Evolution of the speculative activity in
the European carbon market

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Abstract

We explore the evolution of the speculative activity in futures carbon markets, by combining volume and open interest data. A comparison of the three phases in the European market is also provided. The evidence provided is consistent with: (i) a high degree of speculative behavior in the moment of listing the contracts for the first time, for every Phase; (ii) a higher level of speculation in the first quarter of each year (which could be explained by the increase of the number of informed traders in the market during these months, in relation with the specific schedule of deadlines that characterizes the EU Emission Trading Scheme); (iii) Phase II of the EU ETS seems to be the most speculative phase to date; and (iv) the front contract concentrates the majority of the speculative activity every year.

JEL Classification: G13

Keywords: Derivatives, EUA, open interest, trading volume.

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1. INTRODUCTION

Since the launch by the European Commission of the European Union Emission Trading Scheme (EU ETS) in 2005, the European carbon market has developed considerably in terms of the types of contracts being traded and their associated trading volumes. The new market has attracted the attention of a rising number of market participants and academics alike.

Researchers have analyzed several aspects of the European carbon market. Without being exhaustive, some of the issues studied include, among others, the determinants of carbon prices (Mansanet-Bataller et al. (2007), Alberola et al. (2008), Creti et al. (2012), among others), modeling of carbon prices (for example Benz and Truck (2009), Daskalakis et al. (2009), among others), the study of the relationships between carbon prices and energy prices (Bunn and Fezzi (2009), Keppler and Mansanet-Bataller (2010), Fell (2010), among others), stylized facts of CO2 returns (Medina and Pardo (2012), etc. As pointed out by Mansanet-Bataller and Pardo (2008), most of the European Union Allowances or EUAs trades are made in the derivative market and, accordingly, the carbon futures market is more important with regard to volume of trading than the spot one. Accordingly, most of the articles use futures data from the European Climate Exchange as they are considered the most representative carbon market prices.

Traditionally, market participants in derivative markets may be classified into two broad categories: speculators and hedgers (or informed and uninformed traders, respectively). As far as we know, the evolution of the speculative and hedging activities in carbon markets has been left unexplored to date. The objective of this paper is to fill this gap and analyze the speculation and hedging activities in carbon markets, by using measures that combine volume and open interest data in order to explore which of the these two categories is predominant in the futures market during a specific period of time. Provided that the majority of the carbon trades in the EU ETS take place throughout the derivatives market, analyzing the speculative and hedging behavior of market participants in this market is especially relevant.

Specifically, we consider the measures proposed by (i) Garcia et al. (1986) and (ii) Lucia and Pardo (2010). These two measures are based on the convention, generally
accepted in the previous literature on futures markets (see Rutledge (1979), Leuthold (1983), and Bessembinder and Seguin (1993)) that volume gathers information about speculation whereas open interest is related to hedgers’ activity.

The rest of the paper is organized as follows. In section 2 the measures of the speculation and hedging activities are described, in section 3 the specificities of the carbon market are presented and the database described, section 4 presents the empirical analysis and the results, and section 5 concludes.

2. MEASURING THE IMPORTANCE OF SPECULATION IN FUTURES MARKETS

In order to analyze the relative importance of speculation versus hedging activities in carbon markets, we employ several ratios that combine publicly available information from derivatives markets, related to both the volume traded during a specific period of time and the open interest at the end of the same period. Recall that while the volume takes into account the number of contracts that have been traded during a given period; the open interest only considers the number of open positions at the end of that period. That is, the open interest reflects the number of outstanding (long / short) positions in a specific contract at the end of the period, and it only increases (decreases) if none (both) of the two parties involved in the transaction closes out its position. On the contrary, the open interest remains unchanged whenever only one of the two parties closes out its position.\(^1\)

It is important to emphasize that the volume has been considered in the literature as a proxy of the speculative behavior, whereas the open interest has been considered as a proxy of the hedging activity (Rutledge (1979), Leuthold (1983), and Bessembinder and Seguin (1993)). The underlying idea is that hedgers tend to hold their futures market position longer than speculators. Note that the volume takes into account all the amount of trading activity while the open interest only registers the number of outstanding contracts and thus, the intraday positions taken by day traders are not reflected in the latter. Consequently, the ratios that will be analyzed in this study, when relating these two variables, represent proxies of the relative importance of the speculative or hedging behavior of the participants in the market during the period of study.

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\(^1\) For an example, see Lucia and Pardo (2010).
Two different ratios will be considered in this paper. Specifically, the first ratio considered, denoted \( SPEC \) in this paper, was suggested by Garcia et al. (1986) and it is defined as follows:

\[
SPEC_t = \frac{V_t}{OI_t}
\]

where \( V_t \) is the trading volume during the period \( t \) and \( OI_t \) is the value of the open interest at the end of that period. Under this measure, the number of contracts traded during the period relative to the size of the outstanding positions, reflects the relative importance of the speculative behavior in the contract analyzed with respect to the hedging activity. As Robles et al. (2009) put it, the ratio of volume to open interest captures speculative market activity under the assumption that the majority of speculators prefer to get in and out of the market in a short period of time, in contrast to futures traders who are not engaging in speculation. Hence a speculator taking opposite positions (buying and selling contracts) in the market within a given period will generate an increase in registered volumes during the period but little change in open interest. Thus, increasing values of \( SPEC \) are interpreted as rising speculative activity in the contract object of study.

The second ratio taken into account in this study is a modification of \( SPEC \) that was firstly proposed by Lucia and Pardo (2010), which is in turn based on a previous ratio proposed by ap Gwilym et al. (2002). These authors consider that instead of the open interest, a better proxy of the hedging activity is the change in the open interest during the period taken into account. The reason for such a choice is that a positive (negative) change in the open interest gives information on the net opened (closed) positions during the period. The ratio put forward by Lucia and Pardo (2010), denoted \( HEDG \) in this paper, is defined as:

\[
HEDG_t = \frac{\Delta OI_t}{V_t}
\]

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2 Both ratios are theoretically studied in detail in Lucia and Pardo (2010). They also analyze empirically their basic statistical properties when they are applied to real data from some stock index futures contracts.

3 Note that \( SPEC \) can take any positive real number including zero, it takes the value plus infinity whenever the open interest equals zero and it is undetermined when both the volume and the open interest are equal to zero. (See Lucia and Pardo (2010) for details.)

4 The related ratio proposed by ap Gwylim et al. (2002) has several theoretical drawbacks. That is why it is not included in the analysis that follows. (Again, see Lucia and Pardo (2010) for details.)
where $\Delta OI_t$ is the value of the variation of the open interest at the end of the period $t$, $\Delta OI_t = OI_t - OI_{t-1}$, and $V_t$ is the trading volume during that period. In this case, the ratio is a proxy of the relative importance of the hedging behavior in the contract analyzed. Nonetheless, as first noticed by Lucia and Pardo (2010), this ratio can take any value in the range $[-1, +1]$, because the value of the change in the open interest during the period $t$ is in the range $[-V_t, +V_t]$. Thus, a high (close to one) value of $HEDG$ may be interpreted as low speculative activity in the contract object of study. Note that the correlation between $HEDG$ and $SPEC$ should be negative as the former, in contrast to the latter, decreases when the speculative behavior increases.  

3. SPECIFICITIES OF THE EUROPEAN CARBON MARKET AND DATA

The European carbon market has some specific characteristics that have to be taken into account when analyzing the speculative and hedging behavior of its market participants. Those specificities are described in this section.

Firstly, as pointed out by Mansanet-Bataller and Pardo (2008) the most representative futures market is the European Climate Exchange (ECX). Thus, in order to perform our study, data from the ICE ECX futures market is used. Specifically, the most liquid emissions contracts traded in this market, which are the December futures contract on EUAs are considered (an EUA is the right to emit one tone of CO$_2$ in the atmosphere in the European Union). That is, our database is made up with the volume and the open interest of the ICE ECX EUA December futures contracts with deliveries from 2005 to 2020. The data has been obtained directly from the ICE web page.

Secondly, in order to analyze the dynamics of speculation in this market, we have aggregated the daily data available from the ICE web page in weekly data. Specifically, we have considered weeks starting on Monday and finishing on Friday. Thus, when calculating the ratios described above as proxies of the speculative and hedging activity, we are considering the aggregate volume during the week starting on Monday and

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5 Additionally, a positive (negative) value for $HEDG$ indicates that the number of open positions is higher (lower) than the number of closed positions. $HEDG$ is undetermined when the volume and the variation of the open interest are both equal to zero. (Lucia and Pardo (2010))

6 The reason for such a choice is that the expiry of the December futures contracts is either the last Monday of the delivery moth or the penultimate Monday of the delivery month, in case where the last Monday is a non-business day or there is a non-business day in the 4 days following the last Monday. Please see https://www.theice.com/productguide/ProductSpec.shtml?specId=197 for more information on the specifications of the ICE ECX EUA futures contract (last visited 28/05/2012).
finishing on Friday and the variation of the open interest, necessary for computing $HEDG$, from Friday to Friday. Note that the sample period starts with the beginning of the trading in this market that is, on the 22\textsuperscript{nd} of April 2005, and finishes on the 18\textsuperscript{th} May 2012.

Additionally, it is necessary to take into account that the EU ETS is organized in phases. Each phase is defined by (i) a different pre-established cap for real emission for the most important industrial emitters in the EU and (ii) a specific period for which the emissions are capped. Phase I ran from January 2005 to December 2007, Phase II runs from January 2008 to December 2012 (it coincides with the Kyoto protocol commitment period), and Phase III will start in January 2013 and will last until December 2020. In this scheme, the transfer of allowances from one phase to the next one (banking) was not allowed in Phase I but it is permitted in Phase II. The behavior of the agents in different phases may be diverse due to various reasons (such as the degree of maturity of the market, and the proximity of the trading date to the beginning and the end of the phase when the allowances are permitted to be used). Due to this reasons, it is worthy to analyze the speculative and hedging behavior of market participants separately for each Phase. The identification of the phases allows studying the speculative and hedging behaviors within each phase, and additionally permits to carry out a comparative study across phases.

From the daily data we have also built up three so-called front contract weekly series. The Phase I front contract series is constructed with the nearest Phase I December futures contract (that is December 2005, then December 2006, and finally December 2007) and it runs from the 22\textsuperscript{nd} April 2005 to the 14\textsuperscript{th} December 2007. The front contract series for Phase II is constructed with the nearest Phase II December futures contract (starting with the December 2008 and finishing with the December 2012) and it runs from the 22\textsuperscript{nd} April 2005 and finish on the 18\textsuperscript{th} May 2012. Finally, the Phase III front contract is constructed accordingly, and for the time being only the December 2013 contract is included (the only nearest December contract available to date). The Phase III front contract runs from the 11\textsuperscript{th} April 2008, the beginning of the Phase III EUA trading, to the 18\textsuperscript{th} May 2012.

The methodology for the rolling over of the different futures contracts has been the same for the three front contract series: the rolling over takes place the Monday when
the contract expires. This criterion allows the calculation of weekly volumes without mixing different contracts. Consequently, both the volume and the open interest on the rolling over day are the values of the volume and the open interest of the new contract, respectively.7

4. EMPIRICAL ANALYSIS AND RESULTS

Based on the ratios described in section 2, we analyze the evolution throughout time of the speculative/hedging behavior in the European carbon market during each one of the three Phases of the EU ETS by using weekly data. The time series dynamics of the ratios are depicted in Figure 1. Several important insights may be gained by a casual inspection of the graphs included in Figure 1.

[Please insert Figure 1]

Recall that weekly changes in the volume to open interest ratio potentially capture weekly changes in speculative activity. Provided that the SPEC ratio takes high starting values for the three Phases, this indicates a high degree of speculative behavior in the moment of listing the contracts for the first time for each Phase. Additionally, the degree of speculation decreases over time for Phase I (Figure 1A), whereas in Phases II (Figure 1B) and III (Figure 1C) is similar: after high levels of speculation, this ratio fall sharply and then it begins to increase steadily. Furthermore, the information provided by the graphics of the HEDG measure is quite similar: while the HEDG ratio increases along the Phase I period (Figure 1D), which implies dismissing speculative activities, it decreases for Phases II (Figure 1E) and III (Figure 1F), after a period of high values, indicating a relative increase of speculative activities following that period.

If we focus on the front contract, we can observe that since April 2006, when the information about the real emissions of the most carbon intensive European industries was disseminated, the speculation behavior became relatively small in the Phase I Front contract (Figure 1A and 1D) compared to the speculation behavior in the Phase II Front contract (Figure 1B and 1E). Note that since that date, the interest in Phase I was considerably diminishing for several reasons (i) as it has been mentioned, it was not

7 Caution was exercised to avoid calculating variations of open interest considering different contracts: the variation of the open interest for the first week of the new contract was calculated using the value of the open interest for the same contract the previous week.
possible to bank allowances from the Phase I to Phase II, and (ii) the information that arrived to the market was that the global offer of allowances was higher than the total demand for that period provoking a collapse in Phase I prices, as shown in Figure 2, and an increase in the interest for Phase II. These two facts may have raised the speculators’ interest in Phase II.

[Please, insert Figure 2]

A seasonal pattern also emerges during the first quarter in every year (this quarter is marked with dashed vertical lines in Figure 1). Both measures show an increment in the degree of speculation, or informed trading, in all the Phases during the first quarter. This could be explained by the specific schedule of deadlines set by the EU ETS and graphically summarized in Figure 3.

[Please, insert Figure 3]

Firstly, at the end of the month of February, the most emission-intensive companies receive their permits for the starting year. Secondly, one month later, by March 31st, each participant in the scheme has to submit to the European Commission the verified emissions report corresponding to the previous year. Thirdly, by the end of April, the allowances covering the real emissions of the previous year must be surrendered. Finally, the European Commission has until mid-May, to make public those reports. Thus, the companies having a binding emission reduction target, which know exactly their real emissions, may make use of this information during the first quarter of the year. Note that, each year, during the months of March and April, the most emission-intensive industries have in their accounts EUAs for two different years that may be used for compliance within the ongoing phase and also in the next phase (except for the end of Phase I where no bankability was permitted). Therefore, they can manage its inventory of EUAs during this two months taking into account different strategies. They can: (i) surrender the EUAs corresponding to the previous year real emissions, (ii) sell them in the market, or (iii) maintain the EUAs in their accounts.

In order to confirm these insights, we now examine some relevant statistics. First, we will try to state the global picture of the speculation versus hedging activities for each one of the phases. To this aim, the mean, the median and the variation coefficient
(defined as the mean divided by the standard deviation) are presented for the front contract of each phase, in Table 1.

[Please, insert Table 1]

The statistics included in this table confirm that when the SPEC median value is high, the HEDG median value is small. Additionally, the median values indicate that according to SPEC, there is more speculation in Phase I whereas based on HEDG there was less speculation in Phase I. On the contrary, both measures point to Phase II of the EU ETS as the most speculative demand attracting phase in mean terms.

Additionally, in order to complete these findings, we have carried out the analysis of the evolution of the speculative versus hedging demands by year, separately for each distance to the maturity of the contracts. With that purpose, we have obtained for each year of each Phase the mean, the median and the variation coefficient for the two ratios from the first December front contract (Near 1) to the fifth one (Near 5).8

[Please, insert Table 2]

In this table we observe that if we consider the front contract year by year, in median terms both the SPEC and HEDG measures coincide: the speculative demand is concentrated in Phase II, except during the year 2005 when the speculative demand is concentrated in the December 2005 contract.

Table 2 also allows performing both an intra-phase as well as an inter-phase analysis of the speculation and hedging demand in the EU ETS. Indeed, recall that during each one of the phases it is possible to trade not only the EUA futures contracts for that specific phase but also for the next one. To be precise, the futures contracts whose underlying is EUAs for Phase II of the EU ETS started to trade in 2005, at the same time as the futures contracts whose underlying was EUA Phase I. Also, the EUA futures contracts whose underlying asset was EUA Phase III of the EU ETS started to trade in 2008 for the December 2013 and December 2014, and in 2010 for the rest of the December contracts for Phase III. For example, in Table 2, during the year 2006, the first

8 Note that during 2005, the fifth nearest contract was the December 2009. This contract was only negotiated twice during that year and thus, the mean, median and standard deviation in this case is not representative. Hence, those results are not presented in Table 2.
December front contract (Near 1) is the December 2006, the second December front contract (Near 2) is the December 2007, and the third December front contract (Near 3) is the December 2008. Thus, the first two contracts correspond to Phase I of the EU ETS while the third one belongs to Phase II of the EU ETS.

Accordingly, two different pieces of information are provided by Table 2. On the one hand, if we read the table by rows, for each specific year of the EU ETS, it is possible to observe the speculative and hedging demand for the first five consecutive front contracts and thus, determine which contract was attracting the highest level of speculative activity for each year. On the other hand, if we read the table by column, it is possible to observe the evolution throughout time of the speculative and hedging demand that is attracting each maturity. Figures 4 and 5 allow a preliminary inspection of both types of information, respectively.

With regard to the analysis of the relationship between the degree of speculation and the time to maturity of the futures contracts, Figure 4A and 4B show that the contracts with the shortest time to maturity show the median highest values for SPEC and the lowest values for HEDG, while the contracts with the longest time to maturity periods present the lowest values for SPEC and the highest values for HEDG. This indicates that for each year the front contract concentrates the majority of the speculative activity while the hedging demand is concentrated on the furthest maturities. These results are in line with what has been previously determined for other financial markets.9

Furthermore, the inter-phase analysis from Table 2 shows that the same conclusions are obtained when there is no banking restriction between the phases. However, the results are slightly different if we consider the last year of Phase I (the year 2007). In this case, although the front contract is December 2007, the two measures (SPEC and HEDG) coincide to indicate that the contract that attracted the highest degree of speculation was the December 2008 contract. This result is consistent with the graphs presented in Figure 1. As it has been mentioned above, the banking restriction between Phase I and Phase II of the EU ETS provoked that Phase I and Phase II allowances reacted to

specific demand and supply determinants within each Phase. (i.e., they behave as two distinct underlying assets). The highest median value in the measure $SPEC$, which indicates there was more speculative demand for the December 2008 (Near 2) contract than for the December 2007 (Near 1) contract in the year 2007, and the lowest median value in the measure $HEDG$, which indicates that there was more hedging demand in the December 2007 contract than in the December 2008 contract during this period, are both explained by the fact that those two contracts have not the same underlying (the first one is a future contract on Phase I EUAs while the second one is a future contract on Phase II EUAs). Figures 5A and 5B confirm that the highest levels of speculation are concentrated in the front contracts while the Near 4 and 5 futures contracts are the less speculative for all the years considered except for the year 2007 for the reasons just mentioned. The valleys (peaks) observed in 2007 and 2012 in Figure 5A (Figure 5B) for Near 1 are also caused by the proximity of the end of the Phase I and II, respectively. It seems that the end of the phase is related to the lowest levels of the speculation activity.

It is worth noting that the ratio of futures volume to open interest has been used by Holland and Vila (1997) as a measure of the success of a futures contract. A high ratio, indicating that trading is high compared with the number of outstanding contracts, would imply that agents can open and close their positions with relative ease. Given the specific features of the EU ETS, each phase has a different underlying asset and the success must be analyzed for the inter-years of a Phase. Following this interpretation, the inverted U-shape observed for the Phase II in Figure 5B would indicate the rise and fall in the success of Phase II futures contracts.
4. CONCLUSIONS

We have used two measures that combine volume and open interest data in order to explore the relative importance of the speculation versus hedging activities in carbon futures markets.

Both measures indicate a high degree of speculative behavior in the moment of listing the contracts for the first time, for every Phase. Additionally, the degree of speculation diminishes over time for Phase I, whereas the pattern over time in Phases II and III, however, differs: after high levels of speculative activity, it falls sharply and then it began to increase steadily.

For each year, independently of the Phase, we have detected a higher level of speculation in the first quarter of each year. This seasonal pattern could be explained by the increase of the number of informed traders in the market during these months, caused by the specific schedule of deadlines that characterizes the EU ETS.

Both measures point to Phase II of the EU ETS as being the most speculative phase, and they also point out that the front contract is the future contract that concentrates the majority of the speculative activity in every year, whereas the hedging demand focus on the furthest available maturities.
REFERENCES


Figure 1. Evolution of the speculative-hedging ratios.

Figure 1.A. SPEC ratio evolution during Phase I of the EU ETS

Figure 1.B. SPEC ratio evolution during Phase II of the EU ETS
Figure 1.C. SPEC ratio evolution during Phase III of the EU ETS

Figure 1.D. HEDG ratio evolution during Phase I of the EU ETS
Figure 1.E. HEDG ratio evolution during Phase II of the EU ETS

Figure 1.F. HEDG ratio evolution during Phase III of the EU ETS
Figure 2. CO$_2$ price evolution during Phase I, II and III of the EU ETS.
Figure 3. EU ETS compliance timeline.

The emissions take place

\begin{align*}
t &= 0 \\
t &= +1
\end{align*}

- **t = 0**: Reception of emissions (February)
- **t = +1**: Verified emissions (Until 31st March), Surrendered Allowances (Until 30th April), Compliance report (Around 15th May)
Figure 4. Relationship between speculative-hedging median ratios and time to maturity period.

Figure 4.A. SPEC ratio and time to maturity, for each year

Figure 4.B. HEDG ratio and time to maturity, for each year
Figure 5. Evolution of the speculative-hedging median ratios by year

Figure 5.A. Evolution of SPEC by year, for each time to maturity

Figure 5.B. Evolution of HEDG by year, for each time to maturity
Table 1: Speculation-hedging demand ratios for Phases I, II and III Front contracts of the EU ETS

In this table the mean, the median, the variation coefficient (obtained as the quotient between the standard deviation divided by the mean value) and the number of observations are presented for the SPEC and HEDG speculation-hedging demand ratios for the three front contract weekly series.

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<tr>
<th>Phase</th>
<th>SPEC</th>
<th>HEDG</th>
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<tbody>
<tr>
<td></td>
<td>mean</td>
<td>mean</td>
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<tr>
<td>Phase I Front contract</td>
<td>0.29779</td>
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<tr>
<td>median</td>
<td>0.472917</td>
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<td>var. Coef</td>
<td>0.886864</td>
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<td>Phase II Front contract</td>
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<td>median</td>
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<td>var. Coef</td>
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<td>Phase III Front contract</td>
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<tr>
<td>N. Obs</td>
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Table 2: Speculation and hedging demand by year and maturity

For each year of the EU ETS, the mean, the median and the variation coefficient of the first nearest December contract (Near 1), the second nearest December contract (Near 2), the third nearest December contract (Near 3), the fourth nearest December contract (Near 4), and the fifth nearest December contract (Near 5) are obtained for each ratio (SPEC and HEDG, respectively) using the weekly data.

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<th>HEDG</th>
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<td></td>
<td>Near 1</td>
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