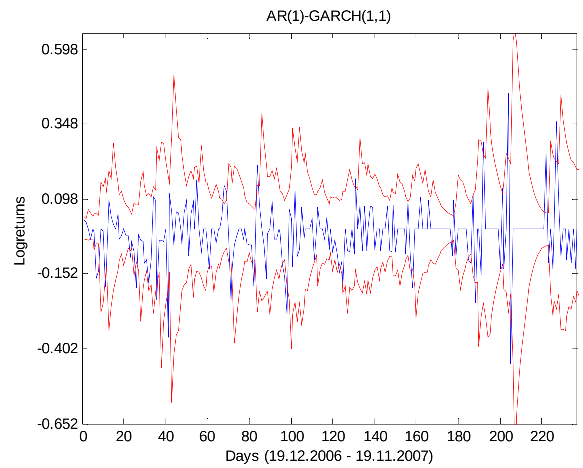


Fig. 2. Logreturns and predicted 95%-confidence intervals for the different models from January 2007 to December 2007. Results for the 'naïve' model of a simple normal distribution (a), AR(1) model (b) and the GARCH(1,1) model (c).

The notion of efficient markets in terms of information leads to a powerful research methodology in the field of finance. If security prices reflect all currently available information, then price changes must reflect new information – the information is included in the price at a very high speed. Therefore it is possible to measure the importance of an event of interest by examining price changes during the period in which the event occurs.

The event study methodology is a technique of empirical financial research that enables an observer to assess the impact of a particular event on a firm's stock price. The statistical approach for the measurement of a particular information release has the objective to compute the difference between the actual return of the respective security and the return that would be expected by the market, which is known as abnormal return. Hence, the analysis requires the use of a model that best presents the market expectations (this is the AR-GARCH in the case of this paper) and uses it to provide forecast for the returns in the period around the event.

The relation of this type of analysis and the matter of efficient markets relies in the possibility of information leakage. The methodology analyzes both the daily differences in the realized and expected returns as well as the cumulated differences for the period around the event. Hence, the possible trends in the cumulated abnormal returns before the event prove the existence of lack of efficiency in the sense that the information about the event is known by some part of the market in advance. Another issue that is also important is the presence of significant cumulated abnormal returns building significant trends after the day of the event. The significant trend after the event is a proof that the market does not succeed to include information in the price in a short period of time. The speed at which the information is included in the price can be considered a measurement of the degree of market efficiency. The lag between the appearance of information and the price movement as a result of this information makes room for arbitrages – riskless gains. As a consequence, the existence of predictable patterns in the movement of securities prices is a proof for lack of efficiency as the information flow should be random and unpredictable. Hence, if prices are predictable then the information is too slowly included in these prices. The existence of patterns around the events reveals therefore the possibility to consistently gain riskless returns.

V. Results

The event-study analysis employed in order to test for the semi-strong market efficiency used 42 NAP announcements and 3 VER announcements and revealed the evolution of the futures prices returns from 10 days before until 10 days after the event (a total of 21 days –from day -10 to day +10).

The NAP events are sufficient to be able to gain satisfactory results from the study of the behavior of futures prices. We can conjecture that the higher the number of events the better the possibility to test for the existence of valuable patterns of the returns around the events. Some of the most notorious results from event studies are the ones that analyze the dynamics of the abnormal returns around the mergers and acquisitions announcements and around the dividends announcements. These studies usually use more than 100 events in order to test for the significance of the patterns. The relatively small number of events in our analysis gave us the opportunity to graphically represent the results of our studies.

The analysis consisted in continuous recalibrations of the AR-GARCH model (previously proven to be the best approach) starting from 100 days before day -10 and moving the calibration window with one day for each announcement. The model provides a one-day ahead forecast for the returns, which is consequently compared with the real return in order to obtain the abnormal return for each day around the event.

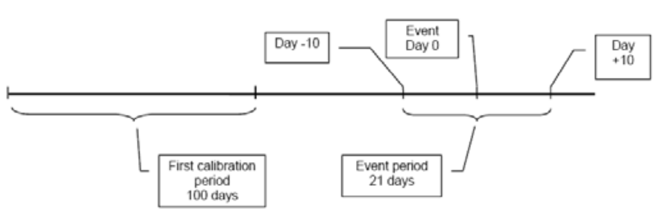
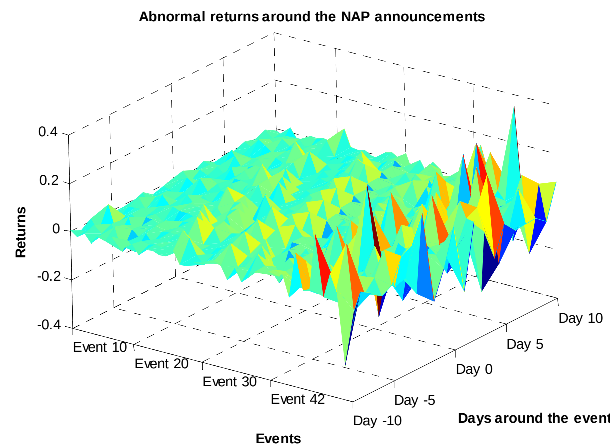


Fig. 3. AR-GARCH recalibration timeline

We considered this dynamic calibration as we know that the model that best fits the data is a suitable tool to provide forecast for short periods of time. This approach provided information about the abnormal returns around the specified events considering one-day holding period returns (the futures contract is entered into in day t and the profit is marked in day t+1). Hence, the cumulated abnormal returns are computed by adding all the abnormal returns from day -10 to day +10, but they do not show the actual result of a possible investment used in the case of simple securities (ex.: buy the stock at day -10 and close the position at day +10). The cumulated abnormal returns show the result from an investment on the futures market, on which the prices are marked to market (updated) daily (the futures contract is similar to entering forward contracts with the same maturity in each day and closing them at the end of the day). We can conjecture that the methodology we are using is adapted to the specific of the futures market.

The results are provided in the following figures.

(a)



(b)

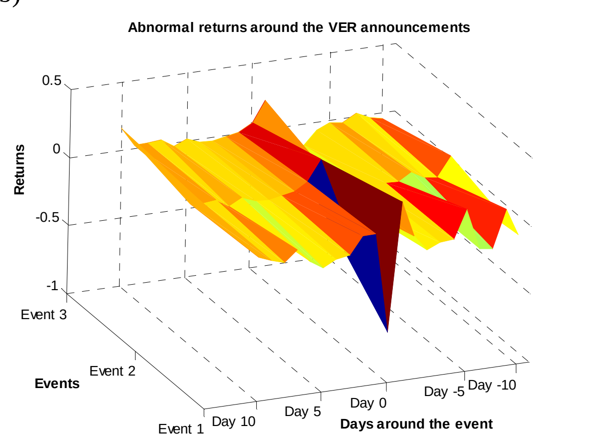


Fig. 4. Abnormal log returns are presented in the period around the NAP (above) and VER (below) announcements.

The figures show the evolution of the abnormal returns for each event and for each day around the event, where events are ordered historically (from the oldest to the most recent ones).

As far as the NAP announcements are concerned, we notice that important positive movements are recorded in the most recent announcements while in the past the abnormal returns fluctuated around 0. The futures prices started to drop dramatically in 2006 and reached very low levels at the end of the year. Our last events happened in May 2007, when returns were quite important – a drop from 5.60 in January 2007 to 0.29 at the last event, on 15th of May 2007.

On the other hand the VER announcements proved to have more effect on the market dynamics. Event 1 happened in May 2007 and the Event 3 was in April 2007. They show the fact that the market participants became more and more aware of the way the market reacts to new announcements. The abnormal returns in these cases proved to be quite significant in the days very close to the event (from day -5 to day +4).

However, the t-statistics for the cumulated abnormal returns computed for all the NAP announcements are in between the interval (-2;+2), which means that, in general, the markets are efficient as no event produced significant changes to the theoretical movements. The same conclusion can be extracted from the analysis of the VER announcements.

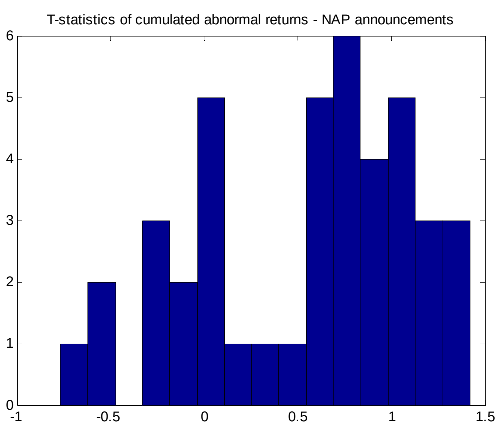


Figure 5. The t-statistics of the abnormal returns for the NAP announcements were computed by dividing the cumulated abnormal returns for each event on the standard deviation of all the abnormal returns.

VI. Conclusion

The purpose of our paper was to analyze the effects of new information on CO2 emission certificates prices by assessing the weak form efficiency of the most important futures market operating under the EU ETS.

The EU ETS demonstrated in the last couple of years that the modeling the impact of events related to total expected emissions, for example, is a very realistic way of thinking about futures prices. The consequences of NAP announcements on futures prices dynamics were captured by an AR-GARCH model.

We observed that jumps in the total expected emissions, when expectations are updated discontinuously around compliance dates (VER announcements), proved to have more effect on market dynamics than NAP announcements. We have observed that market participants had a good estimate of emissions levels and price jumps did not occur.

In conclusion, we found out that, even if the AR –GARCH model is the best model for this type of market, which means that the correlations of consecutive returns has statistical significance, the market participants have the capacity to predict future movements in the market as a consequence of announcements. All the cumulated abnormal returns were not statistically significant, which means that the expectation building is functioning correctly since investors are able to predict the market dynamics.

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