

The CER-EUA Spread: Compliance Strategies and Arbitrage in the European Carbon Market

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Background - Cap-and-Trade Markets

■ Principles & variations

- **Cap:** allocate as much pollution rights as the cap allow
 - Declining cap over time
 - Cap-setting variations: grandfathering / updating / benchmarking / arbitrary or scientifically-based
 - Allocation variations: for free / auction / mixed
- **Trade:** allow trading of pollution rights among those regulated
 - Participants: only capped / open to anyone
- **Penalty** in case of non-compliance
- **Variations:** other means for compliance (intertemporal flexibility like banking/borrowing, acceptance of offsets, etc.), price support (cap/floor).

■ Applications

- Fishing rights
- Pollution: Air pollution (SO₂ and NO_x in the US), local pollution (RECLAIM in the US) and global pollution (GHG)

Background - Global Carbon Markets

■ **The Kyoto market mechanism**

- Cap-and-trade among signatory states (asset = AAU)
- Offset mechanisms CDM & JI (asset=CER & ERU)
- Scope: states
- Trading horizon: 2008-2012

■ **The EU ETS**

- The link with the Kyoto markets:
 - the burden sharing agreement - just a mean to comply with Kyoto initially
 - Acceptance of offsets for compliance
- Scope: 11,000 stationary sources + open to non-compliance-driven participants
- Trading horizon: 2005-2007, 2008-2012 and 2013-2020

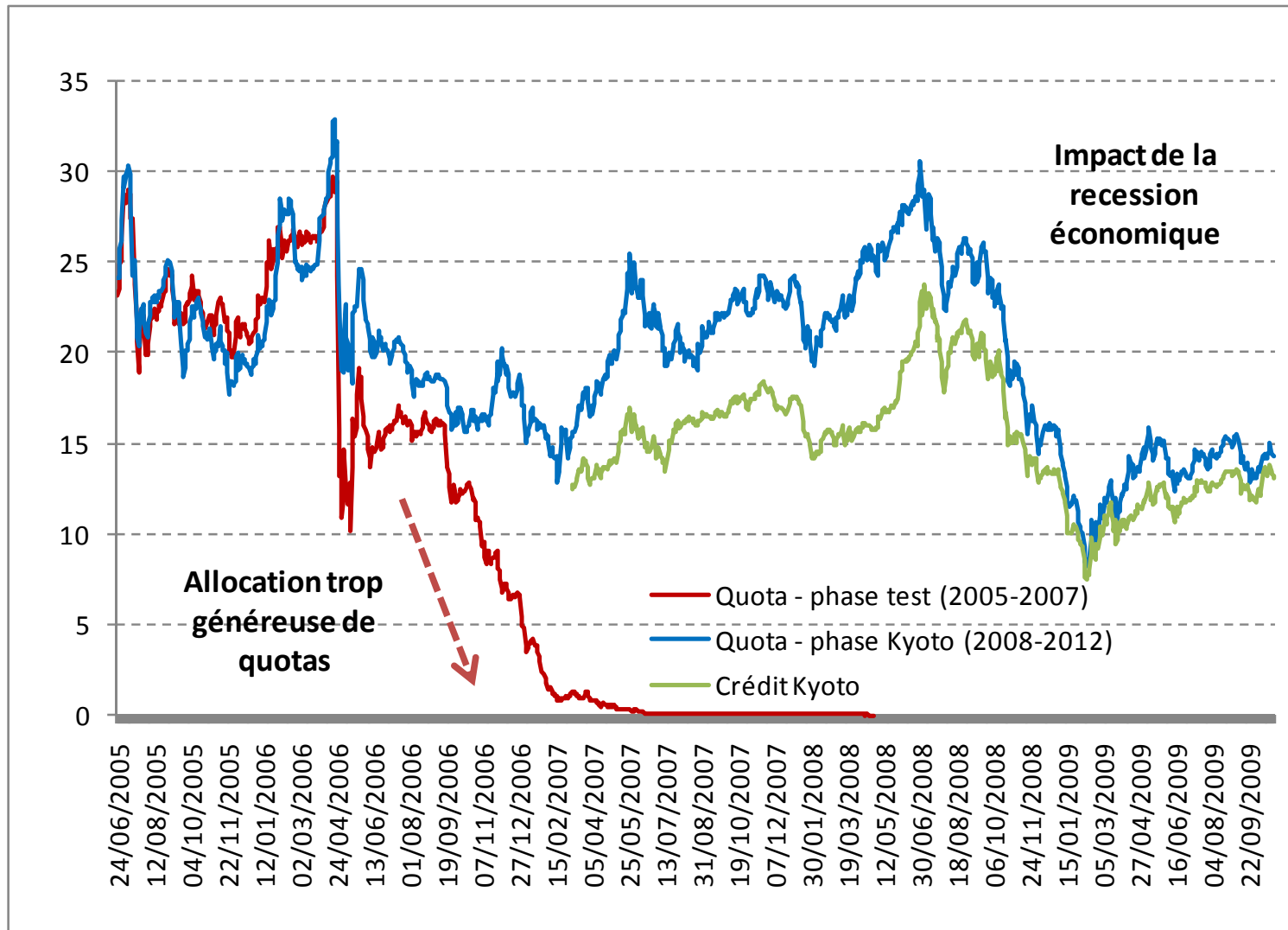
■ **Market development**

- EU ETS actually propelled the Kyoto offsets as the main demand source

Background - Compliance in the EU ETS

- **Reducing emissions** (i.e. reducing the emissions reduction objective to attain)
 - Short-term: reduce production, reduce emissions intensity from production (fuel switching), etc.
 - Mid/long-term: invest in low-carbon or carbon-free technologies like renewables, CCS, etc.
- **Acquiring compliance assets** (i.e. cheaper to acquire than own abatement)
 - **EUAs**
 - **Primary CER (pCER):** invest as shareholder in a CDM project. Once emissions reduction beyond baseline are verified, the UN CDM EB issues CERs to shareholders. => NOT VERY TRANSPARENT
 - **Secondary CER (sCER):** acquire already issued CER
 - ERUs (from JI projects) be they primary or secondary => NOT MUCH VOLUME
- **Use Intertemporal flexibility**
 - Bank compliance assets in excess of current compliance period in expectation of more stringent emissions reduction objective.
 - Borrow compliance assets needed from subsequent years.

Compliance Assets Price Developments



Source:
Reuters, ECX and
Bluenext

Existence of a Spread between EUAs and sCERs



$$Spread_{t,i} = sCER_{t,i} - EUA_{t,i}$$

What's Behind the Spread?

■ Typical types of spreads observed

1. Reflecting an **economic process** (input=>output) and being actively traded for hedging/arbitrage/valuation purposes (by means of options notably): crush, 3-2-1, spark, dark, crack, etc. => **typically reflect an economic margin**
2. Spread between products **similar in all but one characteristic** rather traded for arbitrage/valuation purpose: location/delivery spread, delivery date (forward-spot spread reflecting basis & calendar spread), quality spread, transaction side with the bid-ask spread, etc.

■ The sCER-EUA spread

- Rather belong to the 2nd category: two substitute goods (sCER and EUA) serving a same compliance purpose except for the “use limit”.
 - During phase II of the EU ETS: on average, 13.4% (EU average with a 0~20% range) of compliance assets can be CERs (sCERs and pCERs) and ERUs (again primary or secondary).
- Strong correlation between sCERs and EUAs
 - Historically, a large chunk of demand for Kyoto credits stemmed from EU ETS compliance drivers who wanted to make sure that prices would somehow be related with a discount. This was achieved contractually with some indexing provisions in primary CER procurement contracts (ERPAs).

Theorizing about the sCER-EUA spread

■ Sign of the sCER-EUA spread?

- Arguments in favor of a positive spread (pivotal asset and vector propagating price trends among carbon markets)
- Arguments in favor of a negative spread (current configuration / use limit threshold beyond which worthless in the EU ETS / sCERs not as good as EUAs / additional relative risk for sCERs vs EUAs)

■ Very existence of the spread?

- No spread in theory – both components should trade at parity according to KP & EU ETS governing legal documents and the “no free-lunch” principle.
- Criticism: lack of price history, two major kinds of market participants (compliance buyers and financials) with varying carbon assets (EUAs and CERs) endowment and risk aversion, lack of market (instruments) completion, lack of liquidity, etc. As these imperfections get resolved, these market observers expect the spread to converge towards zero.

■ Is the correlation among its components that obvious?

- sCER pricing irrespective of EUAs is not impossible under some circumstances (CER/ERU use limit for EU ETS compliance buyers exhausted)

Research Questions & Approach Retained

- **Research questions**
 - What are the price drivers for both spread components?
 - How to explain the residual?
- **Methods & sample used**
 - Academic literature on spreads mostly confined to money markets and fixed income
 - Financial econometrics (VAR(4) & GARCH)
 - Sample data
 - Daily futures prices (529 obs.) from March 9, 2007 to March 31, 2009 for sCER (Reuters) and EUAs (ECX) – rolled over on a single date
 - Synthetic spread constituted based on aforementioned variables
 - Several explanatory variables tested for and used in regression (detailed further later in the presentation).

Summary Statistics for all Dependent Variables

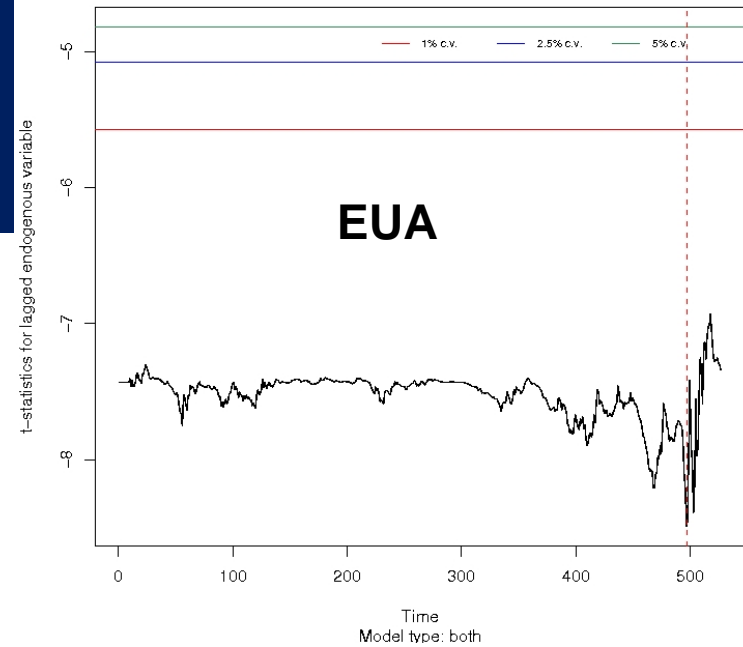
Variable	Mean	Median	Max	Min	Std. Dev.	Skew.	Kurt.
<i>Raw Price Series</i>							
EUA_t	20.40389	21.52000	29.33000	8.20000	4.459218	-0.765966	3.031938
CER_t	15.85798	16.06875	22.8500	7.484615	2.986495	-0.351494	3.135252
$Spread_t$	-4.545912	-4.620000	-0.647857	-9.043571	2.108445	-0.047792	2.292397
<i>Natural Logarithms</i>							
EUA_t	2.986643	3.068983	3.378611	2.104134	0.255164	-1.323179	4.275898
CER_t	2.743941	2.776876	3.128951	2.012850	0.205511	-0.994736	4.182189
<i>Log>Returns</i>							
EUA_t	-0.000437	0.0001	0.113659	-0.094346	0.026833	-0.060828	4.868026
CER_t	-0.000309	0.0001	0.112545	-0.110409	0.024441	-0.370323	5.961950
<i>VAR(4) Residuals</i>							
EUA_t	0.00001	0.001242	0.108251	-0.094873	0.025903	-0.052333	4.522629
CER_t	0.00001	0.000390	0.111584	-0.097672	0.023742	-0.309379	5.520998
<i>First-Differences</i>							
$\Delta Spread_t$	0.002219	0.010179	1.740000	-1.070000	0.295605	0.368420	6.262861

Note: EUA_t refers to ECX EUA Phase II Futures, CER_t to Reuters CER Price Index, and $Spread_t$ to the CER-EUA Spread. Std.Dev. stands for Standard Deviation, Skew. for Skewness, and Kurt. for Kurtosis. The number of observations is 529.

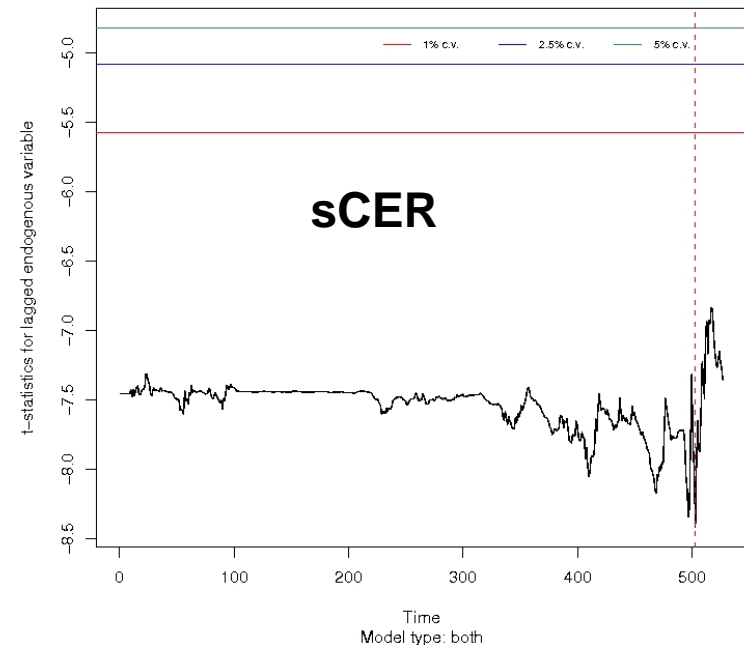
Cointegration Analysis (1/3)

- **Zivot and Andrew's (1992) unit root test**
 - The null of unit root is clearly rejected in favour of the break-stationary alternative hypothesis.
 - Two estimated break points are identified on February 13, 2009 for the EUA variable, and on February 20, 2009 for the CER variable. These break points may be due to a delayed effect of the “credit crunch” crisis on the carbon market (Chevallier (2009)).
- Both time-series are integrated of order 1 (I(1)), thus there exists a potential for cointegration.

Zivot and Andrews Unit Root Test



Zivot and Andrews Unit Root Test



Cointegration Analysis (2/3)

■ VECM and Structural Break

- Tests based on Johansen and Julius (1990) and Johansen (1991): the trace statistic result indicates a cointegration space of $r = 1$, given a 5% significance level. We may conclude that there exists one long-term cointegrating vector between the EUA and sCER variables transformed to natural logarithms.
- VECM: sCER variable has a stronger tendency to adjust to past disequilibria by moving towards the trend values of the EUA variable. This specification confirms that EUAs constitute a leading factor in the price formation of sCERs.

$$\Delta y_T = A_0 + A_1 Ecm_{T-1} + A_2 \Delta y_{T-1} + \epsilon_t$$

where $\Delta y_T = \begin{bmatrix} \Delta S_T \\ \Delta F_{T-1,T} \end{bmatrix}$ is a vector of first differences of EUA and CER prices,

$A_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$ is a vector of constants, $A_1 = \begin{bmatrix} b_{11} \\ b_{21} \end{bmatrix}$ is a vector measuring the speed of

the adjustment to the long-run relationship, and $A_2 = \begin{bmatrix} \gamma_{1,1} & \gamma_{1,2} \\ \gamma_{2,1} & \gamma_{2,2} \end{bmatrix}$ a coefficient matrix.

Hypothesis	Statistic	10%	5%	1%
$r \leq 1$	5.26	5.42	6.79	10.04
$r=0$	16.95	13.78	15.83	19.85

Cointegration Rank Trace Statistic

Variable	EUA(1)	CER(1)
EUA(1)	1.0000	1.0000
CER(1)	-0.4955009	-1.519945

Cointegration Vector

Variable	EUA(1)	CER(1)
ΔEUA	-0.06163548	0.00734759
ΔCER	-0.04490726	0.01821976

Model Weights

Variable	ΔEUA	ΔCER
<i>Error Correction Term</i>		
<i>ect</i>	-0.0197908	-0.0282009
<i>Deterministic</i>		
constant	0.0106349	0.0154190
<i>Lagged differences</i>		
$\Delta EUA(1)$	-0.0641515	-0.0504123
$\Delta CER(1)$	0.2307197	0.1423340

VECM with $r = 1$

Cointegration Analysis (3/3)

- **VAR(4) Modeling**
 - Residuals not auto-correlated
 - ARCH effect very strong => need to resort to GARCH for further analysis
 - Despite some structural instability around the February 2009 breakpoints, the residuals stay within the interval confidence levels.

Test	Statistic	D.F.	p-value
Portmanteau	57.4878	48	0.16
ARCH VAR	97.1946	9	0.01
JB VAR	147.6817	4	0.01
Kurtosis	143.5005	2	0.01
Skewness	4.1811	2	0.1236

Table 3: Diagnostic tests of VAR(4) Model

Note: Portmanteau is the asymptotic Portmanteau test with a maximum lag of 16, ARCH VAR is the multivariate ARCH test with a maximum lag of order 5, JB is the Jarque Berra normality test for multivariate series applied to the residuals of the VAR(4), Kurtosis and Skewness are separate tests for multivariate skewness and kurtosis. The VAR model estimated is:

$$\Delta y_T = A_0 + A_1 \Delta y_{T-1} + A_2 \Delta y_{T-2} + \dots + A_p \Delta y_{T-p} + \epsilon_t \quad (1)$$

where $\Delta y_T = \begin{bmatrix} \Delta S_T \\ \Delta F_{T-1,T} \end{bmatrix}$ is a vector of EUA and CER logreturns, $A_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$ is a vector of constants, and $A_1 = \begin{bmatrix} \gamma_{1,1} & \gamma_{1,2} \\ \gamma_{2,1} & \gamma_{2,2} \end{bmatrix}$, etc. are the coefficient matrices.

EUA price drivers – Survey

- **Supply and demand factors – literature survey**
 - SUPPLY => Fixed by the EC based on NAPs validation (high price sensitivity to related announcement: Alberola et al. (2008) and Chevallier et al. (2009))
 - DEMAND => Energy prices, extreme weather events and level of industrial production (Mansanet-Bataller et al. (2007), Mansanet and Pardo (2009), Alberola et al. (2009a), Alberola et al. (2009b)).

EUA price drivers – Independent Variables

- **ENERGY:** daily brent and natural gas futures from IPE / coal price (CIF ARA)
- **POWER PRODUCERS MARGINS AND CO2 SWITCH PRICE:** theoretical carbon price to switch fuel to generate power (Tendances Carbone) i.e. equalizing CSS & CDS
- **TEMPERATURE INDEX ANOMALIES:** NAP-weighted index around four observations points (Tendances Carbone) / three types of anomalies (change from 10-year average / dummy for extreme hot temp / dummy for extreme cold temp)
- **MACRO VARIABLES:** Tendances Carbone European Production index (based on Eurostat) / ESI (Eurostat)
- **DUMMY VARIABLE FOR CRISIS:** 1 from August, 17 2007 onwards and 0 otherwise
- **MARKET TRENDS:** slope of Euro area yield curve / momentum variable to spot bullish or bearish trends (t minus t-5) / volatility index (CBOE)
- **SUPPLY ANNOUNCEMENTS:** dummies for phase II NAPs, phase III continuity, connection between EUA registry and CER registry (allowing inflow of CERs).

EUA price drivers – GARCH Modeling

- Asymmetric TGARCH (p,q) model by Zakoian (1994) with a Student's t innovation distribution, estimated by Quasi Maximum Likelihood with the BHHH algorithm

$$\begin{aligned}EUA_t = & \alpha + \rho brent_t + \chi coal_t + \delta gas_t + \xi switch_t + \phi tempec_t + \varphi tempshot_t + \gamma tempcold_t \\ & + \eta MCprod_t + \varpi EUESI_t + \iota yield_t + \kappa momentum_t + \lambda crisis_t + \vartheta VIX_t \\ & + \mu EUETSphaseIII_t + \theta NAPphaseII_t + \nu ITL_CITL_t + \varepsilon_t\end{aligned}$$

$$\sigma_t = \alpha_0 + \alpha^+(L)\varepsilon_{t-1}^+ - \alpha^-(L)\varepsilon_{t-1}^- + \beta(L)\sigma_{t-1}$$

- **Two different sets of regression results:** Regression (1) contains main energy variables / Regression (2) contains the switch and market variables

EUA price drivers – Estimation Results

- **ENERGY (1):** Brent and gas have a positive impact on EUA price changes / as the most CO₂-intensive fuel, coal has a negative impact on CO₂ prices.
- **SWITCH (2):** positive sign confirms that when coal prices increase, it becomes profitable for power operators to switch from coal to natural gas including CO₂ costs.
- **MOMENTUM (1&2):** EUA price changes responded positively to market trends during our study period.
- **NAP PHASE II dummy (1&2):** NAPs II did not include major changes in the “generous” allocation methodology enforced so far, thus it did not restore scarcity of allowances on the market.

Variable	$EUA_{t,i}$	
	(1)	(2)
<i>constant</i>	0.0008 (0.0008)	0.0011 (0.0008)
<i>brent_t</i>	0.0013*** (0.0003)	
<i>coal_t</i>	-0.0017*** (0.0003)	
<i>gas_t</i>	0.0003*** (0.0001)	
<i>switch</i>		0.0006*** (0.0002)
<i>momentum_t</i>	0.0082*** (0.0007)	0.0083*** (0.0007)
<i>NAP phase II</i>	-0.0084* (0.0044)	-0.0095* (0.0049)
Adjusted R^2	0.1916	0.1631
Log-Likelihood	1287.749	1274.906
ARCH LM Test	0.7950	0.6360
Q(20) Statistic	26.789	24.322
AIC	-4.7811	-4.8243
SIC	-4.6997	-4.7673
N	529	529

Table 4: TGARCH(1,1) Regression Results for the EUA Price Drivers

sCER price drivers – Supply and Demand

■ Supply and demand factors

- SUPPLY => use of such credits is limited to 13.4% (on average) of surrendered allowances for compliance during Phase II of the EU ETS.
- DEMAND => most of the factors that have an impact on EUAs may also have an impact on sCERs, because both assets can be used for compliance in the EU ETS. Hence, we consider the same explanatory variables as for EUAs in sCER pricing.

sCER price drivers – Independent Variables

- **INDEPENDENT VARIABLES** used for EUAs
- **CDM PIPELINE:** forecast error concerning the number of CERs (i.e. primary) actually delivered by the UNEP Risoe, which is the authority in charge of validating CDM projects. Each month, the UNEP Risoe announces how many CERs are expected to be delivered in the CDM Pipeline . This variable is computed as in Kilian and Vega (2008):

$$CDM_{pipeline}_t = \frac{Realised_t - Expected_t}{\hat{\sigma}}$$

- **CDM EB dummy:** 1 when such reports (where forthcoming CER issuances are announced, hence primary supply), 0 otherwise
- **LINKING dummy:** use/change in use of CERs in other ETS coded as 1, 0 otherwise

sCER price drivers – GARCH Modeling

- Asymmetric TGARCH (p,q) model by Zakoian (1994) with a Student's t innovation distribution, estimated by Quasi Maximum Likelihood with the BHHH algorithm

$$\begin{aligned} CER_t = & \alpha + \rho brent_t + \chi coal_t + \delta gas_t + \xi switch_t + \phi tempec_t + \varphi temphot_t + \gamma tempcold_t \\ & + \eta MCprod_t + \varpi EUESI_t + \tau yield_t + \kappa momentum_t + \lambda crisis_t + \vartheta VIX_t \\ & + \mu EUETSphaseIII_t + \nu ITL_CITL_t + \pi CDMpipeline_t + \zeta CDMEBmeeting_t \\ & + \upsilon linking_t + \varepsilon_t \\ \sigma_t = & \alpha_0 + \alpha^+(L)\varepsilon_{t-1}^+ - \alpha^-(L)\varepsilon_{t-1}^- + \beta(L)\sigma_{t-1} \end{aligned}$$

- Three different sets of regression results

sCER price drivers – Estimation Results

- **ENERGY (3&5):** energy prices have a statistically significant impact on sCER prices with the same signs as for EUAs.
- **MOMENTUM (3&4):** similar as for EUAs.
- **LINKING(4):** positive sign of linking suggests that news about the future development of a global carbon market increase sCERs prices, which is fungible across regional and domestic markets
- **CDM PIPELINE not significant:** This result is conform to the view that sCERs have fundamentals distinct from the delivery of primary CERs.

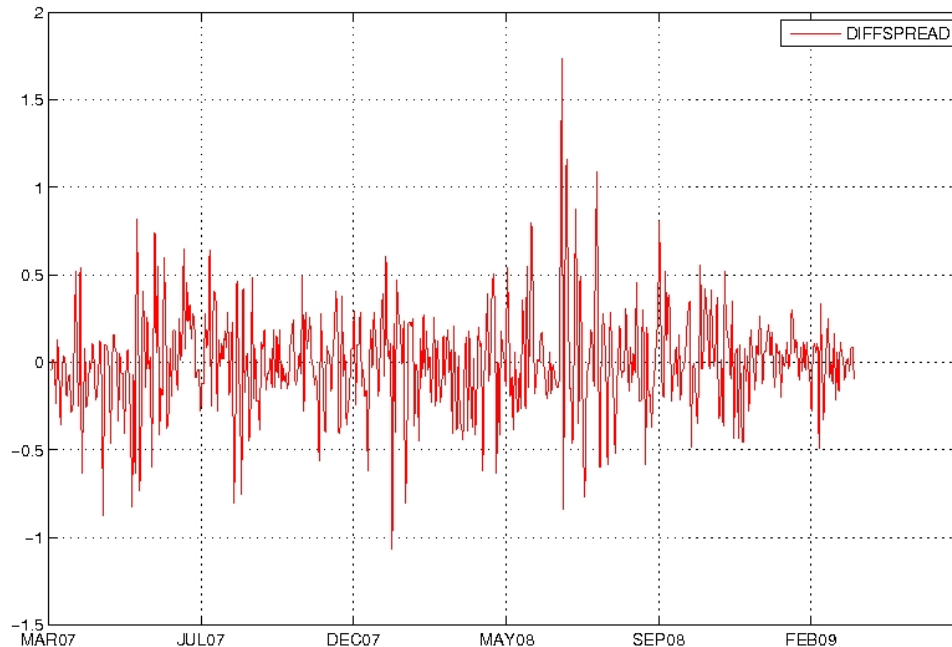
Variable	$CER_{t,i}$		
	(3)	(4)	(5)
<i>constant</i>	0.0008 (0.0007)	0.0007 (0.0007)	0.0007 (0.0013)
<i>brent_t</i>	0.0009*** (0.0002)		0.0005* (0.0003)
<i>coal_t(1)</i>	-0.0008** (0.0003)		-0.0017*** (0.0003)
<i>gas_t</i>	0.0002** (0.0001)		0.0002* (0.0001)
<i>momentum_t</i>	0.0093*** (0.0009)	0.0098*** (0.0009)	
<i>linking</i>		0.0194* (0.0111)	
<i>CDM pipeline_t</i>			0.0005 (0.0013)
Adjusted R^2	0.1582	0.1427	0.0463
Log-Likelihood	1344.581	1339.208	660.743
ARCH LM Test	0.9195	0.9730	0.7560
Q(20) Statistic	25.137	24.396	20.724
AIC	-5.1074	-4.8026	-4.5827
SIC	-5.0341	-4.7783	-4.4542
N	529	529	286

Table 5: TGARCH(1,1) Regression Results for the CER Price Drivers

Spread price drivers – Supply and Demand

- Supply and demand factors not discussed so far in the literature
 - The spread is rather a result than a product being traded

$$Spread_{t,i} = sCER_{t,i} - EUA_{t,i}$$



- Spread seems to widen/narrow depending on bullish/bearish periods on emissions markets.
- Volatility clustering between May and September 2008,
- Volatility decreases near the end of the sample period.

Spread price drivers – Independent Variables

- **PRICE THRESHOLDS:** EUA price level is used as a regressor / dummy taking the value of 1 when spread above EUR 6 in abs. value, 0 otherwise
- **MARKET ACTIVITY:** average trade size for EUAs (most liquid of the component) / open interest level for EUAs / CER contract marketplace development modeled as a dummy when additional contracts, etc. are made available / number of daily trade for EUAs /
- **LIQUIDITY:** change in volume for EUAs and sCERs / relative bid-ask spread calculations for EUAs and sCERs /
- **PANIC dummy:** dummy variable equal to 1 from October 10 to 17, 2008 and 0 otherwise. This variable reflects the sharp increase in the volatility of EUA prices that may be observed in October 2008, as regulated utilities were “rushing to cash” in search for liquidity, and in order to cope with the credit crunch crisis

Spread price drivers – GARCH Modeling

- Asymmetric TGARCH (p,q) model by Zakoian (1994) with a Student's t innovation distribution, estimated by Quasi Maximum Likelihood with the BHHH algorithm

$$\begin{aligned} \text{Spread}_t = & \alpha + \kappa \text{momentum}_t + \upsilon \text{VIX}_t + \pi \text{CDMpipeline}_t + \lambda \text{crisis}_t + \mu \text{EUETSphaseIII}_t \\ & + \nu \text{ITL_CITL}_t + \Pi \text{panic}_t + \zeta \text{CDMEBmeeting}_t + \nu \text{linking}_t + \omega \text{CDMmkt dvlpt}_t \\ & + \phi \text{numbertradeEUA}_t + \psi \text{openintEUA}_t + \chi \text{EUApricelevel}_t + \eta \Delta \text{average tradeEUA}_t \\ & + \xi \Delta \text{volumeEUA}_t + \beta \Delta \text{volumeCER}_t + \varpi \text{bidaskEUA}_t + \zeta \text{bidaskCER}_t \\ & + \gamma \text{thresholdCER}_t + \varepsilon_t \end{aligned}$$

$$\sigma_t = \alpha_0 + \alpha^+(L)\varepsilon_{t-1}^+ - \alpha^-(L)\varepsilon_{t-1}^- + \beta(L)\sigma_{t-1}$$

- Two different sets of regression results

Spread price drivers – Estimation Results (1/3)

- **MOMENTUM (6&7):** When the momentum variable is positive (indicating a bullish move), the spread narrows indicating profit-taking by market participants.
- **LINKING (6):** positive sign of linking suggests that prospects for serious CER demand outside Europe might drive buying interest out of the EU ETS & allow the spread to widen
- **EUA PRICE LEVEL (6&7):** very strong and positive explanatory power but obvious given construction
- **INCREASED TRADING ACTIVITY (6&7):** translate into slightly wider spread

Variable	$Spread_{t,i}$	
	(6)	(7)
<i>constant</i>	-0.0145 (0.0111)	0.0080 (0.0134)
<i>momentum_t</i>	0.0945*** (0.0121)	0.0997*** (0.0151)
<i>linking</i>	-0.2610*** (0.0733)	
<i>EUA price level_t</i>	0.9562*** (0.0322)	0.6726*** (0.0469)
$\Delta vol\ EUA_t$	-0.0007** (0.0004)	-0.0001*** (0.0001)
$\Delta vol\ CER_t$	-0.0013** (0.0007)	
<i>VIX_t</i>		-0.3364*** (0.1213)
<i>crisis</i>		0.4299*** (0.0711)
<i>CDM EB meeting</i>		0.0901*** (0.0541)
<i>threshold CER</i>		-0.0764*** (0.0134)
<i>CDM pipeline_t</i>		0.0161*** (0.0013)
<i>open int EUA_t</i>		-0.0001*** (0.0001)
Adjusted R^2	0.5800	0.5658
Log-Likelihood	141.5910	79.0179
ARCH LM Test	0.5540	0.5278
Q(20) Statistic	36.765	26.371
AIC	-0.5023	-0.4699
SIC	-0.4209	-0.3016
N	529	286

ble 6: TGARCH(1,1) Regression Results for the CER-EUA Spread Drivers

Spread price drivers – Estimation Results (2/3)

■ **VOLATILITY (7):** increased volatility tends to widen the spread

■ **CRISIS (7):** During the period identified as the peak of the crisis, the spread narrowed indicating strong interest in selling sCER and buying EUA – the operator thereby gaining the value of the spread.

■ **THRESHOLD CER (7):** when spread larger than EUR 6, the spread widens which is not what we would have expected – maybe that indicates a tendency to push the width of the spread even further in order to gain the value of even wider spread

Variable	<i>Spread_{t,t}</i>	
	(6)	(7)
<i>constant</i>	-0.0145 (0.0111)	0.0080 (0.0134)
<i>momentum_t</i>	0.0945*** (0.0121)	0.0997*** (0.0151)
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Spread price drivers – Estimation Results (3/3)

■ **CDM PIPELINE (7):** positive (negative) surprises for primary CER issuance are associated with a narrowing (widening) in the spread – the unexpected of influx (shortfall) of primary CER somehow fueling selling (buying) interest in secondary CER.

■ **CDM EB MEETING (7):** whenever the CDM EB meets – be there a surprise or not when it comes to primary CER issuance – the spread narrows. Issuance of primary CER (what market participants primarily look for in CDM EB meeting minutes) is thus followed by selling interest in the secondary market.

■ **OPEN INTEREST (7):** to relate to comments on change in volume.

Variable	$Spread_{t,i}$	
	(6)	(7)
<i>constant</i>	-0.0145 (0.0111)	0.0080 (0.0134)
<i>momentum_t</i>	0.0945*** (0.0121)	0.0997*** (0.0151)
<i>linking</i>	-0.2610*** (0.0733)	
<i>EUA price level_t</i>	0.9562*** (0.0322)	0.6726*** (0.0469)
$\Delta vol\ EUA_t$	-0.0007** (0.0004)	-0.0001*** (0.0001)
$\Delta vol\ CER_t$	-0.0013** (0.0007)	
<i>VIX_t</i>		-0.3364*** (0.1213)
<i>crisis</i>		0.4299*** (0.0711)
<i>CDM EB meeting</i>		0.0901*** (0.0541)
<i>threshold CER</i>		-0.0764*** (0.0134)
<i>CDM pipeline_t</i>		0.0161*** (0.0013)
<i>open int EUA_t</i>		-0.0001*** (0.0001)
Adjusted R^2	0.5800	0.5658
Log-Likelihood	141.5910	79.0179
ARCH LM Test	0.5540	0.5278
Q(20) Statistic	36.765	26.371
AIC	-0.5023	-0.4699
SIC	-0.4209	-0.3016
N	529	286

Table 6: TGARCH(1,1) Regression Results for the CER-EUA Spread Dr

Conclusions

■ Regression results

- EUA prices are driven by (1) Energy prices (input + power producer margins / switch), (2) regulatory announcements for phase II and (3) some market trend-following behavior
- sCER prices are also driven by (1) raw energy prices, (2) announcements for other demand sources for CERs and again (3) some market trend-following behavior. sCER prices seem disconnected from pCER issuance.
- The spread reflects (1) technical trading activity and (2) changes in *expectations* for exhaustion of the Kyoto credits use limit for compliance.

■ Regarding the spread, all depends on the following (unobservable) expectations built by market participants

- Supply of EUA: most stable leg (until recently with legal challenges to the EC)
- Demand for EUA: unpredictable unless resort to some forecasting model
- Supply of sCER: share of pCER becoming sCER unknown and so is pCER supply
- Demand for sCER: different compliance profile among MS/installations (pCER investor/MS use limit)

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