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Assessing Rollover Criteria for EUAs and CERs[1]

Óscar Carchano
Corresponding author
Department of Financial Economics,
Avda de los Naranjos s/n, Faculty of Economics,
University of Valencia, 46022 Valencia, Spain.
Tel.: +34-963828369. Email: oscar.carchano@uv.es

Vicente Medina
Trading Control Analyst,
Department of Middle Office,
Calle Méndez Álvaro 44,
Repsol Trading S.A, 28045 Madrid, Spain.
Email: vicente.medina@repsol.com

Angel Pardo
Department of Financial Economics,
Avda de los Naranjos s/n, Faculty of Economics,
University of Valencia, 46022 Valencia, Spain.
Email: angel.pardo@uv.es

ABSTRACT: This study discusses how to roll over European Union Allowances (EUAs) and Certified Emissions Reduction (CERs) futures contracts with different maturities. The aim is to elucidate whether or not the choice of rollover date is important when constructing EUAs and CERs continuous futures time series. We have applied five different methodologies to link the series and our findings indicate that return distributions do not significantly differ for the different criteria. This result has direct practical implications in the field of applied econometrics of carbon markets given that we prove that the selection of the simple last-day rollover methodology criterion has no downside not only in terms of returns distribution but also with respect to liquidity levels.

Keywords: Rollover date; European Union Allowances (EUAs); Certified Emission Reductions (CERs).
JEL Classification: G1

1. Introduction

The behavior of the prices of European Union Allowances (EUAs) and Certified Emission Reductions (CERs) are of interest to academics, hedgers and traders. Although EUAs and CERs spot markets do exist, Uhrig-Homburg and Wagner (2009) and Rittler (2012), among others, identify the price traded in the futures markets as being the main reference in the price discovery process when studying the relationships between spot and futures markets in the framework of exchange-traded emissions products. However, when analysts focused on European futures carbon markets study long periods of time, they have to use several contracts and decide how to roll over futures contracts for operational and/or statistical purposes.

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In this context, a group of papers has linked the different futures contract maturities using the expiration day of the December contract as the timing for the rollover. This is the case for studies by Mansanet-Bataller et al. (2011) when investigating EUAs and CERs price drivers; Chevallier (2010), who analyzes the interrelationships between EUAs and CERs price series; Chevallier (2011), who proposes a model of carbon price interactions with macroeconomic and energy dynamics; and Mansanet-Bataller and Pardo (2011), who consider EUAs as an additional investing option within the framework of portfolio management.

A different criterion is followed by Koenig (2011) when analyzing correlations in carbon and energy markets using daily observations from April 2005 to August 2010. In order to construct a reference price for EUAs, he combines three maturities into one single EUA futures price series, calling this continuous series the "EUA Tracker". During Phase I, the "EUA Tracker" is equal to the price of the December 2007 contract. In Phase II, the "EUA Tracker" switches to the December 2009 contract, until its date of maturity, after which it switches to the December 2010 contract. Finally, another criterion is followed by Medina et al. (2014) who analyze the timeline of the liquidity in the European carbon market and use the maximum volume criterion in order to obtain the most tradable contract series.

Therefore, studies focused on the European carbon futures market offer a variety of criteria for linking futures series. The question that arises is whether or not the selection of the rollover date affects the empirical results obtained in those papers. Some papers have tried to answer this question for other futures markets. Ma et al. (1992) analyze the rollover date in five different categories of futures contracts with different underlying assets (Gold, S&P 500, T-Bonds, Japanese Yen, and Soybeans) and concluded that, as the differences among the return series obtained using different criteria were significant, the best methodology depended on the underlying asset. Carchano and Pardo (2009) analyzed the relevance of the choice of the rollover date using several methodologies for the case of stock index futures (DAX, Nikkei, and S&P 500) and concluded that regardless of the criterion applied, there is no significant difference among the series obtained. Finally, Saunier (2010) studied the effect of using different rollover methodologies from the point of view of the yield obtained by an investor's commodities portfolio made up of gold, coffee, crude oil, wheat and milk. He concluded that a trader's profit depends on the rollover choice. On the whole, the miscellany of results obtained in these studies implies that a specific empirical analysis must be carried out for each category of futures contract.

The aim of this paper is to analyze whether or not the choice of the rollover date is relevant when linking EUAs and CERs futures contracts. Unlike previous studies, we carry out an analysis not only in terms of return distribution, but also in terms of liquidity. Although different rollover criteria can provide similar long return series, they might not offer appropriate market liquidity levels. For this reason, using the number of transactions as a liquidity variable, we create long series based on the different rollover criteria and we compare their levels of trading activity. In this way we can test if the methodology chosen for constructing long futures returns series also offers appropriate liquidity conditions.

The remainder of the paper is organized as follows: Section 2 details the data used in the study. Section 3 describes the different methodologies reported in the financial literature and different return series are constructed depending on the criterion applied. Section 4 analyzes if there are significant differences among the returns distributions and among the liquidity distributions. Section 5 summarizes and concludes the paper.

2. The Data

The European Union is the leader in global climate policy. Since the European Union Emissions Trading System (EU ETS) was created in 2005, it has become the biggest international system for trading greenhouse gas emission allowances. The EU ETS is a multilateral system that covers more than 11,000 power stations and industrial plants in 31 countries, as well as airlines. In total, around 45% of total EU emissions are covered by the EU ETS. Facilities included in the 2003/87/EC Directive have the obligation to cover their real verified emissions with rights which allow them to emit one tonne of CO_2 -or any equivalent gas- into the atmosphere. Thus, up to 2012, at the beginning of the year, each facility received entitlements or European Union Allowances (EUAs) to fulfill its requirements. Each EUA allows for one tonne of CO2–equivalent to be emitted. These allowances were given for free during Phases I and II (periods 2005-2007 and 2008-2012, respectively), and any excess or deficiency of allowances could be dealt with in the market. In addition, the 2004/101/EC Directive provided the facilities the opportunity to satisfy their hedge obligations with Certified Emission Reductions (CERs), but only up to a given percentage, which varies among the different countries.[2] Starting in 2013, the general rule for allocation will be by auction, and only some installations will receive free carbon permits.

Several electronic markets currently offer trading on exchange-traded emissions products. However, the ICE ECX Market attracts both the largest trading volume and the open interest position. Specifically, the futures contract with maturity in December is considered as the benchmark as it concentrates the most liquidity by far. This is why this study has focused on December ICE ECX futures contracts on EUAs and CERs. It is important to highlight that Phase I allowances could not be used in Phase II. As a consequence, Phase I and Phase II allowances are considered as two different assets.

Our database includes all the available daily data for both EUA and CER futures contracts with maturity in December and also the March 2008 contract, because this was the last contract traded in Phase I. Specifically, the sample period goes from April 22nd, 2005 to March 31st, 2008 for Phase I EUAs, from April 22nd, 2005 to December 30th, 2011 for Phase II EUAs, and from March 14th, 2008 to December 30th, 2011 for Phase II CERs. The daily database contains, for each day, the open, high, low and settlement prices (in Euros), the total volume (in lots) and the open interest (in lots). One lot stands for 1,000 CO_2 EUAs. In addition, to obtain information related to the number of transactions, we have also employed the price (in Euros) and the transaction size (in lots) for each trade.

3. Rollover Criteria

This section discusses the five different criteria that have been used to determine the exact point in time when the switching from the maturing contract to the next one takes place. The first criterion analyzed is the "Delivery-day" or "Last-day" criterion (*LD* in tables). In this case, the switch occurs when the nearest to maturity contract expires.

The next four criteria seek the appropriate market liquidity conditions for the rollover. Thus, the second criterion is based on trading volume (*Vol* in the following tables), defined as the number of contracts traded throughout the day. This criterion implies switching the contract on the day when the volume of the second maturity is always higher than the volume of the first one. The third method used to construct long return futures series is the "Open Interest" method (*OI* in tables). The open interest indicates the number of contracts outstanding at the end of a trading day. This criterion applies the jump between series when the open interest of the second maturity is always bigger than the first one. The fourth criterion is the "Maximum Open Interest" (*M.OI* in tables). In this case, we allow jumping from one contract to another with a maturity different from the next-to-maturity contract that has the highest open interest until maturity. Finally, the last criterion is based on the measure proposed by Lucia and Pardo (2010). In this case, the jump will occur on the day on which the number of closed positions is always larger than the number of opened positions for the nearest contract, this is, when the ratio $R3_t = (O_t / O_t + C_t) - (C_t / O_t + C_t)$ is less than zero until maturity, where $O_t = V_t + \Delta OI_t$ and $C_t = V_t - \Delta OI_t$, with O_t and C_t being the overall number of open and closed positions in the period *t* respectively, while V_t and OI_t are the volume and the open interest of the period *t*. This methodology seeks to anticipate the fall of the open interest of the nearest maturity contract. Following this criterion, when $R3_t$ a negative, analyst is do not take into account the data from the front contract since it is no longer of interest to traders.

[2] The Kyoto Protocol establishes some flexibility mechanisms that allow for the diminishment of the overall cost of achieving emission targets. One of these mechanisms is the Clean Development mechanism. The purpose of the Clean Development Mechanism is to assist developing countries in achieving sustainable development by permitting industrialized countries to finance projects for reducing greenhouse gas emission in developing countries and receive units called Certified Emission Reductions (CERs) for doing so, which can be used by the Annex B country to achieve compliance. One CER allows for the emission of one metric tonne of CO2 equivalent.

A closer review of the financial literature offers an additional criterion, the "Distortion Free" method, proposed by Geiss (1995). As pointed out by Saunier (2010), this criterion is not thought to be adequate for running praxis-oriented tests because it implies a continuous rebalancing each day due to the changing contract proportions. Certainly this would not be good enough for practitioners because the resultant series does not reveal prices quoted in the market and, as a consequence, investors could not use these prices in their investment strategies. For this reason, this last methodology has not been included in our study.

Following each one of the above mentioned rollover criteria, we have built five different return series. Both EUA and CER returns are defined as the first log-differenced price series. It is important to clarify that when we switch from one contract to another, a jump in prices takes place. The return on the rollover day for each criterion has been calculated as the log of the quotient between the closing price of the new maturity contract and the previous closing price of such maturity.

Table 1 displays the percentage differences in the number of data that varies between such series. For the case of the Phase I EUAs, the difference among all the long series is less than 6%. Regarding Phase II permits, both EUAs and CERs series present similar features. The methodologies based on volume and R3 differ less than 4% from the return series obtained following the "Last-day" criterion. Furthermore, the most different methodologies are those based on the open interest. Specifically, the percentage differences between the "Maximum Open Interest" series and the "Last-day" series are 24.08% and 98.45% for Phase II EUAs and Phase II CERs, respectively. These percentages diminish to 14.94% and 45.95%, respectively, when comparing the "Open Interest" and the "Last-day" series. This is because futures contract return series that follow criteria related to open interest, jump to the next contract far sooner than the rest of the methods. The reason is that there is a contract with a later expiry date which dominates the remaining contracts in terms of outstanding contracts. Taking into account these results, the percentage differences in the number of data of each series could make it possible to work with different samples taken from the same raw data, depending on the rollover methodology applied. This is what we analyze in the following sections.

Table 1. Rollover criteria and returns series

This table presents the difference in percentage between the numbers of observations that are different when constructing continuous futures return series following each criterion. *LD, Vol, OI, M.OI, and R3* stand for last day, volume, open interest, maximum open interest, and R3 criteria, respectively. Sample period from April 22nd, 2005 to March 31st, 2008 for Phase I EUAs, from April 22nd, 2005 to December 30th, 2011 for Phase II EUAs, and from March 14th, 2008 to December 30th, 2011 for Phase II CERs.

	Rollover Criteria	LD	Vol	OI	M.OI
Phase I EUAs	Vol	5.21			
	OI	4.01	3.60		
	M.OI	4.01	3.60	0.00	
	R3	0.67	4.54	3.60	3.60
Phase II EUAs	Vol	1.17			
	OI	14.94	15.64		
	M.OI	24.08	24.66	9.14	
	R3	0.47	0.70	15.29	24.37
Phase II CERs	Vol	3.83			
	OI	45.92	42.09		
	M.OI	98.45	96.28	71.98	
	R3	1.45	4.62	44.88	98.55

4. Empirical Analysis

4.1 Returns Distributions

Considering the return series that have been calculated, we have tested the equality of means, medians and variances among the futures return series constructed in the previous section. The equality of these parameters has been tested with the parametric Anova F-test, the non-parametric Kruskal-Wallis test and the Brown-Forsythe's statistic, respectively. The results are displayed in Table 2. As can be seen, Phase I EUAs, Phase II EUAs and Phase II CERs present similar results and the p-values indicate that it is not possible to reject the null hypothesis of equality of means, medians and variances in any case.

Table 2. Equality tests of long futures return series

This table presents the equality tests of means, medians and variances among the continuous return series constructed following the criteria explained in Section 3. The equality of means, medians and variances has been tested with the parametric Anova F-test, the non-parametric Kruskal-Wallis test and the Brown-Forsythe's statistic, respectively. The corresponding p-values appear at the end of the column. H0 stands for the p-value of the equality tests of means, medians and variances between all the continuous return series constructed.

Phase I EUAs	Mean	Median	Std. Deviation
LD	-0.0091	0.0000	0.1202
Vol	-0.0090	0.0000	0.1201
OI	-0.0090	0.0000	0.1202
M.OI	-0.0090	0.0000	0.1202
R3	-0.0090	0.0000	0.1202
H0	1.0000	1.0000	1.0000
Phase II EUAs	Mean	Median	Std. Deviation
LD	-0.0006	0.0004	0.0274
Vol	-0.0006	0.0004	0.0274
OI	-0.0006	0.0004	0.0273
M.OI	-0.0006	0.0000	0.0273
R3	-0.0006	0.0004	0.0274
H0	1.0000	1.0000	1.0000
Phase II CERs	Mean	Median	Std. Deviation
LD	-0.0013	0.0000	0.0258
Vol	-0.0013	0.0000	0.0258
OI	-0.0013	0.0000	0.0259
M.OI	-0.0014	0.0000	0.0257
R3	-0.0014	0.0000	0.0258
H0	1.0000	0.9999	1.0000

All in all, we can conclude that, regardless of the method used to produce a unique and continuous EUA or CER futures return series, we would reach the same conclusions in terms of means and variance. However, given that two series with the same parameters of position and dispersion could result in different distributions, we have applied the non-parametric Wilcoxon/Mann-Whitney test, in order to determine if the returns series have the same general distribution. The results reported in Table 3 indicate that the null hypothesis of equality between distributions cannot be rejected in any case as all the p-values are nearly one. Therefore, we can state that EUA and CER futures contract returns distributions of linked series are not conditioned by the criterion used to create them.

4.2 Transactions Distributions.

The previous analysis points out the "Last Day" criterion as the simplest way to construct long futures return series. However, given that the rest of the criteria are focused on diverse seeking-liquidity criteria, the question that arises is whether the "Last Day" criterion also offers proper market liquidity conditions. In order to determine possible differences in terms of market liquidity among the different criteria, we have chosen the variable "number of transactions" calculated as the number of daily agreements between a buyer and a seller to exchange a given number of contracts for payment. Furthermore, it must be stressed that, since this variable is based on intraday data, this part of the study could be of great interest for microstructure researchers. Moreover, as high frequency data is not always easily at hand, this study would help analysts in their choice of the most suitable rollover criterion when their objective is to obtain the most representative series in terms of liquidity.

Table 3. Distribution tests of long futures return series

This table shows the p-values of the Wilcoxon/Mann-Whitney test that tests the null hypothesis that two continuous return series have the same general distribution.

Phase I EUAs	LD	Vol	OI	M.OI
Vol	0.9799			
OI	0.9966	0.9838		
M.OI	0.9966	0.9838	1.0000	
R3	0.9891	0.9914	0.9924	0.9924
Phase II EUAs	LD	Vol	OI	M.OI
Vol	0.9931			
OI	0.9920	0.9854		
M.OI	0.9957	0.9973	0.9882	
R3	0.9991	0.9922	0.9928	0.9952
Phase II CERs	LD	Vol	OI	M.OI
Vol	0.9846			
OI	0.9914	0.9945		
M.OI	0.8959	0.9101	0.9026	
R3	0.9628	0.9782	0.9703	0.9355

Firstly, following the steps described in Section 3, we have constructed the continuous transaction series. Then, we have carried out the equality and distribution tests over the long series to determine possible significant differences among them in terms of liquidity. Table 4 presents the equality tests of means, medians and variances among continuous transaction series, for Phase I EUAs, Phase II EUAs and Phase II CERs, respectively.

Table 4. Equality tests of long futures transaction series

This table presents the equality tests of means, medians and variances between the continuous transaction series constructed following the criteria explained in Section 3. The equality of means, medians and variances have been tested with the parametric Anova F-test, the non-parametric Kruskal-Wallis test and the Brown-Forsythe's statistic, respectively. The corresponding p-values appear at the end of the column. H0 stands for the p-value of the equality tests of means, medians and variances between all the continuous transaction series constructed. H1 stands for the p-value of the equality tests of means, medians and variances between all the continuous transaction series constructed except OI and M.OI.

Phase I EUAs	Mean	Median	Std. Deviation
LD	45.9272	36.0000	46.6639
Vol	47.7088	39.0000	47.0965
OI	46.4086	37.0000	46.6029
M.OI	46.4086	37.0000	46.6029
R3	46.2340	36.0000	46.6330
H0	0.9683	0.9391	0.9991
Phase II EUAs	Mean	Median	Std. Deviation
LD	665.8476	565.5000	643.4841
Vol	668.3810	574.0000	643.2869
OI	539.8628	371.0000	564.4725
M.OI	464.2176	273.0000	543.2803
R3	666.6706	569.5000	643.3162
H0	0.0000	0.0000	0.0000
H1	0.9931	0.9918	0.9999
Phase II CERs	Mean	Median	Std. Deviation
LD	76.9511	60.0000	69.0848
Vol	77.5613	60.0000	70.5286

OI	69.0260	51.0000	68.9152
M.OI	48.5788	23.5000	71.2423
R3	77.0977	60.0000	69.1805
H0	0.0000	0.0000	0.4537
H1	0.9801	0.9985	0.9531

The results of Table 5 are different for Phase I EUAs and for Phase II EUAs and CERs. In the first case, there is no significant difference among the long transaction series constructed, but in the second case we reject the assumption of equality in terms of mean, median and standard deviation when we compare the five transaction series (H0). This is due to the lower number of transactions contained in the series based on open interest criteria. Then, we repeat the test for Phase II EUAs and Phase II CERs, but now comparing all the series except "OI" and "M.OI" transaction series (H1). In this case, no significant differences have been found among the rest of the series. Table V confirms the previous results, giving evidence of the existence of significant differences in the transaction distributions for OI and M.OI and the rest of the series[3].

Table 5. Distribution tests of long futures transaction series

This table shows the p-values of the Wilcoxon/Mann-Whitney test that tests the null hypothesis that two continuous transaction series have the same general distribution.

Phase I EUAs	LD	Vol	OI	M.OI
Vol	0.3984			
OI	0.7727	0.5800		
M.OI	0.7727	0.5800	0.9999	
R3	0.8584	0.5026	0.9100	0.9100
Phase II EUAs	LD	Vol	OI	M.OI
Vol	0.8998			
OI	0.0000	0.0000		
M.OI	0.0000	0.0000	0.0000	
R3	0.9667	0.9329	0.0000	0.0000
Phase II CERs	LD	Vol	OI	M.OI
Vol	0.9954			
OI	0.0000	0.0000		
M.OI	0.0000	0.0000	0.0000	
R3	0.9593	0.9653	0.0000	0.0000

Therefore, we can conclude that analysts following "Open Interest" or "Maximum Open Interest" rollover criteria to construct long futures return series will face a more unfavorable intraday liquidity environment for the period considered, both in Phase II EUAs and Phase II CERs. This can be due to the fact that traders in Phase II maintained open positions in maturities different from front contract sooner than did traders in Phase I. The most striking case is the Phase II ICE ECX CER Futures Contract with maturity in December 2008, which began to be traded on March 14th, 2008. Only four trading days later, on March 20th, 2008, the open interest of the Phase II ICE ECX CER Futures Contract with maturity in December 2011 was higher than the open interest in the nearest-to-maturity futures contracts (December 2008).

5. Conclusions

The purpose of this study is to analyze the relevance of the choice of the rollover date when constructing continuous futures contract series in the ICE ECX futures market. The main methods

[3] We have repeated all the analyses in Section 4 by using both screen transactions and volume as trading activity measures instead of using the number of transactions. The results are qualitatively similar and are available upon request from the authors.

related to the construction of long futures series have been revised, as well as the different adjustments to be made when linking them. One new criterion, "Maximum Open Interest", has been added to the previous literature, accordingly with the specific features of the futures contract analyzed. Therefore, five criteria have been applied so as to link all the EUA and CER futures contracts with maturities in the period of time running from April 22nd, 2005 to December 30th, 2011.

Our findings indicate that there is no significant discrepancy among the different continuous return series in terms of mean, median and variance. Identical conclusions have been observed when comparing in pairs the general distribution among the different futures series.

Given that there are no storability restrictions within a trading phase, we could expect that the cost-of-carry relationship holds for the carbon futures market, as was shown by Daskalakis et al. (2009). This could explain the irrelevance of the rollover date when constructing long futures return series. However, a further liquidity analysis reveals the adverse liquidity conditions that an analyst will face when following criteria related to open interest. Therefore, when linking EUAs and CERs future series, we recommend switching on the last trading day because it is the simplest method and it offers the highest levels of liquidity.

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