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CO_2 Emission Allowances Trading in Europe – Specifying a New Class of Assets

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Abstract

In the context of controlling greenhouse gas emissions, the directive on an EU-wide trading scheme for carbon dioxide (CO_2) emission allowances may be considered as one of the major steps towards reducing environmental burden. A major question for market participants will be about regarding the price behavior of this new environmental asset. Due to non-maturity of the market, political regulations, fundamentals and certain characteristics of CO_2 allowances it can be assumed that parameters for the price process or even the process itself changes through time. In this paper we review the stylized facts of emission allowances and come up with suggestions to model their price behavior adequately. We conduct a preliminary empirical analysis of CO_2 allowance spot prices supporting our theoretical findings.

Key words: CO_2 emission allowances, emissions trading, spot price modeling.
JEL Classifications: G18, Q48, C50, Q25.

1. Introduction

According to the common position of the EU-Council (2003), large installations from the energy industry and other carbon-intensive industries are part of an EU-wide CO_2 emissions trading system (EU-ETS) that formally has entered into operation in January, 2005[1]. For European environmental policy this represents a shift in paradigms and affected companies will face new strategic challenges. Since environmental policy has historically been a command-and-control type regulation, such as the Federal Immission Control Act, companies had to strictly comply with emission standards or implement particular technologies. The EU-ETS requires a cap-and-trade program where companies have to reduce the amount of emitted greenhouse gases (GHG), and to annually demonstrate that their level of allowances corresponds to their actual CO_2 emissions. Otherwise, severe sanctions will be imposed on the participating companies. Surplus allowances can be sold or, if allowed, they can be saved for future years (banking). Thus, the right to emit a particular amount of CO_2 becomes a tradable commodity (ISI, 2003)[2].

The theory behind using emission trading as environmental policy instrument dates back to Montgomery (1972). Using a static model for a perfect market with pollution certificates, he was the first to show that there exists a cost minimum equilibrium for companies facing a given environmental target. Rubin (1996) extended this model to a dynamic setting with intertemporal transfer of the assets and confirmed the existence of a cost efficient solution. However, Kling and Rubin (1997) showed that in this framework the equilibrium does not coincide with the welfare maximizing first-best solution. According to Tietenberg (1990) reaching the cost minimal equilibrium requires that the marginal cost for abating emissions of all companies equals the market price of emission allowances. Thus, from a theoretical perspective introducing tradable permits is considered as a cost efficient instrument for reaching environmental targets where the initial allocation of allowances does not matter.

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[1]The agreement on a common position was reached in December 2002 and passed the EU-parliament's second reading in summer 2003 (EU-Council, 2003). The European Commission had already published a proposal for a Directive in October 2001 (COM, 2001).
[2]Allowances may either be allocated free of charge, auctioned off or sold at a fixed price. Hybrid systems are also possible.

The price behavior of this new environmental asset is a major question for carbon market participants. CO_2 emission allowances are a new trading good without much historical data and so far no empirical study on their spot price behavior is available in the literature. By studying the new market mechanism and empirical data from existing emission trading schemes, we discuss different issues that have to be considered for setting up an appropriate pricing model. We will show that pricing of CO_2 emission assets cannot only rely on standard models that have been developed for financial or alternative commodity markets.

The majority of publications about price behavior of tradable allowances assesses the 'Acid Rain Program' of the US Environmental Protection Agency (EPA), where operators of power plants have been trading sulphur dioxide (SO_2) allowances since 1992[1]. By using industrial organization models they account for changes in parameters of technology (Rezek, 1999) and electricity demand (Schennach, 2000) and their impact on the optimal equilibrium price path. There are quite a lot empirical papers on ex-post market price analysis, see i.e. Ellerman and Montero (1998) and Burtraw (1996). Literature examining the CO_2 allowances prices from an econometric or risk management angle is rather sparse. The short-term price behavior is of big interest especially for traders but also for participating companies.

The aim of the paper is twofold. We will first give an introduction to the EU-ETS concentrating on special characteristics and the mechanism of the new evolving market. We will also distinguish CO_2 allowances as a new product from other commodities and present the main sources of price uncertainty in the carbon market. We argue that allowance prices will exhibit phases of changing volatility and price behavior due to variations in liquidity imposed by regulatory and/or fundamental market issues. Our second goal is a preliminary analysis of short-term price movements and returns of emission allowances. We explain the observed price dynamics by our model of key price uncertainties and suggest an appropriate pricing model. The considered time series of allowance prices is provided by a major CO_2 trading institution.

The remainder of the paper is organized as follows. Section two provides an introduction to the new market mechanism for CO_2 emission allowances and a classification of this new commodity. Section three discusses the specific price behavior of emission allowances by suggesting a model for capturing the key price determinants. Section four provides preliminary results from a descriptive empirical analysis of allowance prices. Section five concludes and gives suggestions for future work.

2. CO_2 Emission Allowances – Market Mechanism and Instruments

2.1. The EU-Emission Trading System

As already mentioned, allowance trading has primarily been applied in the US, where it has become a crucial policy instrument to address air as well as nutrient pollution in water bodies at federal and state level. In 2002, the SO_2 program covered 3,200 electric generating units and set the cap to 10.2 million tons of SO_2 (almost 70% of nationwide emissions). This is a reduction by more than 7 million tons from 1980 levels. Annual cost savings compared to command-and-control type regulation are an estimated 50% from 1980 (Carlson et al., 2000; Ellerman et al., 2000).

The EU-ETS will result in the world's largest GHG emissions trading system. It covers more than 12,000 fixed sources, representing about 45% of the EU 25 total CO_2 allowances. It is considered as the cornerstone of the European Climate Change Programme and is expected to help achieving the EU's obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol in a cost-effective way (COM, 2001). Under the Kyoto Protocol the EU has committed to reducing GHG emissions by 8% compared to the 1990 level by the years 2008-2012[2].

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[1]Trading was established in the 1990 Clean Air Act Amendments, but the first trades did not occur until 1992 and emission allowances did not have to be submitted to the EPA to cover emissions before 1995.

[2]This period is also referred to as the first Kyoto-commitment period.

This target is distributed between the EU member states according to the Burden-Sharing Agreement, where different targets were set for each member states (EU 15).

While in the proposed EU-Directive most design elements of the EU-ETS are obligatory, it leaves some elements to be decided by the individual EU member states[1]. In the pilot phase of the program, during 2005-2008, only CO_2 emitting installations will be affected. Beginning in 2008, other GHG may follow. Allowances will be allocated annually. Surplus allowances can be transferred for use during the following year, with one possible exception: banking from the pilot phase into the first Kyoto-commitment period beginning in 2008 is left up to the individual member states to decide. Borrowing is principally prohibited between 2007 and 2008, as well as between all future commitment periods[2]. Failure to submit a sufficient amount of allowances results in sanction payments of 100 Euro per missing ton of CO_2-allowances. In addition, companies will have to surrender the missing allowances in the following year.

2.2. Classification of Emission Allowances

Before starting to build up an appropriate pricing model for CO_2 emission allowances, it is important to understand the type of new asset we are dealing with. Basically, a firm's stock of emission allowances determines the degree of allowed plant utilization. Not having enough allowances requires either some plant-specific or process improvements, a cut- or shutdown of the emission producing plant or the purchase of additional allowances and emission credits[3] respectively. With the latter alternative CO_2 becomes a new member of the European commodity trading market (PointCarbon, 2004). There is, however, a fundamental difference between trading in CO_2 and more traditional commodities. What is actually sold is a lack or absence of the gas in question. Sellers are expected to produce fewer emissions than they are allowed to, so they may sell the unused allowances to emit to someone who emits more than her allocated amount. The emissions hence become either an asset or a liability for the obligation to deliver allowances to cover those emissions.

Understanding the characteristics of a CO_2 allowance helps to understand the operation and dynamics of the carbon market, to interpret its signals correctly and to reduce distrust towards the new possibilities it creates. Therefore, in the following we discuss some additional specifications of CO_2 emission allowances by comparing them to other products of commodity markets and by making a classification that can be used to identify an appropriate pricing model.

At a first glance, one may think of CO_2 emission allowances as a traditional stock or commodity. However, having a closer look yields the following important differences (Benz, 2004). While the value of a stock is based on profit expectations of the firm that distributes the shares, the price for emission allowances is determined directly by the expected market scarcity induced by the current demand and supply. The new and crucial issue hereby is, that firms by themselves are able to control market scarcity and hence the market price by their abatement decisions. Activating an abatement measure that can abate relatively cheap a big amount of CO_2 has a significant impact on market liquidity and on price dynamics. Furthermore, it is important to note that the annual quantity of allocated emission allowances is limited and already exactly specified by the EU-Directive for all trading periods. While in the EU-ETS all market participants have to stick to these con-

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[1]Annex B of the Directive contains a list of countries, which are obliged to participate. These include large power and heat generation plants (exceeding 20 MW thermal input), oil refineries, coke ovens, large installations from iron, steel, mineral and paper industries.

[2]In the pilot period borrowing is potentially possible, since the allocation process for the next calendar year takes already place two month prior to the date when firms are required to submit allowances to cover their emissions for the previous year.

[3]Carbon credits are generated from Project-Based Mechanisms, Clean Development Mechanism (CDM) and Joint Implementation (JI). CDM-projects provide technology transfer in developing countries leading to a reduction in the emissions of GHG and earn emission credits called Certified Emission Reductions (CERs). JI projects are emission-diminishing investments of industrial nations in other industrial nations. They result in credits called Emission Reduction Units (ERUs).

straints, a company may decide at any point of time to issue additional shares and thus influence the stocks' liquidity.

Additionally, CO_2 emission allowances have a limited duration of validity. The value of an individual allowance expires after each commitment period. As from the first Kyoto-commitment period (2008-2012) unused allowances will be converted into allowances valid for the ensuing period, i.e. banking is allowed. However, the decision to allow for banking from the pilot period (2005-2007) into the first Kyoto-commitment period (2008-2012) is left up to the individual EU member states. In case of an intertemporal ban in banking all licenses become worthless at the end of 2007 and the environmental institutions have to issue new allowances to the companies. Allowing for an intertemporal transfer of emission allowances in general, the allowances lose their value once used for covering CO_2 emissions.

Generally, trading in commodities that have been so far unknown towards the law creates new legal effects. It is essential to assign a legal classification to the CO_2 emission allowances to ensure their smooth tradability, to eliminate the risk that divergent accounting practices will develop and to create transparency in evolving financial markets. Therefore, according to the suggestions of the International Accounting Standards Board (IASB), the EU agreed on the identification of allowances as *intangible assets*. However, the participating countries individually have to decide and then regulate by law if some trading activities with allowances (commission business, proprietary positions with others) are categorized as financial services. This will result in the need of being subject to authorization and of having obligatory supervision like trading in traditional stocks (IETA, 2005).

A different and maybe more appropriate approach in specifying CO_2 emission allowances is their consideration as a factor of production. The shortage of emission allowances by reducing the emissions cap over the allocation periods classifies the assets as 'normal' factors of production. They can be 'exhausted' for the production of CO_2 and after their redemption they are removed from the market. According to Gutenberg (1951) an allowance fulfils the typical characteristics of an *elementary factor* (Fichtner, 2004). For instance, allowances lose their productive impact after the firm has emitted the corresponding amount of CO_2. Because of their homogeneity and easy transferability, short-term variations in the purchasing process are quite unproblematic. As a stock of allowances can be divided into almost arbitrarily small amounts of units they display *divisible goods* that do not have to be transported or stored. Besides, by diversifying the production process (e.g. fuel-switching, employment of renewable energies) CO_2 can be partially substituted or even completely replaced.

Accordingly, it is more successful to compare the right to emit CO_2 with other operating materials that are directly linked to a production system than with a traditional equity share. Looking for an appropriate pricing model for CO_2 emission allowances, the obvious parallels to a factor of production motivate our idea to adopt common factor pricing models (e.g. for coal, oil electricity) instead of using typical financial stock pricing models.

3. The Price Behavior of Emission Allowances

Having gained knowledge about the particularities of the new assets, it is essential for carbon market players to learn about their price dynamics in order to realize trading strategies, risk strategies and investment decisions.

To understand the price behavior of traditional commodities like stocks, energy sources (coal, oil, natural gas) or electricity, several pricing models have been established. These models help to reduce the risk of price fluctuations and to make predictions about future price developments, see e.g. Pilipovic (1997), Schwartz (1997). So far there does not exist an appropriate model for the market of CO_2 emission allowances. Therefore, in the following we identify their key price determinants and then validate how well the resulting price dynamics can be represented by common model frameworks.

When modeling commodities' price behavior one has to distinguish between deterministic and stochastic factors. The former are mainly due to seasonalities and can be accounted for by detrending the data. On the annual level this can be done through approximation by sinusoidal functions (Pilipovic, 1997), fitting a piecewise constant function of a one year period (Bhanot, 2000) or wavelet decomposition (Simonsen 2003; Weron et al., 2004). Once the seasonal components are removed, only the stochastic part of the process remains to be explained.

3.1. Experiences from the US Market for SO_2 Allowances

The use of emissions trading as an instrument in environmental policy is largely unexplored territory in Europe. Thus, before examining the different price drivers and their potential impact on price developments, we highlight some experiences from the US emission market for SO_2 allowances. Although the US SO_2 and the European Carbon market are likely to differ in some key issues, the US experience provides important insights that help modeling the stochastic part of the price path.

Since the start of the SO_2 scheme the inter-company trading activity increased more than tenfold (PointCarbon, 2004). Explanations for the observed prices fall into two categories. They are either institutional in nature, or hinge on market fundamentals (Burtraw, 1996). From an institutional perspective, the paramount concern has been uncertainty about the policies of the Public Utility Commissions (PUCs) concerning the burden on allowance purchases. For example, the introduction of 'extra' 3.5 million allowances in Phase I affected considerably the supply side. Besides, on March 2005, the EPA issued the *Clean Air Interstate Rule* that demanded from affected entities to reduce SO_2 emissions by more than 70% from 2003 levels. These increased environmental regulations let prices augment. Market fundamentals are the other type of explanation for allowance price dynamics having to do with changes in input markets, including coal markets, rail transportation of coal, emergence of low sulphur coal, and equipment suppliers. According to Sandor (2005) high natural gas prices have been responsible for short-term price shocks as this means a switch to cheaper substitute fuels, mostly to more polluting coal.

3.2. Price Uncertainties in the EU-ETS

In order to capture and structure clearly all price driving factors for CO_2 emission allowances we provide the following general model. At first we make a rough distinction between two categories of key price determinants that is adopted from the US SO_2 market; those are (i) policy and regulatory issues, and (ii) market fundamentals that directly concern the production of CO_2 and thus demand and supply of CO_2 allowances. Thereupon we give both categories a two-dimensional specification. One specification assesses their *temporal impact* on the market liquidity and hence on prices. There can be long-term price effects that result in a change of the price-level for a significant amount of time, and short-term effects that result in an upward or a downward price jump that does not last for a long time and hence does not seriously change the average price level. The second specification of the two introduced categories distinguishes between their *predictability*, meaning how likely it is to expect some political or fundamental changes that may results in an expected or rather unexpected change of the price dynamics. As we are interested to model the stochastic pattern of a time series for allowance prices the latter possibility is of high importance. Summarizing, our model distinguishes between several types of price determinants: regulatory and fundamental issues that can be either anticipated in advance or not and that have a long-term or rather short-term impact on prices.

Applied to the carbon market, we assume the following price determinants for an appropriate pricing model: Similar to other commodity markets, such as oil, gas and power markets, decisions concerning framework conditions and operating guidelines have a key impact on market and hence price developments. In the carbon market these are decisions concerning the National Allocation Plans (NAPs) that set the reduction targets, the 'Linking Directive' that is responsible for the integration of the Project-Based Mechanisms into the EU-ETS, and the future status of the Kyoto Protocol. The so far unknown final decisions about the emission caps for the first Kyoto-commitment period (2008-2012) determined in the NAPII, the existence of a market for credits from CDM-projects after 2012 or political announcements like abandoning nuclear energy play a key role in price developments.

Monitoring price sources only from part (i), it is reasonable to assume that they have a long-term impact on prices with a rather low probability for an exact forecast. Consequently, we assume that prices will stabilize around an average price level with only slight fluctuations and mean-reversion behavior. Depending on the upcoming political information this level will be shifted either upwards or downwards where it stays for a certain period of time.

Incorporating part (ii), emission prices may also show phases of specific price behavior due to fluctuations in weather and production levels. In general, CO_2 production depends on a number of factors, such as weather data (temperature, rain fall and wind speed), fuel prices and economic growth. Among these factors weather has a double effect; firstly cold weather increases energy consumption and hence CO_2 emissions through power and heat generation. Secondly, rainfall and wind speed will affect the share of non-CO_2 power generating sources and thus the emission levels. Hence, weather can cause a swing for power producers and change their position towards their caps from short to long and back during a season. One can also think of power plant breakdowns (nuclear-, coal-fired- or hydroelectric power plants) where more emission intensive power stations have to be set up or unexpected environmental disasters (forest fire, earthquakes, etc.) that will shock the demand and supply side of CO_2 allowances. An additional fundamental price uncertainty that influences CO_2 production results from fuel spreads. A short term measure for the power and heat sector to invest in CO_2 abatement projects are coal, oil and gas prices. There is a considerable scope for switching from coal to natural gas and other CO_2-free fuels in several member states, especially Germany and Spain (PointCarbon, 2004). Finally, we argue that the second source of price uncertainty (ii), coming from quite unexpected events, has a rather short term but substantial impact on liquidity that possibly increases volatility of the allowance prices.

Recapitulating, we assume that in addition to mean-reversion behavior induced by the factors (i), spot prices for CO_2 allowances may exhibit infrequent but large jumps, due to (ii), that shock the price path temporarily. In other words, we assume to observe periods of different volatility and price behaviour for emission allowances through time. It is the challenge of an appropriate pricing model to display this price pattern that distinguishes exactly between these two periods of different volatility.

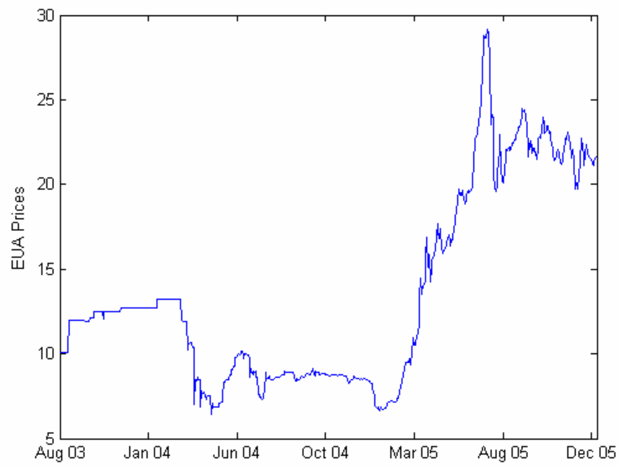

Fig. 1. Daily EUA Prices from August 27, 2003-December 30, 2005

4. Empirical Price Behavior – Preliminary Results

In Figure 1 we provide a plot of daily European Union Allowance (EUA) prices for the period of August 27, 2003-December 30, 2005. The data are provided by Spectron (2005), one of the major brokers in the energy trading industry. The operational trade with EUAs already began in 2003, before the official agreement on the EU-ETS and the preparations of the NAPs. In this 'pre-2005'-period traded volume was quite low, at some days even zero as the highest bidder price was smaller than the lowest seller price and a market price was just determined by the mean of the two figures. This period was more useful for setting up the infrastructure for the official start in 2005 than getting important market price signals (Ulreich, 2005).

Having a closer look at the slope of the time series, the key price drivers mentioned in the previous section can be verified quite well. Before the EU-parliament agreed on the introduction of the EU-ETS in July 2003, prices were quite stable around 5 Euro[1]. Directly afterwards prices started to deviate from this price level as the introduction of the EU-ETS became now reality. The first suggestions for NAPs were published at the end of 2003 and led to an increase in prices. Because of the initially generous allocations to the countries prices calmed down again between February and March 2004. After having reviewed and accepted the NAPs in the second half of the year, prices increased again and settled down around 9 Euro. As the main framework of the trading scheme has been set, the price determinants became more fundamental after January 2005 (Ulreich, 2005). The market began responding increasingly to underlying energy markets and the weather: Prices initially fell due to a quite mild climate and high supply of wind energy from Scandinavia and North

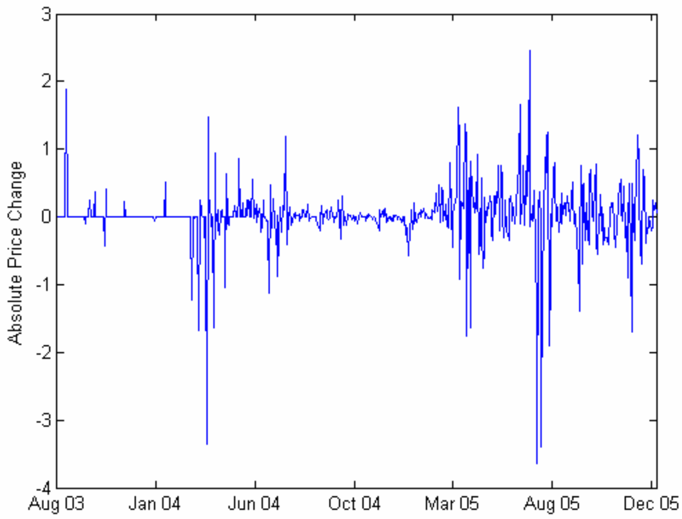

Fig. 2. Daily Absolute Price Changes of EUAs, Aug. 27, 2003-Dec. 30, 2005

Germany. At the end of January an extreme cold snap and constant high UK gas and oil prices, compared to relatively low coal prices, led to a drastically price increase (PointCarbon, 2005). This effect was boosted by an extremely dry summer in the southwest of Europe. The absence of necessary rainfall prevented full utilization of hydraulic plants, especially in Spain. Additionally, the lack of cooling water for nuclear power plants led to higher coal-fired and gas power plant utilization and therefore increased the demand for CO_2 allowances (FAZ, 2005).

[1] Note, the price behavior before August 2003 cannot be seen in Figure 1 as exact data have not been available.

We conclude that from an ex-post perspective it is possible to explain to a certain degree the price behavior of emission allowances. Also, evaluating political and regulatory issues may help to make assumptions about long-term price movements. However, events like extreme weather conditions leading to short-term price shocks or phases of high volatility are rather hard to predict and should be captured by stochastic components in a spot price model.

Figure 2 provides evidence for different regimes of volatility by looking at the daily absolute price changes of EUAs for the same period of time. Before the official start of the EU-ETS the time series displays phases of rather low price fluctuations around a constant price level induced by long-term political signals concerning the set-up of the trading scheme. However, a quite different behavior can be observed just before and during the second half of 2004 due to the mentioned discussions about the design of the NAPs. There is a significant increase in uncertainty in the carbon market and volatility of the spot prices. However, as the allocation process wear on, market prices are not anymore as much as susceptible to political decisions and stay rather constant. The two main volatility clusters of the returns after January 2005 obviously reflect the aforementioned winter and summer 2005 when an increased demand for CO_2 permits could be observed. It seems that after a period of hardly any trading activity in the beginning, there is now more liquidity and response to fundamental drivers in the market. However, the analysis also shows that facing several periods of different market behaviour more data and investigation will be necessary to determine an adequate model for emission allowances spot prices. Still, the observed phases of different volatility behavior can also be found in stock markets or electricity spot markets. In the latter the literature suggests the use of GARCH models (Escribano et al., 2002) or Markov switching models with two underlying stochastic processes: one for the rather low returns in quiet market phases and one for phases with much higher volatility and possible extreme returns (Huisman and Mahieu, 2001; Weron et al., 2004). Applying these pricing models underlines our specification of an allowance as a factor of production rather than as a traditional stock.

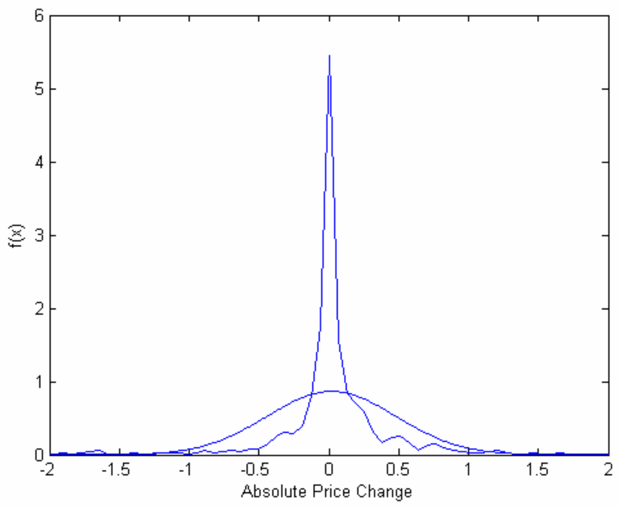

Fig. 3. Kernel Density and Fitted Normal Distribution (area [-2.2]) to Absolute Price Changes of EUA, Aug. 27, 2003-Dec. 30, 2005

While Figures 1 and 2 give a plot of the time series of spot prices and absolute returns, respectively, Figure 3 provides a plot of the empirical distribution of the absolute returns in the interval [-2,2] together with a fit of the normal distribution to the data. As it can be seen the data exhibit excess kurtosis, heavy tails and some skewness. Due to these characteristics it is evident that the normal distribution does not give a good fit to the data. To model the price changes of CO_2 allowances adequately, an alternative distribution has to be chosen. For returns of electricity spot prices, Mugele et al. (2005) show that issues like asymmetry, excess kurtosis or heavy tails can be captured adequately by the alpha-stable distribution. Regarding the additional phases of price and volatility changes through time, an even more appropriate approach may be the use of mixture models or the abovementioned GARCH or Markov switching models.

Figure 4 provides a closer look at prices for the period from June 1, 2005 to December 30, 2005 where the application of these pricing models might be a reasonable approach for modeling the observed price dynamics. For this period we find that, prices exhibit the assumed mean-reversion behaviour and tend to fluctuate around a level of approximately 22 Euro. The high price-level displays the current excess demand of EUAs. The availability of energy producing technology that is low in CO_2 emissions is still below average (BMWA, 2004). Further, the degree of integration of project-based carbon credits into the EU-ETS, that would increase the supply side, is still insecure. We also observe that despite a higher degree of trading and liquidity in the market, quite large price movements could be observed. For example, due to the aforementioned dry summer and limited use of hydraulic plants, price level moves above 28 Euro in July 2005.

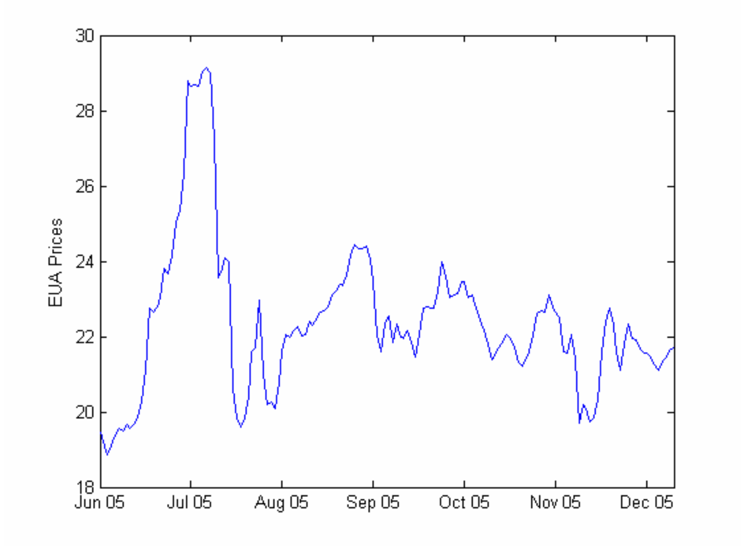

Fig. 4. Mean-Reverting Nature of EUA Prices for June 1, 2005-Dec. 30, 2005

Regarding the price and return time series, we conclude that similar to other commodity markets, for modeling CO_2 emission allowance prices advanced time series models will have to be considered in the near future. The models should not only be able to capture asymmetry, excess kurtosis or heavy tails in the data but also different phases of price behaviour, volatility clustering and price jumps or spikes.

5. Conclusion

In the context of controlling greenhouse gas emissions, the EU-wide trading system for emission allowances may be considered as a milestone in reducing environmental burden. For market participants and especially traders, also the short-term price behavior of the new asset 'CO_2 emission allowance' is of particular interest. Upon review of the stylized facts about the new good and the EU emission trading system we investigate the main sources of price uncertainty in the carbon market. Based on the characteristics of the new asset and on market experiences with SO_2 allowances we make suggestions for modeling CO_2 emission allowance spot prices. We point out that an adequate model needs a distinction between key drivers coming from (i) policy and regulatory issues, and (ii) market fundamentals affecting directly the demand and supply of CO_2 allowances. We then argue that category (i) in the long run may motivate mean-reversion price behavior whereas (ii) yields unexpected, short-term price or volatility shocks. For modeling these price assumptions and especially capturing different phases of volatility in the data, we suggest the use of GARCH or Markov switching models.

We further conduct a preliminary empirical analysis of emission allowance prices, confirming the specific price behaviour of the new asset class. Our findings are excess kurtosis, heavy tails and asymmetry in the data. We conclude that when modeling CO_2 allowances these issues should be taken into account as well.

We further find a current price-level around 22 Euro that – regarding prices below 10 Euro in the initial trading period – can be considered to be quite high. The prices may be a sign for the current excess demand of EUAs. However, according to PointCarbon (2005), in the long run the use of more innovative and efficient production technologies, the shutdown of old plants and the employment of energy efficient power plants will ensure the market clearing of EUAs. Similar behaviour could be observed in the U.S. SO_2 trading scheme, where competition among input markets and suppliers of abatement technology has led to technical innovation among the various options for abatement. Therefore, from a long-term perspective the CO_2 trading system is likely to result in improved dynamic efficiency and may reduce the cost of compliance.

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