Options Based on CO$_2$ Emissions:
A Comparison with Traditional Options

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Abstract

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Key words Black & Scholes, Certified Emission Reductions, emission markets, European Union Allowances, options, pricing

Purpose This study intends to compare traditional options with the CO₂ based instruments EUAs and CERs options in the fields of pricing, cap and trade, political influence, economical effects and market function.

Methodology A combined research methodology is used in this study, which includes both a quantitative and a qualitative approach. A deductive research approach is brought out over the whole study.

Theoretical perspectives The theoretical framework is based upon previous empirical research concerning the fields in this study. The Black & Scholes formula for option pricing has a central position.

Empirical foundation Market data has been used to analyse the field of pricing. Interviews have been conducted with actors on the European emission trading market for a further understanding of cap and trade, political influence, economical effects and market function.

Conclusions We have in this research identified that the CO₂ based market differs from the financial market when it comes to political decisions and price fluctuation. We have also identified that the CO₂ based market is not mature enough for a complete internationalisation.
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<th>Description</th>
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<tr>
<td>CER</td>
<td>Certified Emission Reductions</td>
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<tr>
<td>CO₂</td>
<td>The chemical formula for Carbon Dioxide</td>
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<td>EC</td>
<td>European Commission</td>
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<td>ECX</td>
<td>European Climate Exchange</td>
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<td>EU</td>
<td>European Union</td>
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<td>EUA</td>
<td>European Union Allowances</td>
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<tr>
<td>EU ETS</td>
<td>European Union (Greenhouse Gas) Emissions Trading Scheme</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHG</td>
<td>Greenhouse gas</td>
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<td>GNP</td>
<td>Gross National Product</td>
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<td>IET</td>
<td>International Emissions Trading</td>
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<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<td>NAP</td>
<td>National Allocation Plan</td>
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<td>OTC</td>
<td>Over the Counter</td>
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<td>SO₂</td>
<td>The chemical formula for Sulphate Dioxide</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<td>WMO</td>
<td>World Meteorological Organisation</td>
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1. Introduction

The discussion addressing whether or not options based on carbon dioxide (CO$_2$) emissions can be compared with traditional options, or if they have an economical or financial market impact, has indirectly been highlighted by numerous of researchers. Specifically, on the basis of the reviewed literature, no research that compares these environmental based types of options with traditional ones has been conducted. Hence, in this study, we will focus on how the comparison between CO$_2$ based options and traditional options can be done and why it is important to make such a comparison.

1.1 Background

Statistics from the International Energy Annual published by the US government shows that the world CO$_2$ emissions from consumption and flaring of fossil fuels rose by nearly 58 percent$^1$ during the period 1980-2006 (EIA, 2008). Between the years 1970 and 2004, the total annual anthropogenic$^2$ emissions of greenhouse gases (GHGs) rose by 70 percent. The Intergovernmental Panel on Climate Change (IPCC) stipulates that it is very likely (>90%) that most of the observed increase in global average temperatures since the mid 20$^{th}$ century are due to the increased GHG emissions (IPCC, 2007). This enumeration of the climate change could precede a lot further, but let us instead look upon some important key factors towards adaption and limitation against these changes:

- In May 1992, The United Nations Framework Convention on Climate Change (UNFCCC) opened for signature after 15 months of development. The framework convention was founded due to scientific findings in the 1960s and 1970s that showed increasing concentrations of CO$_2$ in the atmosphere (UNFCCC, 2006).
- The Kyoto Protocol was approved in December 1997 (UN, 1998).
- The European Union (EU) took action by developing the first unofficial operation period for emissions trading, the European Union (Greenhouse Gas) Emission Trading Scheme (EU ETS), commencing in January 2005 (SEA, 2009).

Within the frames of the Kyoto Protocol, three flexible mechanisms were developed in order to help the parties achieve their goal of lowering their GHG emissions (UN, 1998). In this study, we will focus on one of them, the International Emissions Trading (IET). On the basis of the IET, the most important platform or market for organised emission trading in Europe, the European Climate Exchange (ECX),

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$^1$ Own calculations with EIA’s official figures, see EIA (2008)

$^2$ Anthropogenic may be defined as *caused by humans*
was created. The environmental-related market instruments or carbon financial instruments that are traded on the ECX market today are the *European Union Allowances* (EUAs) and *Certified Emission Reductions* (CERs) options and futures contracts (ECX, 2009a). Together with traditional options, the EUAs and CERs options contracts are the foundation of this study. In particular, we will evaluate if and how these CO₂ related instruments can be compared with traditional options and why that is important.

To specify the background above, the following will address the background to the important points that are taken into consideration when comparing the two counterparts in this study:

- First of all, estimating the price and the trading path of options, regardless of the underlying value, is a difficult task, as there is often an exposure to risk. The risk notion implies a valuation concept (Murphy, 2008). Internal and external effects are something that should not be overlooked. A comparison between the financial side and the environmental-related instruments are obvious. Therefore, we have the Black & Scholes valuation concept to consider when comparing the two counterparts (Black & Scholes, 1972, 1973). We will define the model and explain how we are going to use it further on in the study.

- The emissions trading market appears a bit different when it comes to risk. The price volatility on the EU ETS has become visibly sensitive (Shapiro, 2007), as there is a certain number of allowances on the market and the market price highly depends on the supply and demand (Köppl et al, 2008). This calls for a discussion about the cap and trade-effect on the ECX, in comparison to a system without a quantity constraint (Muller, 1999).

- The emissions trading market also appears differently when it comes to the political influences from policymakers. It has to be considered that the foundation of the market is due to the climate policy drawn from the Kyoto Protocol (UN, 1998).

- Further, there is also a discussion concerning how the emissions trading scheme affects the economy in certain business sectors or industry sectors (Alberola et al, 2008, Capros & Mantzos, 2000, Reilly & Paltsev, 2005, Viguier et al, 2003 and Whittaker et al, 2003). Investment decisions by companies and the affect that the environmental-related market has on businesses may appear different compared to the traditional view.

- It is easy to say that the traditional options have a wider theoretical background and supposedly, we can say that the traditional options have a greater history than its environmental-related equivalents. For example, we can mention a publication from L.H. Bigelow & co. (1892) that talked about options over a hundred years ago. Despite these traditional aspects, the trading markets appear to be similar in regards to the various
instruments. They are traded on exchange markets and in the over the counter (OTC) market (ETX, 2009, Hull, 2008) and can therefore, to some extent, be compared concerning this market nature topic.

1.2 Problem Discussion

As we briefly described above, the discussion whether or not options based on carbon dioxide (CO\textsubscript{2}) emissions can be compared with traditional options, or if they have an economical or financial market impact, has been highlighted indirectly (Alberola et al 2008, Busch, 2006, Capros & Mantzos, 2000, Plinke, 2002, and Schröder, 2003). However, on the basis of the reviewed references and only with a few exceptions with Stronzik, 2006 as an example, no research that compares environmental-related instruments with financial instruments has been conducted.

Options make it possible to buy and sell assets in the future (Hull, 2006). The environmental-related exchanges provide this mechanism in the very same way as the emissions trading market, ECX. This market and the emissions trading mechanism has been said to be the most self-evident influence on climate change (Busch, 2006). Nonetheless, it is very interesting to question the structure and effectiveness of this new\textsuperscript{3} market, and further inquire: can the emission trading market and its assets with advantage be compared with the traditional trading with options?

The intentions within both markets naturally differ. The question that can be drawn from our research, nevertheless, is if the environmental-based market can be more efficient in the meaning that emissions can be lowered even more if the environmental-based market works in a direction closer towards the financial one. This is, however, not a question that we will answer in this study. Rather, we will examine, if we can identify differences on the two markets, and if so, in which of the five fields that we have recognised as important.

1.3 Research Question

With the background and problem discussion in mind, we have formed the following research question:

- How do the CO\textsubscript{2} based instruments, EUAs and CERs options, differ from traditional options concerning pricing, cap and trade, political influence, economical effects and market function?

\textsuperscript{3} The first official trading period started in January 2008
1.4 Purpose
This study intends to compare traditional options with the CO₂ based instruments, EUAs and CERs options, in the fields of pricing, cap and trade, political influence, economical effects and market function. The aim is to identify the differences of the markets where the instruments are traded; in order to give an understanding of these differences available for further research.

1.5 Disposition of the Research
In the first chapter of this research, we have clarified the background and the main problems concerning this research, as well as the research question and purpose of the study. In the second part, we will elucidate the theoretical methodology followed by the nucleus literature study. In part four, will the empirical methodology will be illuminated, alongside the empirical findings. The fifth part of this study contains a critical analysis of the empirical findings reviewed together with the literature framework and the purpose of the study. The last part of the study will hold a conclusion followed by suggestions for further research. There will also, for each and every major part presented, be a shorter explanation or background in order to clarify the content.

1.6 Clarifications

- With pricing, we refer to option pricing on the European Exchange Market, ECX.
- Cap and trade, in this study, concerns the profitability of having a non-existing latter for environmental-related market instruments.
- In this study, references to political influence imply the differences in the effect of policymakers on the environmental-related market and the traditional options market.
- In this research, Economical effects are a wide subject that we define as the economical effects that trading on the environmental-related market has in comparison with the traditional options market.
- In this study, we will define market structure as the nature of the market; this is how the options are traded and which rules and regulations there are for making the trading possible.
2. Methodology

In the first chapter of this thesis, we explained the background and our research question. When a valuable and relevant question is determined, it is crucial to follow a methodology, particularly, for the outcome of the study. It is important to have a straightforward and systematic approach when presenting the research and the previous theoretical framework. This chapter will explain which research theoretical methodology will be carried out, and why we consider it to be the most sufficient. The empirical methodology will be presented further in part four of this study.

2.1 Discussion of the Methodology

Jacobsen (2002) describes that the key word for research is methodology. When conducting an empirical research, regardless of the methodology, the risk of creating a result drawn from the actual research method occurs. To mitigate this problem, it is important to follow a certain structure. This is also important for the overall impression and outcome of the study. Which precise type of methodology that should be used is determined after a relevant question is fixed; the study should always start with a question (Iwasaki, 2008).

Our research question is manifold when it comes to its specific outcome, hence, it will be beneficial for us to use a more flexible research methodology. This will be further clarified by evaluating some discussions of general methodology.

2.2 Qualitative and Quantitative Research Method

Depending on the nature of the determined research question and the study’s purpose, there are first, two different research methods to consider, the qualitative and the quantitative. If there are several realities that are socially defined, we usually talk about qualitative research methods (Firestone, 1987). In the concerning research topic, relatively long statements are assembled through interviews in order to get data collected for the qualitative research. A researcher that deals with the qualitative method has to guarantee that the credibility of the collected answers is secured. The conducting of data collection should be carried out repeatedly in a defined sequence of stages (Iwasaki, 2008). Generally speaking, the advantages of using a qualitative research method are openness, high internal validity, possibility of different perspectives, closeness and flexibility. The qualitative method is therefore used when we are interested in finding clarity in a conception or phenomena (Jacobsen, 2002).

Methods that communicate that behaviour or schemes can be clarified through objective facts can be defined as quantitative research methods (Firestone, 1987). A researcher that deals with the quantitative research method has to concretise (the often indistinct and unclear) conceptions that he wants to measure, as well as form the questions as correct as possible. Generally speaking, if this
method can be easily carried out, the advantages of using a quantitative research method include, a lot of research objects, high external validity, exactness, structure and the possibility to remain distant from the research objects. The method is used when there is a good understanding about the conceptions that are considered and when there is the desire for describing a phenomena’s frequency or extent (Jacobsen, 2002).

2.3 Deductive or Inductive Approach
Within the frames of the methodology, we have two different research approaches that are used to interpret reality. The deductive and inductive research approach can be explained through the following figures drawn from Jacobsen (2002):

*Figure 1 – Deductive Research Approach (Jacobsen, 2002)*

- Interpretation level 1: The researcher has his view of reality and standardise it with for instance a questionnaire
- Interpretation level 2: The research object interpret the researcher’s questions his way
- Interpretation level 3: The researcher interpret the information that the research object has given
- Interpretation level 4: The reader of the research interpret the results his way
Jacobson (2002) further discusses that the deductive approach has been criticised due to the supposition that the researcher will only find what he is looking for. The better alternative would be a more open and open-minded inductive method. Criticism was then aimed at the advocates of the inductive means; it is impossible to approach something in a completely open-minded way. The discussions have been directed away from the traditional approaches and we are now focusing on a more open approach. Particularly, the notion that the assumption of separating the both approaches is easily done but would be deceptive to do so, is something that Saunders et al (2007) mentions.

Both of the approaches can advantageously be used in the same research or study.

2.4 Choice of Methodology

Based on the fact that the research question of this study is manifold, we have also chosen to have a combined research methodology. Our research question is based on the assumption that it is possible to compare CO₂ based options with traditional financial ones. Our presumption of specific research fields makes it ineffective to deal with an inductive research approach; hence, we have chosen a deductive one. This is illustrated throughout the entire research.

The empirical framework of this study will be based on market data, as well as interviews. Hence, in this case, we will use both a quantitative and qualitative research approach. When it comes to the question of the pricing field or the valuation model of this study, we have a good understanding of the market price, as well as earlier theoretical assumptions. Therefore, in this study, we feel it is appropriate to utilize a quantitative approach to analyze the market data. Regarding the other research fields of this study, including cap and trade, political influence, economical effects and the
market structure, the theoretical framework has not always been straightforward. This requires an openness that is not possible with the quantitative approach; hence, we have chosen to work with a qualitative approach in these sections. Preciseness is however, lost with a qualitative approach in these sections. In particular, the decisions within the process of selecting precise data can be harder to carry out.
3. **Theory**

*In the first chapter we defined the points that we consider as important when comparing the environmental-related options with the traditional financial ones, including pricing and valuation models, cap and trade, political influence, economical effects and the market structure. We will in this chapter we will develop these points more profoundly and by doing so, provide an understanding of the theoretical background.*

3.1 **Introduction, Issues and Discussions**

As we mentioned in the background, the comparison between options based on CO₂ emissions and traditional options have only been highlighted indirectly. Hence, the theoretical background with its discussion has not always been straightforward. However, in the theoretical part we will develop (or “expand upon”) discussions that are relevant for our study. The relevant issues discussed are the commencing and development of the EU ETS and the CO₂ emission allowances, as well as the valuable points regarding traditional options. These issues will be stressed in order to clarify the incentives that we cope with on an emission trading market and hence why and how the market was intended to develop.

This study will stress (or “focus on”) a comparison view, and in order to share an analysis over the price fluctuations and other difficulties that both markets cope with, we will also emphasise valuation models that have been discussed by authors and researchers over time. The risk aspects for both the environmental-related market and the traditional one are also vital; both in regards to concern over fluctuations on respectively market as well as political influence.

3.2 **Development of the Convention and the IET**

If we regard the purpose of this study and the identification of differences on the environmental-based and financial market, it is important to understand the principle background for the environmental-based market. Specifically, the development of the CO₂ based market in this study, has its starting point in 1988, when the IPCC was founded under the support of the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO). Since the start, the mandate of the IPCC has been to provide policymakers, for instance the European Commission, with scientific technical and socio-economic information from an objective point of view (IPCC, 2009).

In May 1992, the UNFCCC was opened for signature after 15 months of development. The framework convention was founded due to scientific findings in the 1960s and 1970s that showed increasing concentrations of CO₂ in the atmosphere, as well as the establishment of the IPCC and their first assessment report in 1990 (UNFCCC, 2004, 2006). After the IPCC’s second assessment report in 1996, that stated that there was a human influence on both the human and economic development, the
Kyoto Protocol was approved in December 1997.

Within the frames of the Kyoto Protocol there are three flexibility mechanisms or Kyoto mechanisms. These instruments allow the member parties to achieve their undertaking of lowering their overall GHG emissions by at least five percent below 1990 levels within the commitment period 2008 to 2012 (UN, 1998). One of the mechanisms refers to International Emissions Trading (IET). The organisation and definition of the emissions trading should, according to the Kyoto Protocol (UN, 1998), be decided by the conference of the parties, this including relevant principles and especially rules for verification and accountability. For the parties’ undertaking of lowering their emissions, the parties included in Annex B4 may partake in the emissions trading. The emissions trading mechanism has been mentioned as the most recognizable influence on climate change (Busch, 2006).

3.3 The EU ETS, Price Development of Emission Allowances and the European Climate Exchange

*The establishment of the EU ETS made a structured and organised emission allowances trading scheme possible. In this part of chapter three, we will provide an understanding about this scheme. Further, we will look upon the price development of emission allowances as well as the structure of the European Climate Exchange, where emission allowances are traded.*

3.3.1 EU ETS 2005-2007

In the beginning of January 2005, the EU ETS started their operations, which were the largest, and covered most sectors in a world-wide GHG trading scheme. EU ETS is based on Directive 2003/87/EC of the European Parliament, which obtained legal force on the 25th of October 2003. During the first period of emission trading, 30-50% of all the trading with GHG emissions in the member states were covered by the EU ETS, and approximately 12 000 companies were involved (Köppl et al, 2008).

The first period ran over three years until the end of 2007 which were categorised as a training period for the crucial second period which started in January 2008. The lessons learned from the first period were implemented in the second trading period so that the targeted goals from the Kyoto Protocol shall be achieved. This goal involves reducing the CO$_2$ emission in the European member states by 8% compared to the quantity of CO$_2$ emission in 1990 (EC, 2008c).

The installations that are required to take part in the EU ETS are the ones with a turnover of more than 20 Mega Watt (MW) per year. The installations that do not extend this level are not forced to partake, but have the opportunity to be included voluntarily. The industries that are required to participate in the EU ETS are the ones that have a production or are an industry of the following

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4 Industrialised countries with GHG-emissions limitation or a reduction commitment, defined in the Kyoto Protocol (UN, 1998).
categories; combustion plants, oil refineries, coke ovens, iron and steel plants, factories making cement, glass, lime, bricks, ceramic, pulp and paper (Köppl et al, 2008).

All member states included in the EU ETS were obliged to provide the European Commission (EC) with a National Allocation Plan (NAP) and to decide the extent of their own emission cap. The total volume of all member states emission caps determine the market for CO$_2$ allowance. The member states NAPs had to be approved by the EC, so that the NAPs met the guidelines that were provided by the EC. The total volume for each country should be consistent with the underlying Kyoto Protocol target (EC 2008c). When the NAPs have been approved by the EC, each member state allocates their approved allowances to the individual installations within the nation. The allocated allowances for the first emission trading period were in general, free of charge (Köppl et al, 2008).

3.3.2 Price Development under the EU ETS 2005-2007 and Expected Price Development

The intended effect of the introduction of emission trading was to establish a price on CO$_2$. The price of CO$_2$ is dependent on the fluctuation of the existing allowances on the market. This meaning that the price will increase if there is an overall short position occurring on the market or vice versa. This occurs if installations are in need of buying allowances to not exceed their allocation. From the start of the first trading period, EC issued more allowances than what was necessary for the installations; this lead to an overall long position on the market. In a situation such as this, one a low or even a zero price on CO$_2$ can be expected (Köppl et al, 2008).

During the start of the first trading period the prices on allowances were high for the duration of 2005 until the first quarter of 2006, when it reached its maximum price at €30,5 per ton of CO$_2$ in April 2006. This phenomenon was mainly due to the fact that the power sector started to purchase allowances so that they would not exceed their allocation. However, the installations that made additional allowances were not ready to sell, which made the price rise to a high level. This was revealed when the verified emission for year 2005 was published in the spring of 2006 (Köppl et al, 2008). From this publication, the participants could see that the market was in an overall long position with a surplus of 4%, causing a sharp decline in the price to €12 per ton CO$_2$ in the autumn of 2006 (Alberola et al, 2008). The price kept on falling due to the verified emission of year 2006 which was published in spring 2007. It was revealed that the market was still in a long position, causing even further decreases in price. In the end of the first period, the spot price ended at €0,02 per ton CO$_2$ (Köppl et al, 2008).
Under the second first official period, which started in April 2008, we have seen a more stable price variation on the CO$_2$ emission allowances; however, the ECX indices show a persistent price fall. The first price was set to €22.40 per ton CO$_2$. Since then, the price has fallen to around half, €11.45 per ton CO$_2$.

Note that we have chosen to label the horizontal axle with Time Period; this in order to raise the understanding concerning the fluctuation over the period rather than to highlight a specific price or rate at a certain date.
During the last decade, different price estimating models for CO$_2$ emissions have been brought forward. In these models the estimated prices range from $3 to $70; hence, it is very difficult to forecast the price development on this market. A lot of different factors have an impact on the price development, including transaction costs, limited sectoral coverage of an emission trading system, as well as unexpected political and economical development. However, the permit price for tradable GHG emission permits is expected to be lower than $10 per ton of CO$_2$ in 2010. The price highly depends on whether the United States will fully join the Kyoto Protocol and by doing so creating a wholly international based market. In macro-economical terms, it is also estimated that the law of one price will not apply to the CO$_2$ emission trading market. We might also see price differences from region to region or from nation to nation due to different or stricter regulations within the region or nation (Springer & Varilek, 2004).

### 3.3.3 The European Climate Exchange

The most important platform for organised emission trading in Europe is the European Climate Exchange (ECX). ECX is a member of the Climate Exchange Plc that also includes the Chicago Climate Exchange, which is the most important North American trading system for GHGs (ECX, 2009a, CCX, 2009). As mentioned above, the EU ETS began in the beginning of 2005 and the trading on the ECX started in April of the very same year. The environmental-related market instruments or carbon financial instruments that are traded on the ECX market today are EUAs and CERs futures and options contracts. The trading started with EUAs and followed with CERs options and futures in 2008 at the start of the second trading period (ECX, 2009a).

There is, according to an ECON (2006) report commissioned by the Nordic Council of Ministers a need for this type of gathered European market. Particularly, in 2006 there were seven member states without a national emission trading scheme. A central part of the emission trading is this national registry.

### 3.4 Traditional Options and Risks

*This part of chapter three will stress the second foil of this study: traditional options. Here, we will provide the basic understanding concerning the contract as well as a brief introduction to the risk aspects that cannot be overlooked.*

### 3.4.1 Traditional Options

The traditional options trading market, has been earlier mentioned in this study, a much longer tradition. The structure of this market has been formed over numerous of decades and it has an economical motivation rather than one developed through parliamentary policies.
When trading with options, you are able to trade on an exchange or on the OTC market (Hull, 2008). If that person owns an option it gives that person the right, but not the obligation to buy or sell (exercise) the underlying asset (Smith, 1996). If that person buys an option he assumes the long position of the option, or if that person sells his option he takes a short position. When a person buys an option he pays a premium to the seller. The premium is described as the price of the option.

The buyer of an option has the choice to exercise his option, which means that you want to exercise the actual terms of the option. For example, you own one June call on IBM with a strike price of €80. This gives you the right, but not the obligation, to buy 100 shares of IBM at €80 per share. You are able to exercise the June call anytime prior to the expiration date in June (American option). On the other hand, the seller of an option has no right to exercise; he must wait until the buyer wants to exercise and then the seller is obliged to sell 100 shares of IBM at the price of €80 per share (Smith, 1996).

There are two different types of options. American options can be exercised prior to the expiration date. These options were applied in the previous example. Secondly, we have European options, which can only be exercised on the expiration date (Hull, 2008).

In the option market, there are two basic types: call and put. A call option gives the buyer the option to buy the underlying asset. The buyer of a call option expects the price to increase to make a profit, and in case it does not increase, the buyer will not exercise his call and then lose the initial investment (premium), while the seller of the call hopes that the price will decline or at least stay stable. The buyer of a put option has the right, but not the obligation, to sell the underlying asset of the put. However, the put option buyer expects the price to decline to make a profit, and if the price does not decline under the period of the put option, the put will expire worthless and lose the premium, while the seller hopes for increasing or a stable price (Smith, 1996, Hull, 2008).

To describe an option’s payoff or the value of the call option at expiration, we will use an example from Berk & DeMarzo (2007, p.659-660); figure 5 below shows that example. The call will be exercised if we have a price of a stock that exceeds the strike price. The payoff for the holder will be the diversity between the stock and strike price. The call option will not be exercised if the opposing situation occurs, if we have a lower stock price than the strike price.
This can mathematically be described as;

\[ C = \max(S - K, 0) \]

where;
- \( C \) is the market value of the call option;
- \( \max \) is the maximum of the two quantities in the parentheses;
- \( S \) is the price of the underlying security;
- \( K \) is the exercise price.

The value of the call option is the \( \max \) of the variation between \( S - K \), and zero.

If we consider a put option it slightly varies from the call. The owner of a put option will exercise it when the stock price is below the strike price.

This can mathematically be described as;

\[ P = \max(K - S, 0) \]

The owner will receive the strike price value when the stock is worth its price, the stock price. The return is thereby the same as \( K - S \).
3.4.2 Risk and Risk Aspects on the Markets

Murphy (2008) defines risk as “the danger of loss”. Predicting the price and the trading path of options regardless the underlying value is a difficult task; there is often an exposure to risk. On the environmental-related market and the financial market we have several risks to consider but we have chosen to review a few that go along with this study, including market risk, credit risk, operational risk, price volatility and political influence.

- Assets on a market fluctuate; the prices change and a comprehensive understanding of market risk can thus be the loss based on these price fluctuations.
- Volatility is also something that can come in mind when speaking of market risk; as prices on the market do not solely depend on the market structure, but also the volatilities.
- Credit risk, however, is the loss when we expect a future positive cash-flow but there is a risk that the counterparty does not fulfil its obligations; credit risk refers to the risk of non-performance on contractual engagements.
- Operational risk depends on the influence of internal processes, people, systems or external events.

All of these points above are risk aspects that are influencing both the environmental-related market and the financial one. Another risk aspect that also will be described further in this chapter is the political influence on the environmental-based market. The distinguished agreements of the Kyoto Protocol were solely political (Zhang, 1998), and future political decisions will influence this market in a greater way than the financial one. Finally, there are also other views to consider when it comes to the environmental-based side and risk, and this is something that we also want to stress with the outcome of this study. Baldursson & von der Fehr (2004), for example, discuss the efficiency of a market based environmental policy. They ground their meanings on the assumption that the behaviour of firms will vary under uncertainty and risk-aversion.
3.5 Pricing, Valuation and Mathematical Terms

As discussed above, in order to cope with the risk notion and “the danger of loss”, we have to estimate a certain future price of an asset. Regardless of the underlying asset, the price estimation is vital for investors. In this part of chapter three, we will supply the discussion regarding pricing of emission allowances, options, as well as an understanding concerning the valuation models and mathematical terms used in this study.

3.5.1 Pricing of Emission Allowances

As an example of a valuation model for estimating the price of emission allowances, we can mention a valuation model for emission allowances that was created by Coggins & Swinton in the mid 1990s. This model was based upon the US Acid Rain Program and Sulphur Dioxide (SO$_2$) emissions. With the valuation model, Coggins & Swinton estimated an even handed price based upon the reasoning that the value of one allowance should be equivalent to the marginal cost of achieving the last unit of SO$_2$ abatement at balance (Coggins & Swinton, 1996).

Later estimations of allowance prices (as discussed above in 3.3.2) based upon CO$_2$ have not been as tangible; estimating the future price of emission allowances is difficult. The price depends on many different factors including transaction costs, limited sectoral coverage of an emission trading system, unexpected political and economical development, as well as the large impact that United States have had with their withdrawal from the Kyoto Protocol (Springer & Varilek, 2004, Springer, 2003). This is also something that cannot be overlooked when concerning the research question of this study. When pricing traditional options, we have various models to imply but when it comes to the environmental-based market, the factors involved in the pricing makes it much more difficult. Springer (2003) also mentions that an emission allowances trading market that might be diverged and complicated needs more attention in future studies.

During the whole period, the settlement price of the environmental based EUAs and CERs options has been fairly stable. The two figures below display the settlement price of respectively instrument during their complete trading period until March 2009 (observe that the trading period’s span is not equal):

---

6 US SO$_2$ based emission allowance trading scheme
3.5.2 Options Pricing

As mentioned in the previous section of this study, there is a greater difficulty to find a valuable pricing model for CO₂ based options than to find it for traditional options. Despite these difficulties, we have chosen to employ a traditional pricing model for options for the CO₂ instruments as well. This is carried out in order to make it possible to make a comparison regarding the field of pricing in our research question.
Traders and analytics have, through time, used the Black & Scholes model in order to estimate the future value of options. The Black & Scholes model helps to determine the value of a European call and put option that has a non-dividend stock derived. The model explains how volatility can be either estimated from historical data or implied from option pricing (Hull, 2008). To be able to use the Black & Scholes formula, there are some variables which have to be applied in the model which are: current market value of the underlying share, the strike price, the time to maturity of the contract and the risk-free rate of interest. All of these variables have to be present in the model to give as accurate a valuation as possible (Stern & Chew, 2003).

When, for example, the stock price takes an extreme value, for instance becomes very large, the call option will, with a high certainty, be exercised. When this occurs, the call option has many similarities to a forward contract. Also, when the stock price becomes very large the price of the put option approaches zero (Hull, 2008).

3.5.3 The Black & Scholes Valuation Model

The Black & Scholes formula is a model, which is used to value the price of European call options. The option price in the formula depends on a various number of variables, which has to be taken in to consideration, including market value of the underlying share, the strike price, the time to maturity of the contract and the risk-free rate of interest (Stern & Chew, 2003). It is in the valuation formula supposed that the distribution of the stock price is lognormal, that the short-term interest rate is constant through time (Black & Scholes, 1973).

The formula is specified;

\[ d_1 = \frac{\ln(S_0) + (r + \frac{\sigma^2}{2})\tau}{\sigma\sqrt{\tau}}; \quad d_2 = d_1 - \sigma\sqrt{\tau} \]

\[ d_2 = \frac{\ln(S_0) + (r + \frac{\sigma^2}{2})\tau}{\sigma\sqrt{\tau}} = d_1 - \sigma\sqrt{\tau} \]

\[ C = S_0 \cdot N(d_1) - Ke^{-r\tau}N(d_2) \]

\[ P = Ke^{-r\tau}N(-d_2) - S_0N(-d_1) \]
where;

$C$ is the market value of the call option;

$P$ is the market value of the put option;

$S$ is the price of the underlying security;

$K$ is the exercise price;

$\tau$ is the time until the option expire;

$r$ is the short-term interest rate which is continuous and constant through time;

$\sigma$ is the variance rate of return for the underlying security, also entitled volatility;

$N(d_i)$ is the cumulative normal density function evaluated at $d_i$.

In the model it is also assumed that the owner of the underlying security does not pay cash distribution, as well as that there is no transaction costs connected to either the buyer or the seller of the option respectively the underlying security (Black & Scholes, 1973, Macbeth and Merville, 1979).

3.5.4 In the Money, Out of the Money and At the Money

In the money, out of the money and at the money are three situations that are mentioned when we compare the strike price of an option with the current market price of the very same. The situation in the money means that the strike price is below the current market price for a call option and above the current market price for a put option. For out of the money we have the reverse state, the strike price is above the current market price for a call option and below the current market price for a put option. The third situation, at the money, means that the strike price and the current market price are equal to each other (Marc, 1998, Berk & DeMarzo, 2007).

3.5.5 Bank Rate

Bank rate is also referred to as the discount rate, the bank interest rate which the central bank charges on the loans given to the commercial banks and other financial institutions. The bank rate is also defined as a risk-free interest rate, which means that banks are able to loan money over a short period of time without risk (Berk & DeMarzo, 2007). Adjustments done to the bank rate are often implemented to control the money supply in the country.

The bank rate has been lowered by the Bank of England numerous times in last years from 5,75% all the way to 0,50% (Bank of England, 2009).
We have chosen to use the bank rate from the Bank of England as the interest rate in our calculations due to that the ECX market is located in England. We have also implemented the changes done to the bank rate in our calculations.

3.6 Volatility
When using the Black & Scholes formula all variables except the volatility are directly observable. There are two strategies how to uncover the value of the volatility. The first and more direct used strategy is to use historical data, which means that you use already know variables. The second and more complicated strategy to use is the approach, which is called “back out” the volatility by using the Black & Scholes formula. This approach is also called as the implied volatility (Berk & DeMarzo 2007).

3.6.1 Normal Distribution
The probability or chance that a general dispersed random variable will employ a value less than $d$ is referred to as normal distribution or the cumulative normal distribution, $N(d)$. In the figure below, the cumulative normal distribution is displayed as the shaded/blue field to the left of $d$. $N(d)$ employs a value between 0 and 1 due to its probability notion (Berk & Demarzo, 2007, Hull, 2008).
To calculate the value of \( N(d) \) you can advantageous use the Microsoft® Excel function NORMSDIST(d), this form of calculation method is also used in this study.

### 3.6.2 Standard Deviation

The statistical indicator of standard deviation is one of the most frequently used tools to examine the risk attached to any asset. On the whole, the indicator shows the dispersion around the expected value (Stoltz & Viljoen, 2007). We have in this study used the standard deviation to decide the disparity or the amount of scattering when analysing the EUA and CER Options, concerning both calls and puts, with the Black & Scholes formula. We have also here used a Microsoft® Excel function, STDEVP (number 1, number 2, ...) for the yearly population and STDEV (number 1, number 2, ...) for the sample population by quarter of a year in order to simplify the calculation process.

The mathematical formula for standard deviation used in this study is as follows;

\[
\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{n} (k_i - \bar{k})^2}
\]

Where;

- \( k \) is the average (number 1, number 2, ...)
- \( n \) is the number of values \( k \) in the total population
3.7 Cap and Trade and Political Influence

The political influence and the discussion concerning whether a cap and trade system is the most efficient when it comes to emission trading are both important factors in our comparison. Hence, in this part of chapter three, we will provide some aspects concerning these discussions.

3.7.1 Cap and Trade

The underlying policy of the Kyoto Protocol is to lower GHG emissions (UN, 1998); a cap and trade system like the EU ETS allows the parties to fulfil that requirement. The short run implications and the effect over time of a cap and trade system with the purpose of lowering GHG emissions have, among others, been discussed by Stavins (2008a, 2008b) and Buckley (2004). Both Stavins and Buckley mean that a cap and trade system for lowering GHG emissions is feasible in the short to medium term. An efficient and cost reductive cap and trade market can only be implemented when it is straightforward and does not consist of constraints that can complicate the trading for the actors involved.

A study on a similar emission trading scheme has shown that firms will not generate trade if the arranged amount of emission ratios are set to the same level as the current ratios. However, when this is combined with a cap and trade system the emission trading scheme will expand and the supply of the emissions becomes more effective at the same time as the prices falls (Muller, 1999).

On the financial market, a popular interest rate option in the OTC market is a so-called interest rate cap. Insurance in opposition to the rate of interest on the floating rate note rising above a certain level, the cap rate, is provided by the interest rate caps (Hull, 2006).

3.7.2 Political Influence

It is obvious that the political influence on the emissions trading side is greater than on the financial market; the distinguished agreements of the Kyoto Protocol were solely political (Zhang, 1998). The climate policy with its IET mechanism of the Kyoto Protocol is formed to lower GHG emissions, the incentives on the financial markets can generally not be the same, and changes on the emissions trading markets are highly influenced by policymakers. As an example we have the discussion whereas the EU should introduce a sector-wide, company level emission trading market where the incentive is the possibility to monitor emissions and guarantee fulfilment (EC, 2008b). However, these types of international schemes will take years to set up and a more loose regulation system can be necessary to affect the behaviour of consumers and businesses (Zhang, 1998).

On the financial market there is a regulation system that provides the market with structure and a frame of laws on how the trade should be done, while the rest is up to the market itself (Hull, 2008).
On the climate exchange the market also takes its own path but the incentive of the trading is the lowering of GHG emissions.

3.7.3 Economical Effects

*There are a lot of different aspects of economical effects, both when speaking about environmental-related instruments as well as financial instruments. Here, we are going to highlight a few discussions regarding the EU ETS effects on the economy and finance.*

3.7.4 Economical Effects of a European Emission Trading Scheme

First, we will show the extensive role of the eco-industry as an example of the economical effects of the environmental sectors overall in the EU. The so-called eco-industry in the EU has grown to be one of the biggest industrial sectors. As the chart below shows, the annual turnover of the eco-industry accounted for 2.2% of EU's total Gross Domestic Product (GDP) in the year of 2004. The two foremost industry sectors, resource management and pollution management, refer to technologies and services in waste management, air pollution control, soil remediation, and recycling as well as renewable energy plants and water supply (EC, 2007).

*Figure 14 – Total turnover by Member State (ECON, 2006)*

On the EU and EU ETS level we have a wide economical effect. The EU ETS covers over 11,500 energy-intensive installations according to the EC (2007); these installations are covering just about half of the CO₂ emissions in the EU. The EC further claims that the annual costs of achieving the undertaking targets of the Kyoto Protocol are estimated to be €2.9 to €3.7 billions, about 0.1% of the EU’s GDP. The welfare cost of meeting the targets differs between the different EU member parties. Without trading it has been estimated to 0.6% to 5% and according to Viguier et al (2003) is...
the unfavourable effect on the Gross National Product (GNP) in most of the EU countries limited by favourable terms of the trade.

On a local business level, the emission trading and the EU ETS have generated a future of business opportunities. However some of the actors on the financial markets are not aware of the negative or positive impacts that the future will bring (Busch, 2006). For the more energy intensive companies a new input factor for CO₂ emissions have been created. Even though that the energy sector is responsible for the largest amount of CO₂ emissions, is the industry sector also under supervision. (Fichtner, 2006).

3.7.5 Future Economical Effects

With the underlying commitments in the Kyoto Protocol the expected amount of CO₂ emissions are expected to fall until 2020 in most sectors in Europe (Viguier et al, 2003).

*Figure 15 – CO₂ emissions by sector in Europe, scenario (% of total emissions) (Viguier et al, 2003)*

However the adaptation towards new technology and change in attitude will create new sectors and change whole societies. An example of this can be drawn from the two foremost cities in Scandinavia, Stockholm and Copenhagen, where so called clean tech clusters have been created in order to develop the sector within the city regions (Stockholm Business Region, 2009, Copenhagen Capacity, 2009). It is also estimated that the net welfare gain of the trading is positive in most of the participating countries and the gains with inter-sectoral trading have an optimistic potential (Betz & Sato, 2006).
The first EU ETS period carried out an establishment of a necessary infrastructure for monitoring, reporting and verification of the emission trading (EC, 2008a). The second trading period has a different prospect in several dimensions, a better understanding of how the scheme should work and are working and the necessities are implemented and both the economical and underlying emission reduction prospects are wider than from the start of the first, unofficial period.

3.8 Market Nature
As earlier mentioned in the first chapter of this study the EUAs and CERs are traded on the European Climate Exchange. When it comes to the financial side we both talk about an exchange and an OTC market. This is something that we will provide a brief understanding about in this part of chapter 3.

3.8.1 The Exchange Market

The environmental-based carbon trading market ECX, which is concerned in this study, had an estimated total value of €92bn or $125bn in 2008. Some 100 global businesses are involved in the ECX in order to participate in the emission allowances trading (ECX, 2009a). The whole EU ETS covers around 45% of total CO₂ emissions and is the largest carbon trading scheme in the world, and the ECX the largest trading market (Betz & Sato, 2006).

Besides the hard facts there is also another discussion concerning the market participators’ walk on the allowance market or the EU ETS; they may not have a rational behaviour. The emissions are viewed as an opportunity cost when installations or operators at occasions strive to sell unused allowances in the market. Economically it would be irrational to not account for real opportunity costs (NERA, 2007).

Traditional options have a longer history when it comes to exchange trading markets, in order to bring farmers and merchants together were the Chicago Board of Trade (CBOT) founded in 1848. The popularity of options has proved to be vast and a lot of exchange markets around the world are trading the instrument in addition to other instruments as futures (Hull, 2008).

3.8.2 Over the Counter Market
When trading on the over the counter market (OTC), the trades are made either over the phone or via computer, which means that there are no physical trading floor only an electronic network. Trades which are made on the OTC are most often between two financial institutions or one financial institution and one of their clients. The traders in the OTC market are always prepared to quote both bid (price prepared to buy) and offer price (price prepared to sell). Participants on the OTC market are free to trade with anyone on the market and they are able to negotiate any mutually attractive deal (Hull, 2008).
The stocks or bonds that are traded on the OTC market have often an inability to meet listing requirements. Their inability can depend on that their stock is considered too risky to be traded on a major exchange, due to that fact that the stock are not large or stable enough. For example, there is a small risk that the contract will not be honoured. On the other hand this cannot appear on an exchange because they have organized the trading to eliminate virtually all credit risks (Hull, 2008).
4. Empirical Methodology and Analysis

In part 4 we will stress the specific methodology that we have chosen to use when analysing the market data and the interview results, as well as an analysis of the empirical results. We will together with the research question and the theoretical ideas from the previous part provide this in relevant means in order to provide an understanding of our findings.

4.1 Empirical Methodology

Jacobsen (2002) provides a solid argumentation for how the empirical methodology should be conducted, and since we have chosen a double research approach including the quantitative and qualitative approach we have also chosen to use a varied empirical methodology in order to meet the diversified nature of our research question. Jacobsen’s (2002) empirical methodology includes the selection process, gathering of empirical data, analysis approach, empirical analysis, reduction analysis, validity and reliability and we will in this chapter clarify each of these parts together with our implemented findings and theoretical framework.

4.2 Selection Process

As mentioned earlier, there have been no specific researches done within the nature of our research question. The discussions that have been brought forward around the EU ETS have mostly covered the environmental improvement effects and the affect on specific business sectors. We have as a result chosen to build a theoretical background on our fields of study, the environmental-related options and the traditional financial ones. Within the frames of this theoretical background there are some methods that we are going to use upon the market data. As discussed in the first chapter of this study the environmental-related market instruments or carbon financial instruments that are traded on the ECX market today are EUAs and CERs futures and options contracts (ECX, 2009a). The trades of these instruments are registered and by a ten minutes delay communicated as market data. The market data shows trade information, different components and incidental evidences including prices, volumes, exchange for physical, exchange for swap and open interest (ECX, 2009b). This is also roughly the same when it comes to traditional financial futures and options with a minor disparity in the information that is given. According to Jacobsen (2002) we are dealing with different kinds of criteria when it comes to how we should gather the empirical data and with a market data analysis we can avoid some of these difficulties including costs, swiftness and answer frequency.

When it comes to the interviews conducted in this research we aimed towards a base of interview subjects that possessed a great deal of knowledge concerning the tangible topic. This can be called the information approach according to Jacobsen (2002).
4.3 Operationalisation

We will in this section briefly describe how we use the theoretical concepts and formulas to get an understanding of our findings.

4.3.1 Market Data Analysis

The trading with environmental based instruments on the ECX market started in April 2005. However the price indices, as well as the statistics over the instruments traded, that are presented as market data by ECX are related to the first of January 2006. The market data gives extensive information concerning the components that we will need when implementing the market data with the Black & Scholes formula including the market value of the put option, the price of the underlying security, the exercise price, and the variance rate of return for the underlying security. However, in order to use the Black & Scholes formula to its full extent we had to estimate the time until the option expires in years as well as the short-term interest rate. For the time until expiration we were given the total amount of trading days by the trading scheme for the ECX (2009c). Thereby we could together with the date to expiration calculate the time until the option expires in terms of years in order with the Black & Scholes formula. This was done by a monthly extinction in order to standardise the variable as well as to make it easier for us to implement the variable in to our calculations. For the short-term interest rate we used, as earlier mentioned in part three, the official bank rate of England. We adopted the rate by fluctuation over time in order to obtain a put and call option price as accurate as possible.

After using the Black & Scholes formula for \( d \) we further needed to determine the value of \( N(d) \). This we did by using the Microsoft® Excel function NORMSDIST\( (d) \). Then we had all the variables needed to prospect the call and put option prices. We will in the appendices provide complete graphs that show the fluctuations of our estimated put and call options prices.

As described in section 3.5.6, there are two approaches used to determine the volatility. The first and more direct employed strategy is to use historical data, which means that you use already know variables. This strategy is the one we connected to our study. The market data provided by ECX revealed the implied volatility and in order to determine an option price as accurate as possible we used this market-based volatility (ECX, 2009e) in our calculations.

Further we also conducted a divergence index in terms of percent where we wanted to bring theoretical evidence together with our research’s purpose forward. The directory basically shows if the call or put value is positive or negative in comparison with the settlement price. This will be discussed further in the section on empirical results as well as the discussion of the latter.
In addition to the divergence index we use a standard deviation analysis. We have, as earlier mentioned in this study used the standard deviation to decide the disparity or the amount of scattering when analysing the EUA and CER Options, concerning both calls and puts, with the Black & Scholes formula.

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4.3.2 Open Interview

During several occasions in this study we have pointed out that the theoretical background concerning the comparison between environmental based instruments and traditional options is
limited. Generally, the qualitative approach is suitable when we want to research what a phenomenon contains and when there is little or no information concerning the topic, more specific, an open interview approach is suitable when we have few research objects and we want to observe the individual’s belief. The open interview can be costly, a physical movement is often required, and in order to circumvent this problem we have chosen to conduct interviews via telephone. This type of interview can also help to avoid the so called *interviewer effect*\(^7\) which correlates to that the present of the interviewer may affect the object in an unwanted way (Jacobsen, 2002).

We will further in this chapter describe the approach which we are going to use when analysing the interview findings, however, we can also mention that the persons we have conducted our interviews with are working in different fields of the emission markets. The interviewees include traders and analysts on the EUAs and CERs market, as well as one person employed as the Director for Market Development at the ECX in London in addition to one employed as the Chief of the Climate Unit at the Swedish Environmental Protection Agency.

### 4.4 Analysis Approach and Model

Within the frames of our study and as shown above we have chosen to include both a qualitative and quantitative research approach, as this allows us to use a wider analysis approach. Within the area of pricing we will present the empirical results with a classification approach and within the other four matters analysed in this study including cap and trade, political influence, economical effects and market function we will use a more descriptive approach.

#### 4.4.1 Classification Approach

Concerning the pricing comparison in this study we have as earlier mentioned chosen to use the Black & Scholes formula to valuate the option price (Black & Scholes, 1973). We will use this model to standardise the market data from the environmental based trading market ECX (ECX, 2009d) in order to find similarities or dissimilarities with the traditional and options market. Thus, we are questioning whereas the pricing of traditional options also can be understood with environmental based options and with this means we seek to carry out an effective analysis that includes an extensive number of units (Jacobsen, 2002). We have also chosen, in addition to the latter to include the R-squared value, this in order to see how well the model fits the data. We will together with the theoretical framework and the major findings in the next chapter analyse the outcome of our study based on this approach.

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\(^7\) Established by Groves & Kahn (1979)
4.4.2 Descriptive Approach

The unexplored nature of our topic requires us to develop a model that allows a valid interpretation of the empirical findings. With this model we can analyse the disparities between the environmental based market and the traditional trading market:

*Figure 16 — Descriptive Approach (Kristiansson & Nilsson, 2009)*

In this study we seek to find answers to how the CO₂ based emission trading market are different from the traditional options trading market. Within the frames of the descriptive approach model, we will define what we are seeking in every field in question including cap and trade, political influence, economical effects and market function. In the same way as the classification model, that will be used to analyse the quantitative base, we will use the description model to analyse the outcome of the qualitative data.
4.5 Empirical Results

We will in this section of the research first provide how we have chosen to standardise the results from the Black & Scholes model on option pricing and the ECX market data analysis. We will provide this with different figures with some reflections on containment. We will also in addition to the latter imply the standard deviation to reflect on the fluctuations on the market. Secondly, we have the interview standardisation where we in this section will mention the most relevant aspects concerning the research question if the CO$_2$ based market differs to the financial counterpart.

4.5.1 Market Data Results

All of the findings brought forward are based on the estimations we have done by using the Black & Scholes model. Figure 16 below shows us the divergence in terms of percentage between the settlement price and the EUA and CER options, this for calls respectively puts, for each quarter of the year as well as the total over the year. The call option buyer expects the price to rise in order to make a profit and the put option buyer expects the price to decline to make a profit (Hull, 2008). Thus would the expected divergence be a positive value for the calls and a negative number for the puts. The result shows us that this is not always the case for the environmental-based market.

On the right hand side for EUA options contract respectively CER options contract we see that the divergence for calls are always positive. However, on the left hand side we see that the divergence for puts starts out as negative and then turn to positive in the third quarter of 2008 for EUAs and the third quarter of 2008 with one exception for CERs.
### Figure 17 – Divergence for Calls and Puts (%)

<table>
<thead>
<tr>
<th></th>
<th>EUA Options Contract</th>
<th>CER Options Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Divergence for Calls</td>
<td>Divergence for Puts</td>
</tr>
<tr>
<td>2006</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Q1</td>
<td>7,15%</td>
<td>-20,2%</td>
</tr>
<tr>
<td>Q2</td>
<td>19,3%</td>
<td>-17,4%</td>
</tr>
<tr>
<td>Q3</td>
<td>32,4%</td>
<td>-14,2%</td>
</tr>
<tr>
<td>Q4</td>
<td>33,8%</td>
<td>-12,4%</td>
</tr>
<tr>
<td>2007 in total</td>
<td>25,5%</td>
<td>-13,6%</td>
</tr>
<tr>
<td>Q1</td>
<td>34,2%</td>
<td>-6,78%</td>
</tr>
<tr>
<td>Q2&lt;sup&gt;8&lt;/sup&gt;</td>
<td>32,2%</td>
<td>-5,54%</td>
</tr>
<tr>
<td>Q3</td>
<td>47,8%</td>
<td>16,7%</td>
</tr>
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<td>86,4%</td>
<td>1405,8%&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
<tr>
<td>2008 in total</td>
<td>39,8%</td>
<td>353,8%&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
<tr>
<td>Q1</td>
<td>18,7%</td>
<td>6,67%</td>
</tr>
<tr>
<td>Q2</td>
<td>13,1%</td>
<td>7,22%</td>
</tr>
<tr>
<td>2009&lt;sup&gt;11&lt;/sup&gt; in total</td>
<td>16,1%</td>
<td>6,37%</td>
</tr>
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</table>

Figure 18 and 19 displays the fluctuation of the standard deviation and as described earlier is the standard deviation, an indicator that displays the dispersion around the expected value (Stoltz & Viljoen, 2007). The notion to pay attention to is the rather high fluctuations from one quarter to another than the whole sequence. However, the greater movement from one quarter to another displays a greater fluctuation between the periods, as well as a greater standard deviation displays a high fluctuation within the time period.

<sup>8</sup> From 08-05-16 for the CER Options  
<sup>9</sup> 2 out of 44 digits raise the divergence with 1375,8%  
<sup>10</sup> 2 out of 243 digits raise the divergence with 349,1%  
<sup>11</sup> Until 09-05-13 for the EUA Options and 09-05-11 for the CER Options
4.5.2 Open Interview Results

The interviews conducted in this study were conducted in May and June 2009. The interviewees are actors on the EU ETS including traders, analysts and actors with higher organisational positions. The presentation beneath is divided into four parts, as was the interview. A wholly inclusive interview guide can be found in the appendices.

4.6 Questions with Reference to a Cap and Trade market

The notion of the EU ETS and its connected trading markets is to lower emissions. A cap is therefore a natural boundary. Hence, the incentive of the environmental market differs from the financial one.
However, other forces that affect the environmental based market as political influence or limited sectoral coverage (Springer & Varilek, 2004, Springer, 2003) cannot, as the interviewees claim, be changed as easily in the same way. The market is not ready to take the final steps towards a more free market. Still, it is not developed enough to run as efficient as the regular financial markets.

The interviewees agree upon the idea that the Kyoto protocol is affirmative, however the economic differences between some of the Western and Eastern European countries are still too large for a free market to work efficiently. The general opinion concerning the cap and trade system is positive, but it is also mentioned that it is difficult to establish an optimal form of an emission market; however the belief that the cap and trade system is a good way to lower CO₂ emissions is prominent.

It is also mentioned that even if new implementations with a lower quota of and an auction on the allowances will be adapted for the third EU ETS period in 2013, the price on the market will still drop in a similar pace as it has been doing during the first years of trading.

4.6.1.1 Questions with Reference to Political Influence

As we mentioned in the theoretical part of this thesis there is a significantly greater influence from policymakers as politicians on the environmental market than there is on the financial markets. The guidelines and trading quotas were set in beforehand, and this had a major impact on the market price. This makes it more difficult to deduce a correct price for the market. If this is compared to the financial markets we see a difference where the price is established through supply and demand.

One major problem that was brought up during the interviews was that the trustworthiness of the emission market is very low due to the, non-controllable uncertainty in the market system. The solution to this problem is that the politicians should not make small changes; they should rather be upfront early and implement the changes between the trading periods. However, some might also argue that other organisations like the Organisation of the Petroleum Exporting Countries (OPEC) can cut the oil production at any time and there by directly affect the price; almost every market has different interventions and on the emission market there are only the guidelines set in beforehand and then can the trading be done without interference. It is just that an artificial demand had to be created for the emission allowances market.

4.6.1.2 Questions with Reference to the Economical Effect

An emission right has no real money value; the only value is the positive impact it has on the environment. This is the reason why the emission quota is set, the quotas make the emission market more efficient; however this also makes the price harder to predict on an emission market in comparison to the financial markets. This argument is why the environmental based market has such
a high fluctuation; however it also goes hand in hand with the political decisions concerning the sizes of the quotas given to each of the trading countries. These quotas are set in the local governments and by the EU Commission and there is a risk that it might be done in an inequitable way.

Incorrect quotas have its base in the beginning of the EU ETS when politicians did not have the knowledge to run a financial market and the market directors did not know how to be politicians. As an example we can mention when the prices decreased all the way down to €0,02 per ton CO₂ in the spring of 2007 (Köppl et al, 2008). If comparing the fluctuation on both of the markets, the traditional financial markets are not able to fluctuate even close to the same extent as the emission market, because the supply on the traditional financial markets are in symbiosis with the demand.

According to the majority of our interviewees, most of the companies had a negative attitude to the whole emission market mainly because they were forced into the market. Nevertheless, today the companies have accepted the emission markets; they have understood that there is money to make and that they need to be more focused on the environment. The companies also have to protect themselves against even one more market risk, which they are exposed to. However, this is very hard to determine since the emission trading market is still very young.

As we mentioned in the theoretical part there are thoughts of creating a fully international emission market (EC, 2008b, Zhang, 1998), which according to our interviewees would be a positive change, however the knowledge has to increase in the market before implementing an international emission market. The liquidity on the market would also rise if an international emission market would emerge, which would bring a more stabilised price. The interview subjects all concur to the issue that it would be remarkable if the USA and China would join into the same market; the prices would be more tangible which at the same time gives better conditions for the prices of emission allowances.

Some also argue that an international market is not possible before all of the involved countries are on the same level; different regions of the world have set different emission lowering goals. The market could become more unstructured and more inefficient than the national markets due to dissimilar rules, guidelines and taxes. This has to be standardised before it is even possible for a fully international market to function. Nevertheless, all the interviewees agree that a solely international market would lower CO₂ emissions in the most proficient way.

4.6.1.3 Questions with Reference to Market Structure and Nature

According to the interviewees, the differences between trading on the emission market and trading on the financial markets are slim or even none, even though the environmental based market has only been in force for five years. This connection between the two markets has occurred since the
emission market is established on the knowledge from the financial markets trading systems. The environmental based market is also viewed as a financial market through the perspective that it can be compared to a regular commodity or credit market even though it still has more rules and constraints.

The main difference in the market structure is according to the interviewees that the emission market is forced upon the companies and constructed by policymakers, on the financial market the participants are the ones in control. In addition, the emission allowances market can be seen more as a wholesale market rather than retail as the financial one. The emission market is still too small for investors and private persons. Nonetheless the ECX market solely gained 770% during the last year and is moving closer towards the financial ones.

4.7 Reduction analysis
When it comes to choice of an optimal reduction analysis, which also suits your research question, it is critical to decide upon the correct type to obtain the most valid data for your research question (Jacobsen, 2002). Thus, the choice will directly reflect upon your findings.

For our thesis, we have chosen two different types of reduction analysis; the first one is based on ECX market data, so called historical data. In this case we chose to look at the full population meaning that we did not reject any of the obtained market data. We also chose to standardise the data and then analysed it by using the Black & Scholes formula so that the information we got would in the most appropriate way be valid and useful for our field of research.

The second type of reduction analysis we use is regarding our interviews and the so-called information approach. When reducing the persons to interview down to the degree that all the interviewed persons have a good knowledge in the field which you are making your research in can be described as the information approach. When using this approach you as an interviewer have to have good knowledge in the same field to be able to analyse what the valid information is (Jacobsen, 2002). We choose the information approach due to the cause that the field of the CO₂ emissions market is a fairly new market and to be able to get the valid data we had to interview persons closely related to the market and those who have good knowledge in the field of our research.
4.8 Validity and Reliability

In this part of the study we intend to stress some of the factors that might have a negative impact on the research findings, this concerns validity and reliability in both research methods that we used in this study.

4.8.1 Validity

A well-performed research study should measure what it actually intends to measure, this is called validity. The validity can be divided into two parts where one is the internal which treats the soundness of the result and the other, external, which treats the generalisation of the research. There are different ways to trial your internal and external validity, where a comparison with other researches and a critical analysis of your results can be mentioned. The validity cannot always be defined to be the same for a quantitative and a qualitative research method, however, the notion is if the study measures what it intends to (Jacobsen, 2002).

As we discussed in the previous section, reduction analysis, we did not reject any of the obtained market data from the market that we wanted to analyse. We also used the Black & Scholes model, which has been recognised theoretically and does not exclude any of the valid information when using it, for option pricing. Both together, make the output of our findings valid when it comes to the quantitative part of our research. Concerning the interviews and the qualitative research method is not the purpose to generalise, rather to get a sound understanding of the differences between the environmental based trading market and the traditional options market. This lowers the external validity of the research but increases the internal.

Since the environmental-based ECX market is one of a kind, it is complicated to apply the results of this thesis to other, comparable markets. A generalisation could be done in the future, however, the small amount of interviews conducted in this study, might not give a true picture of the situation in the fields of cap and trade, political influence, economical effects and market function.

4.8.2 Reliability

Simply, if you can be dependent on the results of the research and its outcome, you talk about a high reliability. As mentioned earlier in part two of this study can the actual research method create the results for the latter (Jacobsen, 2002). This can for example be the interaction between interviewer and interviewees, personal interests or views that the responder might have as well as how the analyse of the registered data is performed.

Concerning the market data analysis in this study we are viewing if we are having similarities or dissimilarities on two different markets concerning price. A negative impact concerning this study is
that we have only reflected upon the environmental based market. We are here depending on the theoretical framework on how option pricing has been conducted on financial markets in the past as well as the qualitative research of this study.

Referring to the interviews conducted in this study, we have been putting our faith in interview subjects with a great deal of knowledge. However, we have for this part of the study only conducted five interviews altogether. This can be a negative factor if the interviewees for example have a personal interest by answering in a certain way or by not having the knowledge concerning a certain question and just answer with presumptions (Jacobsen, 2002), or other problems that could be erased with a greater deal of interviewees.
5. Discussion of the Empirical Results

The theoretical notions, the empirical findings together with our conclusions will be stressed in this part of the study in order to meet the aims of the purpose of this study as well as to provide answers to the diverse natured research question.

5.1 Discussion of the Market Data Results

We can, with the research question and the aim of this study in our minds, say that the traditional financial market and the new environmental based market are both comparable and have dissimilarities in the field of pricing. We have in this study applied the Black & Scholes model which has been used by traders and analysts over time on the financial markets (Hull, 2008). The applying of the model has been possible since the environmental market fulfil the same requirements for pricing options as on the financial market including current market value of the underlying share, the strike price, the time to maturity of the contract and the risk-free rate of interest (Stern & Chew, 2003). However, a comparison of the outcome is not really possible, the price of the environmental based market depends on many different factors including transaction costs, limited sectoral coverage of an emission trading system, unexpected political and economical development, as well as the large impact that United States have had with their withdrawal from the Kyoto Protocol (Springer & Varilek, 2004, Springer, 2003). This is also something that the interviewees pointed out, for example that their will be new implementations on the market from 2013 and that there might be mergers between different CO\(_2\) emission allowances markets that will cause a higher liquidity on the market, which both will have an impact on the settlement price for options.

Further, the divergence in terms of percent between call options price, put options price and settlement price for both EUAs and CERs shows us that the market works in an expected way until the end of 2008. We can see the average price for the EUAs and CERs puts have been in a position of in the money for the period until the last four quarters in our table where the position has been out of the money. The put option buyer expects the price to decline to make a profit (Hull, 2008) and here we can see that the put options are not profitable to buy. This shows that the price for the put options for EUAs and CERs have risen more than expected and the options were not exercised with profit. The standard deviation, that we also employ in the operationalisation process show us the same thing; that the expected prices differ a lot from the settlement prices on the CO\(_2\) emission allowances market. This is also something that we confirm as a difference with the financial markets by the verdict of our interviewees. We will continue this further in the discussion concerning the interview results.
5.2 Discussion of the Interview Results

This part will continue the previous section by stressing the other fields in the research question as well as it meets the aims of the purpose of this study. Many of the major findings we have obtained in our interviews are similar to each other and also similar to some of our thoughts of the area under discussion.

5.2.1 Cap and Trade

As the majority of our interviewees mention that the market has not reached the proper level of development or obtained enough knowledge to be able to work as efficient as financial markets. Here we can see a clear difference between the two market types and this is also highlighted in the theory by Buckley (2004) as well as Stavins (2008a, 2008b) that the cap and trade system cannot be as efficient as a traditional financial market when it consists of constraints that complicates the trade.

There is also another side to this problem which is the large gap between the Western and Eastern European countries. It is out of an economic point of view difficult for the market to be efficient. However, the general opinion of those interviewed is that the cap and trade system is a good and reasonable way to lower the GHG emissions. Nevertheless, it is also brought up that it is difficult to find an optimal way to trade CO\textsubscript{2} emissions and right now there is no other system that can work efficiently for this matter.

We agree with the interviewees beliefs that the market will gain from the changes that will be made to the third period that starts in 2013. Allowances are going to be auctioned out to companies as well as that the quotas of allowances will be lowered, and we believe that these implementations will stabilize the price; however, the price will keep on declining. The falling price is caused by the expansion of the market which makes the supply of the emissions more effective (Muller, 1999). The discussion regarding risk and the market risk that is defined by Murphy (2008) is here not the same for the environmental and financial markets due to the various types of implementations. This is on the financial market, as the interviewees also mention, defined more by supply and demand.

5.2.2 Political Influence

The method policymakers like politicians are using upon the environmental based CO\textsubscript{2} emission market is one of the greatest differences between the markets highlighted in this study, this referring to how policymakers set the d for the environmental based market. This is also something that is confirmed by all of the interviewees.
Further is a major difference between the emission market and a traditional financial market that the emission market has been forced on the companies by the policymakers; an artificial demand had to be created, this is something that the interviewees mention.

However, some of the interviewees argue that there are always two perspectives for every situation. The example that best describes this is one related to an interviewee who claimed that almost every market has different interventions. Look upon the Organisation of the Petroleum Exporting Countries (OPEC) that can cut the oil production at any time and there by directly affect the price. The quotas and guidelines from policymakers lay the base but then the trading is free. This is also something that we can relate to the financial market and the literature where Hull (2008) cites that a frame of laws on how the trade should be done is set, and then is the rest is up to the market itself. Here we can see a similarity between the markets, even though, that the opinion is not shared by every interview subject.

5.2.3 Economical Effects

The emissions trading mechanism have been mentioned as the most self-evident influences on climate change (Busch, 2006) and the EC (2007) estimated that the economical impact is higher if the involved countries do not meet their undertaking goals within the frames of the Kyoto Protocol. Hence, the emission trading has both environmental and economical benefits. As the interview results show, there is an international market and a stable market price to prefer. The greater market we have, the greater environmental and hence economical results. However, the law of one price will not apply to the CO$_2$ emission trading market. Further, we might also see price differences from region to region or from nation to nation due to different or stricter regulations within the region or nation (Springer & Varilek, 2004). This is also confirmed by our interviewees who mention that this has to be standardised before it is even possible for a fully international market to function. Nevertheless, all the interviewees agree upon the conception that a solely international market would lower CO$_2$ emissions in a proficient way.

Again, we have to mention the price fluctuation notion. The price still depends on the quotas set by National Governments and the EC; this direct price impact affects the market. This problem was shown when the market price decreased all the way down to €0,02 per ton CO$_2$ in the spring of 2007 (Köppl et al, 2008). If we compare the influence that the quotas and price fluctuation have on the different markets highlighted in the study, the traditional financial markets are not able to fluctuate as much as the environmental based market due to the fact that the supply on the traditional financial market directly depends on the demand, according to the interviewees.
5.2.4 Market Nature

We have identified that some of the theoretical frameworks show ideas that the emissions should not be treated as financial assets. NERA (2007) state that the emissions should be viewed upon as an opportunity cost where the installations can sell their unused allowances in the market, which most of the companies have absorbed to do today. The emissions are viewed as an opportunity cost when installations or operators at occasions strive to sell unused allowances in the market.

Another identified difference between the two markets highlighted in this study is that the traditional option market has a longer “experience”. Traditional options have a longer history when it comes to exchange trading markets overall, in order to bring farmers and merchants together where the Chicago Board of Trade (CBOT) founded in 1848. However, the interviewees do not see any real differences when it comes down to how the assets are traded.
6. Conclusions and Suggestions for Further Research

This research aim is to identify the differences on the CO$_2$ based emission trading market and the traditional financial one in five different fields including pricing, cap and trade, political influence, economical effects and market structure or nature. We have, by using the Black & Scholes model highlighted pricing and by interviews analysed the other four notions of our research.

6.1.1 Conclusions

First, we can mention that the CO$_2$ based market differs from the financial one when it comes to the different implementations on the market. The price on the CO$_2$ based market depends on a lot of different factors besides the risk notion that the financial market also is exposed to; the foremost disparity that we have identified is the political influence. The policymakers including politicians set the paradigms for the CO$_2$ based market, which subsequently affects the price. The CO$_2$ based market had to be created due to other factors than the ones on the financial market. The market was forced upon nations and companies; it was solely a political decision that was not approved by all of the affected parties. This is also something that we can see concerning the cap and trade notion of our research question. The whole concept of the CO$_2$ based market is to have a cap in order to lower CO$_2$ emissions.

We have also identified the price fluctuation as a difference. The financial market depends more on supply and demand whereas there are more factors that can affect the price on the CO$_2$ based market. Further, both the CO$_2$ based market and the financial market have different economical effects but the CO$_2$ based one also has positive environmental effects that the financial one does not contend with.

An international market is preferable. The greater market that we have, the greater the environmental and, hence, economical results there will be. The financial market has a longer tradition and is more widespread throughout the world; this is due to several factors not the case for the CO$_2$ based market. A solely international market would lower CO$_2$ emissions in a proficient way and be more efficient in that sense. The CO$_2$ based market is however not mature enough to take this step towards internationalisation.

The environmental, CO$_2$ based market is an extremely new market. As we mentioned in the beginning of this study, there has only been one conducted research concerning the comparison between the environmental based market and its financial counterpart.
6.2 Suggestions for Further Research

With this research we aim to provide an overview of the differences on two markets, however, we suggest that significant input is needed to understand the complexity of this field. A larger number of interview subjects is needed in order to make a generalisation possible. The market data can be analysed further with other types of valuation models. The market is still in a pre-phase, and a comparison in the future could give a more relevant result.
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- Anonymous, Emission Allowance Analyst, 2009-06-02
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- Lars Westermark, Chief of the Climate Unit at the Swedish Environmental Protection Agency, 2009-06-09

**Electronic Resources**

  http://www.swedishenergyagency.se/WEB/STEMEx01Eng.nsf/F_PreGen01?ReadForm&MenuSelect=0650E42872736D32C1256E780028DE47

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Appendix 1 – Standard Deviation

Figure 20 – Standard Deviation for EUA and CER Options

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12 From 08-05-16 for the CER Options
13 Until 09-05-13 for the EUA Options and 09-05-11 for the CER Options
Appendix 2 – Interview Guide

This interview guide is a framework on the path of finding answers to the questions in this study which refers to a cap and trade market, economical effect and in some sense political influence.

Questions with reference to a Cap and Trade market

1. How do you believe that the CO₂ based market will react to an open market approach? That is without any constrains except the amount of rights.
2. Economics might argue for disadvantages with a cap and trade system, such as equity. Do you believe that an emission trading market can work as a financial market?
3. Which approach would you find more efficient for the emission reduction market respectively the financial market?

Questions with reference to the Economical Effect

1. From an economical point of view, is it more profitable for companies to have a “business as usual” approach or an adapting approach?
2. Climate change is considered by the majority of global companies as a business risk. Do you believe this to be relevant?
3. If all of the emission trading allowances would be traded at same market, would it be more efficient than today’s scheme?
4. Do you believe that a sole national trading scheme would have a larger total economical impact on the society than an international one (like the EU ETS)?

Questions with reference to Market Structure and Market Nature

1. What are your impression of the differences in the market structure between the environmental-based market and the traditional options and futures market?

Questions with reference to Political Influence

1. In which extent do you think that policymakers such as political representatives affect the emission allowance trading market?
2. Do you believe this to have a broader impact than with the financial markets?