# The Price Impacts of Linking the EU ETS to the CDM

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## Abstract

*Many countries have begun to look increasingly towards the Clean Development Mechanism (CDM) as one of the key tools to increase the cost-effectiveness of fulfilling their compliance requirements with the Kyoto Protocol. It is believed, from a theoretical point of view, linking emissions trading schemes to the Kyoto's flexible mechanisms can lead to a decrease in carbon prices and so a reduction of the overall compliance costs. This paper provides an analysis of the relationship between the European Union Emissions Trading Scheme (EU ETS) and the CDM. I take into consideration dynamic interactions between European Allowance (EUA) prices and Certified Emission Reduction (CER) prices. I use time-series econometric techniques to test for the existence of long-run links and causal relations between the prices. Further, the generalised impulse response analysis has been chosen in order to investigate temporal interactions among the variables. The results show that CER prices do not have a statistically significant effect on EUA prices; rather, it is the EUA prices which have driven CER prices during the period investigated. The policy constraints on the availability of CERs emanating from supplementarity and additionality criteria, stipulated by the Kyoto, is one of the major factors that can be hypothesised to account for this finding.*



**Key words and Phrases:** Carbon Emissions Trading Scheme; Clean Development Mechanism; Certified Emission Reduction; Granger-causality Tests; Generalised Impulse Response Function

# 1. Introduction

Most countries have ratified the Kyoto Protocol in an attempt to slow down and stabilize the pace of climate change. Under the Kyoto Protocol, the Annex B countries, mainly industrialised countries, commit to reduce their emissions by an average of 5.2% below their 1990 levels over the commitment period 2008-2012. However, in order for mandated economies to meet their compliance requirements at the lowest possible cost, participants are also allowed to meet their reduction targets by purchasing emissions allowances or credits created through three flexible mechanisms: the Emission Trading Scheme (ETS) by purchasing emissions permits from financial exchanges, Clean Development Mechanism (CDM) by purchasing Certified Emission Reductions (CERs) from projects in developing countries (non-Annex I countries), and Joint Implementation (JI) by purchasing Emission Reduction Units (ERUs) from projects in other Annex B countries.

The CDM is considered by many industrialized countries as a more cost effective way to respond to climate change; however in order to ensure that the certified project activity reduces emissions more than that would have happened anyway and to prevent industrialised countries from overusing of project-based, the criteria of additionality and supplementarity have been stipulated by the Kyoto Protocol (UNFCCC, 2002). These criteria impose some access restrictions on credits and make them more sophisticated to use so they can reduce the attraction of cheap project-based credits for Annex B parties and influence their flexibility and cost-effectiveness in efforts to reduce emissions.

The European Union, under the Kyoto Protocol, is required to reduce its greenhouse gas emissions by an average of 8% below 1990 levels over the 2008-2012 period. The EU may do so through three main policies: domestic reductions through European Union Emissions Trading Scheme (EU ETS) for energy-intensive sectors; domestic reductions outside of Emissions Trading Scheme for non energy-intensive sectors; and emissions reductions abroad. For implementing the latter, the EU-15 Member States planned to fill part of their Kyoto gap with 540 $MtCO_2e$ through the flexible Kyoto Mechanisms-CDM & JI- (World Bank, 2008). As a result the European Commission decided to establish a link between the CDM and the EU ETS to increase the cost-effectiveness of fulfilling obligations and in order to meet its target at minimal costs (EU, 2004). This paper intends to shed light on the price impacts of this link by considering the dynamic interaction between the price of European allowances and Certified Emission Reductions under the current EU ETS regulations. In other words, with respect to EU compliance to Kyoto reduction commitments, the purpose of this paper is to investigate whether or not linking the EU ETS to the CDM can lead to any significant cost-saving through driving down the EUA prices.

From a theoretical point of view, as the marginal cost of abatement in developing countries is lower than in Annex B countries, the price of credits generated under the CDM would be lower than the European allowance (EUA) prices, although being equal value in terms of carbon emissions. It means, linking the EU ETS to the CDM indicates that the recognition of CERs as equivalent to EU allowances- hence CERs can serve as important substitutes for high priced EU ETS allowances- will drive down EUA prices and, in turn, lead to a reduction of the overall EU compliance costs with the Kyoto Protocol. In other words, by supplying excess credits to a large extent, the demand for European allowances will be decreased which in turn, will lead to a decrease in EUA prices. Therefore, it is believed that the linkage of the EU ETS to the Kyoto Protocol's mechanisms can increase the low-cost compliance options within the Community Scheme and it can lead to a reduction of the overall compliance cost with the Kyoto Protocol (EU, 2004). It can also improve the liquidity of EU ETS.

However, the European Union has imposed some restrictions on the availability of CERs for its Member States and their operators owing to the supplementarity and the additionality criteria which can significantly influence the expected effects and more specifically the extent of the decline in EUA prices.

There are many studies dealing with carbon markets, and more specifically with the EU ETS, that provide comprehensive overviews on issues such as: context and history, allocation, competitiveness, distributional effects, market, finance, and trading (Betz et al., 2006, Christiansen and Wettestad, 2003, Benz and Trück, 2009, Böhringer et al., 2006, Ahman et al., 2007, Alberola et al., 2006, Weyant and Hill, 1999, Weitzman, 1974, Convery, 2009). However a few studies have investigated the economic effects of linking EU ETS to CDM. These studies have mainly been carried out over the last several years and they have arrived at different results based on different assumptions about the supplementarity and additionality criteria and different approaches to modelling the issues (Anger et al., 2007, Criqui and Kitous, 2003, Jotzo and Michaelowa, 2002, Michaelowa et al., 2003, Anger, 2008, Klepper and Peterson, 2006, Langrock and Sterk, 2004). For example, Criqui and Kitous have shown that by linking EU ETS to the CDM, the compliance costs of ETS sectors would reduce by about 60% (Criqui and Kitous, 2003). According to Klepper and Peterson (2006), in the case of availability of hot-air[1] the price of carbon will drop to zero. Furthermore, Anger et al. (2007) show that by linking EU ETS to the CDM, the price of allowances would reduce to less than US$2.5 in a scenario which the additionality issue is considered and using of hot air is not allowed.

My study is one of the first studies which analyses the economic effects of linking the European Union Emissions Trading Scheme to the project-based Kyoto mechanism (CDM) through quantifying the price impacts of this link by using econometric evidence from the EU ETS and the CDM. As the earlier studies were primarily theoretical in nature and they carried out based on numerical simulations, the analysis undertaken in this paper is rather different.

To answer this question whether or not the economy-access to project-based abatement options in developing countries within linked EU ETS can induce large additional cost-savings

[1] The excess emission rights of transition economies whose targets are below their business-as-usual (BAU) levels resulting from the economic break down of their economies are called hot-air.

(through driving down EUA prices), I use time-series econometric techniques to test for existence of causal relation and long-run links between CER and EUA prices, using data on EUA prices (future contracts which expire on Dec 2008) and secondary market CER (where guaranteed CERs are traded) 2008 and 2008-2012 prices from Point Carbon. The models are estimated on a daily data sample from the 25th of May 2007 to the 1st of September 2008.

The findings would be helpful for countries which are considering whether and how to link up with the Kyoto's flexible mechanisms in order to meet their targets at the lowest possible cost. By understanding how this link may or may not affect emissions trading scheme and the extent to which CERs may affect the permit prices, policy makers will be in positions to make better decisions in order to tackle climate change in the most cost effective way by taking into account this link when designing an appropriate emission trading scheme.

The remainder of this paper proceeds as follows: in the next section, I give an overview over the Clean Development Mechanism under the Kyoto Protocol, how it works and the current situation of the CDM markets. Section 3 presents the models in order to investigate the interaction between CER and EU allowance prices and reports the empirical findings based on the estimated models. Section 4 summarises the results and draws some conclusions.

## 2. Some Background on Clean Development Mechanism

The Clean Development Mechanism was defined under the Article 12 of the Kyoto Protocol in 1997 ( UNFCCC, 1997) and it is the first Kyoto mechanisms that came into effect and the only method in which developing countries are involved to curb their greenhouse gas (GHG) emissions.

Developing countries can deliver large volumes of cost effective emission abatements to meet the science-based emission reduction target, so the CDM was designed to make Annex B Parties eligible to purchase CERs credits, which are generated from investment in emission reduction projects in developing countries, in order to fulfil their compliance requirements in an economically efficient way.

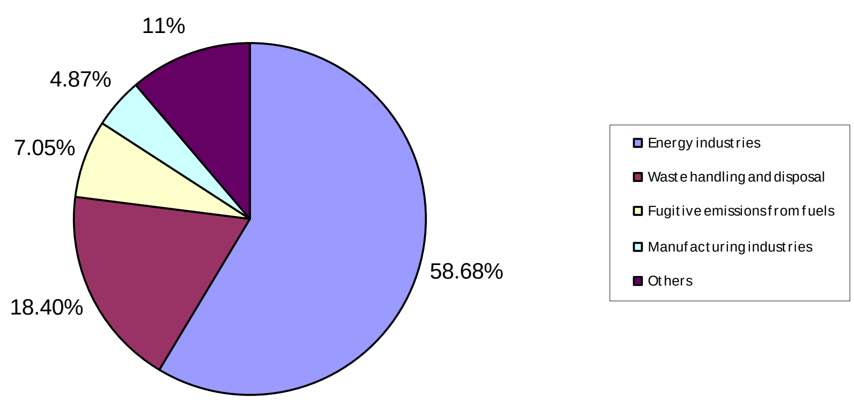
The CDM Executive Board (EB), which operates under the authority of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC), supervises the CDM project activities. Seven steps should be taken so that the Certified Emission Reductions (CERs) get issued: 1) Project design and formulation, 2) National approval, 3) Validation and registration, 4) Project financing, 5) Monitoring, 6) Verification and certification, and finally 7) Issuance of CERs (UNEP, 2004). The Certified Emission Reductions can be issued by the EB once the CDM projects complete the registration process and the project can generate the credits from the starting date of the project activity. At the end of March 2008, about 30% of CDM projects ,978 out of 3,188 CDM project, have been registered and there are 2,022 projects, or approximately two third of projects, at validation stage (World Bank, 2008).

Currently, three types of CERs exist in the market: issued CERs, forward streams of CERs and secondary market CERs. Issued CERs refers to CERs which have been generated and issued by projects already undertaken but forward streams of CERs are credits which are supposed to be generated by projects that are under construction and expected to come between 2008 and 2012 (the first Phase of the Kyoto Protocol). Carbon credits which are presented with a guarantee of delivery by some financial institution or a rated entity such as bank or fund, refers to the secondary market credits. The price of secondary market CERs is usually higher than those which are bought directly from a project (primary CERs) because the entity takes all project risks (TFS Green, 2008).

Most of the project-based market activity has been done through the CDM and it accounts for 87% of volumes and 91% of value transacted in the market in 2007. The volume and the value transacted through the CDM projects were about 791 $MtCO_2e$ and 12877 MUS$ respectively in 2007 (World Bank, 2008). The value transacted grew exponentially, more than 100 percent, while transacted volumes experienced 40 percent growth from 2006, due to exponentially growth in the secondary market for guaranteed CERs (World Bank, 2008).

The distribution of registered project activities by scope (UNFCCC, 2009) shows that projects involving energy industries (renewable and non-renewable sources) are to be the biggest in terms of number of projects (Figure 1).

**Figure 1: Distribution of registered project activities by scope**




The market share of clean energy projects (renewable energy, fuel switching and energy efficiency), in terms of volumes transacted, reached 64% in 2007 (World Bank, 2008). Existing statistics show that industrial gases play important role in the CDM markets and since 2003 HfC23 and $N_2O$ projects together have accounted for 50% of purchases which is about 480 million $tCO_2e$. However, the market share of HFC23 continued to drop from its 2005 peak. The market share of coal mine methane projects was about 7% in 2006. Carbon credits derived from Land Use and Land-use change and Forestry (LULUCF) remained constant at 1% of volumes transacted in 2006. This could be due to their limitation of usage in the EU ETS (World Bank, 2007).

Most of the CDM projects have currently been undertaken in Asia and South America. From supply side, the market is dominated by China, once its market-share of transacted volume was about 73% in 2007, compared to 54% market share in 2006. After China, India and Brazil were second and third respectively in terms of 2007 transacted volume, at 6% market share each. The supply of CERs could amount to 1.6 billion $tCO_2e$ by 2012 (World Bank, 2008).

European countries and their entities have significant effects on the CDM market through their demand either directly, by natural compliance buyers and the funds in which they are participants, or indirectly by entities planning to sell back these credits on the secondary markets. Their market share was about 90% in 2007. Private sectors such as entities from large energy utilities, power utilities, industrial manufacturing, oil and gas companies, banks, financial institutions and investors funds across Europe, that purchase CERs in order for compliance requirements with Kyoto targets or in order to speculate on the market or hedging and arbitrage purposes, have been the most active buyers, with 79% of volume transacted in 2007. Within Europe, 59% of market-share in terms of volumes purchased has belonged to the UK, and London is still considered as the carbon finance hub of the world (World Bank, 2008).

Some large purchases also by Japanese companies have been recorded in the World Bank confidential project database (World Bank, 2008), its 2007 market share reached 11% from 6% in 2006. The amount allocated by the government of Japan to purchase at least 100 $MtCO_2e$ credits through 2008-12 has been reported about US$815 million, €490 million (World Bank, 2008). The remaining industrialised Annex B governments have planned to buy about 20 $MtCO_2e$ from the Kyoto mechanisms. Moreover, it is expected that new demands for CERs from North America (after the Canadian announcement in late April 2007 to reduce its emissions and the California trading programme following the enacted bill in California in August 2006) will influence the CDM market. The total demand for CDM and JI over the 2008-2012 period is estimated about 2.1 billion $tCO_2e$.

## 2.1 The state of the CERs market

It seems the carbon market is increasingly seen as a central plank of the response to climate change. This corresponds to a transacted volume of carbon emissions about 3 billion $tCO_2e$ that was valued at US$64 billion (€47 billion) in 2007 (World Bank, 2008). The EU ETS has continued to dominate the market, however, a strong interest to buy project-based credits has been seen in the carbon market and CDM accounts for most of the project- based market activity.

The secondary market for CERs has grown dramatically since the second half of 2006 (World Bank, 2007). There are some advantages for the buyers to purchase a secondary market CER. For example, there is no risk of project performance on any one project and a secondary market CER can be considered as a near compliance-grade asset with firm volumes deliveries and guarantees. The trade of CERs for different purposes such as compliance, hedging and arbitrage purposes have been facilitated by the increased standardization of contracts in the secondary market, which has effects on its exponentially growth. However there are some risks in this market such as International Transaction Log (ITL) risk which is related to the time of CER delivery (not a case any more for EU ETS after establishing a direct link). According to the World Bank report in 2008, the volume transacted through secondary CER market was about 240 $MtCO_2e$ in 2007, up 40% from 2006, worth roughly US$5.5 billion (€4.0 billion). The secondary CER market accounted for 42%, in terms of transacted value in 2007, compared to 7% market share the year before (see Table 1).

**Table 1: Annual volumes and values for project-based transactions**

| | Volume | Value | Volume | Value | Volume | Value |
|---|---|---|---|---|---|---|
| | 2005 | | 2006 | | 2007 | |
| | (MtCO2e) | (MUS$) | (MtCO2e) | (MUS$) | (MtCO2e) | (MUS$) |
| Compliance | 382 | 2,894 | 597 | 6,466 | 832 | 13,376 |
| of which | | | | | | |
| Primary CDM | 341 | 2,417 | 537 | 5,804 | 551 | 7,426 |
| Secondary CDM | 10 | 221 | 25 | 445 | 240 | 5,451 |
| JI | 11 | 68 | 16 | 141 | 41 | 499 |
| other | 20 | 187 | 19 | 76 | na | na |
| Voluntary market | 6 | 44 | 14 | 70 | 42 | 265 |
| Total | 388 | 2,937 | 611 | 6,536 | 874 | 13,641 |

World Bank, 2007 and 2008

Although project-based market activity was supported by European buyers and they continued to show strong appetite in this market, the EU ETS was still the most active carbon market in 2007. It dominated the global carbon market, both in value and volume transacted. Its market share, in terms of 2007 transacted value was above 78% and in terms of 2007 transacted volume was about 70%. In 2007 about 2 billion tons allowances were traded in this market, worth about €37 billion or US$50 billion, almost twice the amount traded in 2006 (World Bank, 2008).

According to a Point Carbon report, in 2008 approximately $100 billion (€70 billion) EUAs and secondary CERs were traded in the European Carbon market. In this year, the total transacted volume of EUAs, bought and sold, reached nearly above 2.7 billion. Furthermore, around 400 million CERs were traded in Europe's carbon desks in 2008. The EUAs and secondary CERs had an average price of about €22.65 and €17.30 respectively in this year (Point Carbon, 9 January 2009).

## 2.2 How to price CERs

CERs are priced based on the evaluation of a number of factors which affect the project and thereby the value of CERs. These factors impacting on the price of CERs include EUA prices; credit which describes the financial positions of buyers and sellers; terms and conditions of the sale which explain delivery guarantees offered, the likelihood of generated volumes, the project validation and registration, the costs of the Project Design Document (PDD) and who is supposed to pay; sovereign risk; stage of project development; quality risk; delivery risk; registration risk; and finally access to market (TFS Green, 2008).

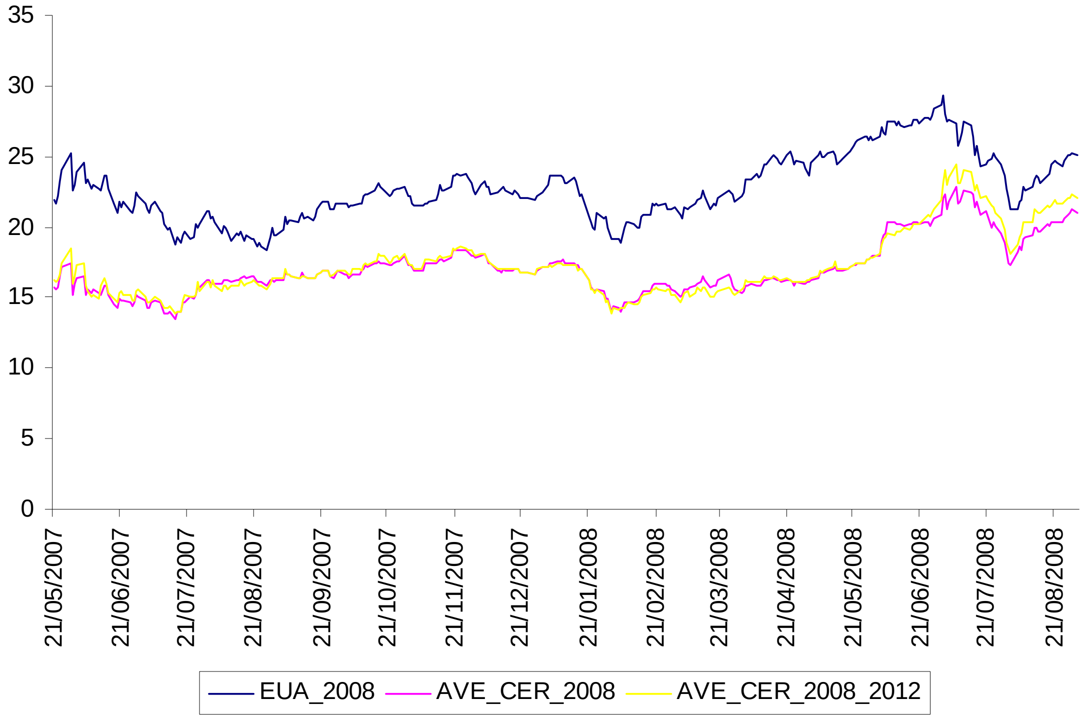
In contrast to European allowance-based market, project-based market experienced greater price stability in 2006 and 2007, although the early stage pricing of CERs occurred in a situation of uncertainty about the entrance of the Kyoto Protocol into force. For example early trades of Certified Emission Reductions happened with an average price between US$4 and US$6, however in 2006 the weighted average prices for primary CERs were about US$10.90 per $tCO_2$ which experienced a 52% growth in comparison with its level in 2005 and were slightly lower than the US$11.10 which was observed in the first quarter of 2006 (World Bank, 2007). The average contracted price in 2007 was about US$13.60 or €9.90. The lowest price for a CER was about US$6.80 in 2006 which was about 172% higher than US$2.5, the lowest price paid for a CER in 2005. In 2007 the minimum price for CERs rose to US$9 (€6.5), up 32% from 2006 (World Bank, 2008).

Currently, it seems having a benchmark for CER pricing is preferred by both buyers and sellers and Chinese informal policy, which requires a minimum acceptable price before providing Designated National Authority (DNA) approval to projects, as dominant leader of the supply side of the CDM markets has significant influence on the price of CERs. This minimum or floor price ranges between €8 and €9 (World Bank, 2008). Moreover, the observed price on the secondary market has been reported the other main market benchmark for CER pricing.

The existing statistics show that the price of issued CERs and a secondary market guaranteed CERs were observed around 80% of the price of EUA-08 and were higher than the price of primary CERs (World Bank, 2008). The range at which secondary CERs were transacted in 2006 was between US$10.75 and US$27 (World Bank, 2007). In 2007 the Dec'08 guaranteed CERs were traded at a price of €16-18 which is about 75-80% of December 2008 EUA price. It is expected that the price of secondary CERs will experience an upward trend because of greater regulatory certainty for non compliance in an emissions trading scheme and the linking directive under EU ETS which lead to an increase in demand for CERs[2]. The following graph compares the average bid and offer price for secondary market CER (2008), the average bid and offer price for secondary market CER (2008-12), and Dec'08 prices for EUA.

[2] However the European commission's recent proposal for a Phase III EU ETS which would impose a tight limit on the availability of CERs and any changes in rules of eligibility of EU companies in favour of using Assigned Amount units can drive down CER prices dramatically.

**Figure 2: The price spread between EUAs and CERs**




A price differential between EUA and CER can be attributed to some factors such as non-transparency of the CERs, uncertainty about post- Kyoto CERs, cap on amount of CERs and the link between the International Transaction Log[3] (ITL) and the Community Independent Transaction Log (CITL). As European buyers are the most active player in the CDM market and perhaps accounting for the largest source of the demand on the secondary CER market, any restrictions on the use and availability of CDM credits within Europe due to supplementarity and additionality regulations would impact on the CDM market and thereby on the CER prices significantly. So despite the existence of a guaranteed delivery for secondary market the common 10-30% price spread between the secondary guaranteed CERs and future EUA prices can be primarily attributed

[3] Each registry must send transaction proposals to the ITL which verifies them to ensure they are consistent with the Kyoto's rules.

to these restrictions and the ITL risk which causes some limitations and delay in order to deliver and transfer CERs across national registries[4] (World Bank, 2007). The price spread between secondary CERs and EUAs was about €6-7 but it widened to nearly €10 due to a reaction to the European Commission's recent proposal for a Phase III, which limit the availability of project-based credits up to 1,400 $MtCO_2e$ until 2020 for its Member States and their operators, under the scenario which no global agreement would be achieved on the post-Kyoto (World Bank, 2008). However, as prices for EUAs delivered in 2008 began to drop at the second half of 2008, the price spread narrowed (see Figure 2).

As mentioned, from a theoretical point of view it is expected that by linking EU ETS to CDM, the EUA prices go down. However, the extent of the decline in prices can be influenced significantly by regulations and restrictions emanating from the supplementarity issue. In the following some of existing regulatory restrictions on the usage of project-based credits in European community are reported.

## *2.3 The EU ETS rules*

One of the policy tools the European Union has designed in order to contribute to fulfilling the commitments of the community and its Member States to reduce anthropogenic greenhouse gas emissions under the Kyoto Protocol at the most cost-effective way is to establish a link between the EU ETS and the CDM. According to Article 11 of EU Amendments to Directive, 2004, "Member States may allow operators to use CERs from project activities in the Community scheme from 2005 and all CERs that are issued and may be used in accordance with the UNFCC and the Kyoto Protocol, may be used in the Community scheme"(EU, 2004).

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[4] It is not a case for the EU any more because the European Commission, Member States and the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) completed the live connection between the Community Independent Transaction Log (CITL), the UNFCCC International Transaction Log (ITL) and Member State registries on 16 October 2008.

According to the Kyoto Protocol, Article 6.1.d, “the acquisition of emission reduction credits shall be supplemental to domestic actions for the purposes of meeting commitments under article 3”, but no quantitative limit has been defined for that in the Marrakech accords. So the European Union in an attempt to quantify supplementarity issue states that the Member State cannot use more than 50% of its reduction commitment through importing credits from the project-based mechanisms in order to meet its target (Langrock and Sterk, 2004).

Apart from the supplementarity issue under the Kyoto Protocol, which limits government trading, there is another supplementarity issue under the European Union which is regarded to installation-based trading. According to the EU amending directive, “Member States may allow operators to use, in the Community Scheme, CERs from 2005 and ERUs from 2008 and the use of CERs and ERUs by operators may be allowed up to a percentage of the allocation of allowances to each installation, to be specified by each Member State in its national allocation plan for that period (EU, 2004). Moreover, the European Commission (2006) states that “EU ETS installations in that Member State would only be able to use JI/CDM credits up to a level of less than 10%, the Commission considers that as a minimum threshold installations should be allowed to use JI/CDM credits up to a level of 10%. In other words the Commission will assess consistency with supplementary obligations based on import limit of ten percent of a Member State’s assigned emission cap (EU, 2006). For example, in the UK, operators are allowed to use CERs or ERUs up to 8% of its annual allowance surrender in Phase II (Shaw, 2007).

Currently, Member States and all covered installations by the EU ETS are allowed to use CERs[5] to fulfil their EU Kyoto targets. At the moment, the EU ETS only covers energy-intensive installations such as electricity generation, paper production, metals production installations and mineral industry which emit more than 45% of the European $CO_2$ emissions. According to the EU

[5] There are two exceptions: CERs from nuclear facilities and sink projects.

Linking Directive, the installations subject to the ETS are allowed to use CERs but governments can put some restrictions for the use of CERs by them to meet the supplementarity issue.

It is believed that linking EU ETS to the CDM makes European companies able to reduce the cost of European Kyoto compliance through increasing the diversity of low-cost options within the Community and it can increase the cost-effectiveness of achieving the emission reductions. However, policy driven regulations can decrease the efficiency gains from project-based credits. In other words, the CERs access restrictions for energy-intensive sectors and the remaining industries in the EU which result from the additionality and supplementarity criteria play important roles on how the linking to the CDM can impact on carbon markets. Hence, in the following section, the price impacts of this link or more specifically the effects of CERs import on EUA prices are investigated.

## 3. Econometric Model and Preliminary Data Analysis

The models presented in this paper are empirically estimated based on daily data from the 25th May 2007 to the 1st September 2008. The December 2008 delivery EUA price, the secondary market CER 2008 (bid and offer), the secondary market CER 2008-2012 (bid and offer) have been extracted from Point Carbon. All prices are quoted in €/t $CO_2$ and all variables are expressed as logarithms. I only report empirical results which are based on the average bid and offer prices for secondary market CER in the following tables, although the interaction between variables are investigated for bid and offer prices separately.

As the order of integration of a time series is very important for analysing the economic time series, a part of this section is dedicated to investigate the existence of a unit root in the selected price series. Then I perform cointegration tests on all price series. In order to investigate the temporal interactions among the variables Granger-causality test and impulse response analysis are used.

### *3.1 Unit root tests*

The Augmented Dickey-Fuller, ADF, (Dickey and Fuller, 1979) and Kwiatkowski, Phillips, Schmidt & Shin, KPSS, (Kwiatkowski et al., 1992) tests are statistical tests which have been chosen for investigating the integration properties of series. In Table 2 the results of the ADF and KPSS tests for both the logarithm series on levels and the first differences are presented.

**Table 2: Unit root tests**

| | ADF | KPSS |
|---|---|---|
| Variables in (log) levels | | |
| **EU_2008** | -1.87 | 1.12*** |
| **CER_08_12_Bid** | -1.00 | 0.99*** |
| **CER_08_12_Offer** | -0.96 | 0.96*** |
| **CER_08_Bid** | -1.28 | 1.04*** |
| **CER_08_Offer** | -1.33 | 1.00*** |
| **AVE_CER_08_12** | -0.93 | 0.97*** |
| **AVE_CER_08** | -1.26 | 1.02*** |
| Variables in log differences | | |
| **EU_2008** | -18.09*** | 0.05 |
| **CER_08_12_Bid** | -18.75*** | 0.11 |
| **CER_08_12_Offer** | -18.90*** | 0.13 |
| **CER_08_Bid** | -18.60*** | 0.08 |
| **CER_08_Offer** | -19.66*** | 0.08 |
| **AVE_CER_08-12** | -18.44*** | 0.14 |
| **AVE_CER_08** | -18.83*** | 0.09 |

Note: * denotes statistical significance at 10% level, ** denotes statistical significance at 5% level,*** denotes statistical significance at 1% level. Tests are performed for variables in levels with optimal lag lengths chosen by SIC criteria.

The conclusion from the ADF tests is clear: at the 1% level the unit root hypothesis cannot be rejected for all series on levels. The KPSS test confirms the result. It clearly rejects the stationary hypothesis at the 1% level for all series in levels. Moreover, these tests support the stationary hypothesis for the first differences of all series. Thus, the appropriate tests support the conclusion that the series may be treated as I(1) and specifying a stationary model for the first differences seems appropriate.

### 3.2 The Granger causality test

As mentioned, I use time-series econometric techniques to test for existence of long-run links and causal relationships between the EUA and CER prices. I have started by investigating the unit root of the series; the next step is then to investigate possible cointegration relations between the selected price series to specify appropriate models. In this paper, testing for cointegration in a VAR model is done by using maximum likelihood cointegration tests provided by Johansen (Johansen, 1991, Johansen, 1988). According to the cointegration tests (the Trace statistic), there is very strong evidence for a cointegration rank of zero[6]. In other words, the two variables (EUA'08 and different secondary CER prices) in each of systems do not appear to be cointegrated.

The next step in my analysis is then to specify appropriate models. On the basis of my unit root and cointegration analysis results, it seems that the application of an unrestricted VAR in first differences is appropriate to investigate temporal interactions between the variables. Therefore, this study models price series on the first logarithm differences in unrestricted VAR models with optimal lag lengths chosen by the Akaike Info, the Final Production Error and Hannan-Quinn Criteria, long enough to ensure absence of autocorrelation. After estimating the models, Granger-causal relations between variables can be investigated. Testing for Granger-causality needs checking if specific coefficients are zero, so the standard tests for zero restrictions on VAR coefficients (Wald tests) can be used here (Lütkepohl and Kratzig, 2004).

Tests for causality based on VAR(1) models in first differences are given in Table 3 and 4. In Table 3, none of the p-values are smaller than 0.05. Hence, using a 5% significance level, none

[6] The results are quite similar in favour of no cointegration regardless of considering trend, constant and different number of lags.

of the non-causality null hypotheses can be rejected. In other words, on the basis of these tests no causal relations from CERs to EUAs prices can be diagnosed with any certainty. These results show that the CERs prices do not Granger-cause the EUAs prices[7].

**Table 3: Tests for causality from CER to EUA prices based on the VAR(1) models in first differences**

| Depended Variable: EUA_2008 | Test value Chi-sq | p-value Prob. |
|---|---|---|
| AVE_CER_2008 | 0.00 | 0.96 |
| AVE_CER_2008_2012 | 0.14 | 0.70 |

All variables are first log differences.

**Table 4: Tests for causality from EUA to CER prices based on the VAR(1) models in first differences**

| Dependent Variables: | AVE_CER_2008 | | AVE_CER_2008_2012 | |
|---|---|---|---|---|
| | Test value Chi-sq | P-value Prob. | Test value Chi-sq | P-value Prob. |
| EUA_2008 | 1.22 | 0.26 | 5.48 | 0.01 |

All variables are first log differences.

[7] The results are the same once offer and bid prices are considered separately.

According to Table 4, there is, however, strong evidence of a Granger-causal relation from EUA'08 prices to CER 2008-12 prices because the p-value of the related test is at least less than 5%[8]. Based on these results, one would expect that it is the EUA prices which drive the secondary market CER prices.

Moreover, in order to investigate temporal interaction between these prices during the periods, I also estimate the VAR in levels and test for Granger-causality. If the VAR contains I(1) variables, standard tests for zero restrictions on VAR coefficients may have non-standard asymptotic properties (Lütkepohl and Kratzig, 2004). These problems can be removed by fitting a VAR whose order exceeds the true order and ignoring the extra parameters in testing for Granger-causality (Dolado and Lütkepohl, 1996, Toda and Yamamoto, 1995). It means the singularity problem can be removed by overfitting the VAR order, VAR ($\rho+1$) instead of a VAR ($\rho$) process and the Granger-causality test can be performed on the $A_i, i=1...\rho$ .

The results of Granger-causality tests based on the VAR models in levels are quite similar to what has been found based on the VAR models in first differences, it means on the base of these tests, using a 5% significance level, no causal relations from CERs to EUAs prices can be diagnosed. However there is strong evidence of a Granger-causal relation from EUA 2008 to CER 2008-2012 prices.

The statistical evidence does not support any strong substitution effects of CER for EUA and the major factor for this can be access constraints on CERs, which would limit their ability to cause any significant effects on EUAs prices. Other factors such as generous allocation of allowances to the ETS sectors, the determination of EUA prices in a more mature and established

[8] There is also weak evidence of a Granger-causal relation from EUA'08 to CER 2008 Offer prices, since the p-value is at least less than 10%. There are strong evidence of Granger-causal relations from EUA'08 to either CER 2008-12 bid or CER 2008-12 offer.

market, and non transparency of the CDM market and its post-2012 uncertainty can also be attributed to this finding which is discussed in the concluding section.

### *3.3 The impulse response analysis*

In order to analyse the dynamic interaction between the EUA and the CER prices, impulse response function is the method which is chosen. As the models have the status of reduced-form, so the generalised impulse response analysis could be an appropriate method to investigate this dynamic interaction which is not sensitive to the order in which the variables are entered to the VAR and it requires no identifying restrictions (Pesaran and Shin, 1998).

Figures 3 and 4 show the impulse response functions based on the VAR(1) models in first differences. The response standard errors are computed based on analytic (asymptotic) standard errors.

According to the estimated VAR models and considering the standard error bands, the estimated dynamic impact of a sudden increase in European allowance price has a significant positive effect on the CER prices for about two days. In other words a positive shock to EUA price increases the Certified Emission Reduction price for about two days before it returns to its initial level. The interval estimate indicates that the European allowance price does not react significantly to a positive shock to the CER price and it dies immediately after the shock has occurred[9].

[9] The results have produced based on the VAR(1) in first differences once the average price of CER_2008_12 has been chosen. The findings are quite similar based on the VAR models in first differences for different CER price series.

**Figure 3: Response of CER price to Generalised One S. D. EUA 2008 Innovation**

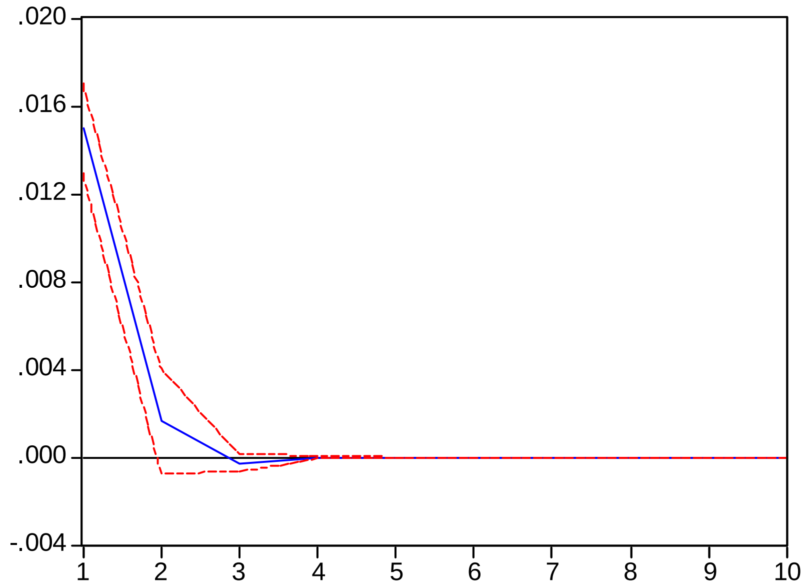
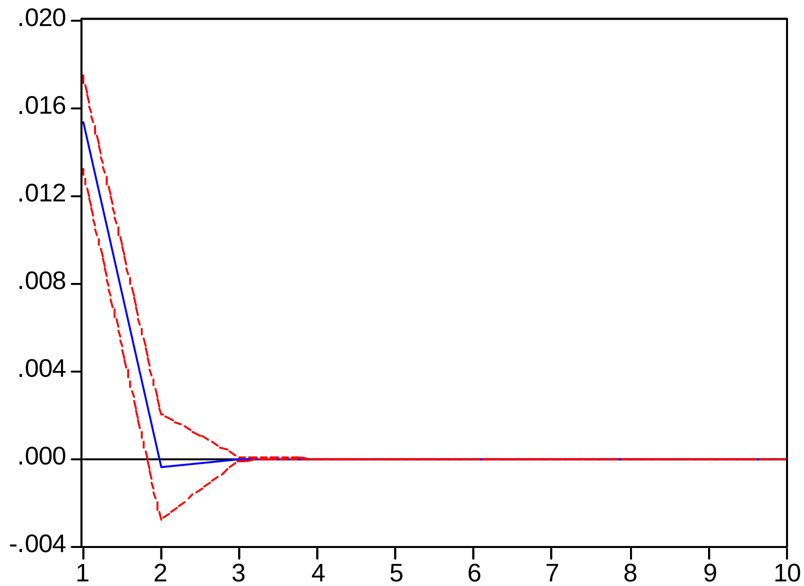



**Figure 4: Response of EUA 2008 price to Generalised One S. D. CER Innovation**



## 4. Summary and Conclusions

Most countries are considering a CDM as a helpful tool in order to scale up their efforts to reduce greenhouse gas emissions while growing their economies. Since it is believed that developing countries can deliver large amount of cost-effective emission abatement, the CDM's biggest strength is its ability to engage developed and developing countries to contribute meaningfully to climate change mitigation and lessen emissions globally in the most cost effective way. As a result, one of the policy tools which the EU has designed to fulfil its compliance requirements, is to establish a link between the EU ETS and the CDM. From a theoretical point of view, having access to the Kyoto project-based mechanisms, can lead to some cost–saving of meeting the EU Kyoto target through increasing the compliance options within the Community, using cheap project-based credits by operators and decreasing the European allowance prices. In other words, Economic theory suggests that linking the EU ETS to the CDM and the indication of recognising CERs as equivalent to EUAs will drive down EUA prices and, in turn, lead to a reduction of the overall EU compliance costs. However, the expected effects and, more specifically, the extent of the decline in EUA prices can be influenced significantly by the CER access restrictions in the EU emanating from the supplementarity and additionality criteria stipulated by Kyoto.

This paper provides an analysis of the relationship between the EU ETS and the CDM. In particular, it measures the price effects of this link by focusing on the dynamic interaction between the European allowance prices and Certified Emissions Reduction prices. I have employed time series econometric techniques to investigate the relationship between these prices. More specifically, in order to test the temporal interaction between these variables the VAR models have been specified (based on results from unit root and cointegration tests) and Granger-causality tests as well as generalized impulse response analysis have been used.

The results show, based on the estimated VAR models, CER prices do not have a statistically significant effect on EUA prices during the period investigated. In other words, the statistical evidence does not support any strong substitution effects of CER for EUA and it suggests that the changes in CER prices do not cause statistically significant changes in the European allowance prices. Thus, with respect to EU compliance to Kyoto reduction commitments, it appears that under the current EU ETS regulation, access to project-based abatement options in developing countries would not lead to any significant cost-saving, through driving down the EUA prices. This is contrary to what one can expect from theory.  However, there is strong evidence of a causal relation from EUA'08 to secondary CER 2008-12 prices and it appears rather, it is EUA price which drives CER price during the period investigated. There seems to be a desire for pricing CERs based on the EUA prices, especially European buyers, as the most active buyers, prefer to tie the value of CER to the EUA price as the most established trading system for emission allowances.

The analyses suggest that the dynamics of EUA prices are currently independent from the price of CERs for this period. A number of factors can be hypothesised to account for this finding. Firstly, it is believed that emissions allowance allocations to European energy- intensive industries were very generous in Phase I (Anger, 2008) and it implied low level of efforts for them in order to reduce their emissions. Moreover, the policy constraints on the use and the availability of CERs in order to quantify the supplementarity issue may limit the substitutability of project-based credits, so they cannot serve as equivalent substitutes for EUAs and their impacts on permit prices cannot be as significant as expected.

In addition, the EUA prices are determined in the EU ETS, which is the most established and major market for greenhouse gas emission allowances and it dominates the global carbon market, both in transaction and monetary value (World Bank, 2008). In comparison the secondary CERs market is a relatively new market. Concerns regarding issues such as the CDM's procedural inefficiency (too many projects await registration and issuance), its additionality, its sustainability (too many complex rules which are changed too often) and its uncertainty about the long-term future of the CDM market and its role post Kyoto, could result in CDM market failures that limit its ability to cause any significant impact on the EU ETS and thereby on EUA prices.

In conclusion, answering this question whether linking EU emissions allowance trading with the CDM can provide flexibility and cost-effectiveness in efforts to reduce emissions in the EU depends upon who is allowed to use CERs and under which circumstances and policy on this question is of fundamental importance to the market. A more efficient climate policy to reduce the costs of the European emission mitigation strategies would be to provide the unlimited use of the project-based credits for both operators and Member States. Limiting the availability of project-based credits can impact on the efficiency of this link significantly. Moreover, as European operators are the world's biggest buyers of CERs, the EU has a major say in how the CDM market will operate in a future climate deal and any plan by the European Commission can impact the global carbon market remarkably. For instance, the EC's latest proposals (Point Carbon, 30 January 2009) to scaling down the CDM project activities in main CERs' supplier countries (China, India and Brazil, issued 75% of CERs so far), shifting to higher quality projects by phasing out all HCFC projects (generated more than 50 per cent of CERs), and limiting the availability of project-based credits after 2012, all will impact on the CDM market, and more specifically, on the efficiency of the link.

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