ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

SCHOOL OF ECONOMIC SCIENCES

DEPARTMENT OF ECONOMICS

The European Union's Carbon Market

Tzanetakis Theodosios

Dissertation submitted

in partial fulfilment of the necessary prerequisites

for the acquisition of the MSc Degree

Athens

January 2020

Supervisor: professor Andriana Vlachou - AUEB

Examiner: professor Elias Tzavalis - AUEB

Examiner: assistant professor Spyridon Pagratis - AUEB

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ABSTRACT

Human-induced climate change is considered a prominent political issue, in both international and national agendas, since the late 20th century. It is also the reason behind the search for regulatory "solutions", in the effort to meet the needs of these changes. The Kyoto Protocol is essentially the first transnational endeavor with legally binding targets towards preventing human-induced climate change and controlling the enhanced greenhouse effect. It also paved the way for the European Union's Emissions Trading Scheme (EU ETS), which was designed by the European Union's countries in a way to meet their obligations in a cost effective way. In this way, emission trading has become the most broadly favored strategy of modern governments. Carbon emission permits and their derivatives have quickly become very important financial instruments in new markets, which can turn over billions of dollars a year.

Based on these grounds, the main purpose of this dissertation is the review of the literature concerning the European Union's Emissions Trading Scheme, which is the flagship of European Union's environmental policy in an effort to mitigate the problem of climate change by reducing the greenhouse gas emissions in the atmosphere. In particular, this paper provides evidences of the ongoing debate concerning the main characteristics of the EU ETS as well as its performance so far.

INTRODUCTION

The challenges of climate change and global warming are undoubtedly a reality that mankind has to face in order to adapt and survive in the future. The prevalent views regarding the causes of this phenomenon argue that apart from the natural causes it is the result of various anthropogenic activities that lead to the increasing levels of greenhouse gases (GHG) concentrated in the atmosphere and the development of climate imbalance. Inarguably, the implications of climate change affect the whole world in both direct and indirect ways and are a factor that contributes to the destruction of habitats, the occurrence of droughts, floods, ice melting and the rise of sea level, as well as, exacerbate global inequalities and immigration.

In an effort to face this global threat, the adoption of the Kyoto Protocol (December 1997 in Kyoto) from a vast majority of countries that constitute the United Nations (UN) is considered very important. Kyoto Protocol began to operate in February 2005 and requires developed countries to plan and implement legal commitments, so that they can reduce their carbon dioxide footprint in the atmosphere. The main objective of the Kyoto Protocol is the collective but still individual effort of the industrialized countries to reduce their emissions. For this purpose, domestic actions are necessary. Nevertheless, the Kyoto Protocol provides certain flexible mechanisms in order for the developed countries to earn credits for investments that reduce emissions in developing countries (Stern 2007).

In this fight against the negative effects of climate change the European Union decided to play a pioneering role by instituting a pan-European cap and trade system of carbon emissions permits. This system is called the European Union's Emissions Trading Scheme and its goal is to help the European countries and businesses to reduce their GHG emissions in a cost effective way by setting a price on carbon. This was designed by setting a cap, i.e. an upper bound, to the maximum amount of GHG emissions that can be emitted by the installations covered by the system over a specified calendar year. This cap wanes over time in order to ensure a smoother transition to lower carbon emissions levels. In turn, the companies covered by the system receive or buy emission allowances of the scheme which they can trade between them as they see

fit. A restricted amount of international credits through the flexible mechanisms of the Kyoto Protocol is also allowed. Finally, at the end of each period each company must report their yearly verified emissions and subsequently submit the corresponding quantity of permits to cover these emissions.

Research aim

The purpose of this study is to acquaint with and evaluate the main characteristics and results of the European Union's Emissions Trading Scheme (EU ETS), which is one of the main policies of the strategy the EU has developed in order to cut down GHG emissions and meet its Kyoto Protocol targets.

Methodology

For this study it was chosen to use the bibliographic review in order to evaluate the scientific data derived from different studies and articles regarding the EU ETS. Data mining was done from scientific and academic databases, utilizing the following keywords: European Union Emission Trading Scheme – carbon market – cap and trade – environmental economics.

Finally, this method was considered to be the most appropriate, because it can ensure a comprehensive coverage of the many facets of the EU ETS and moreover lead to valid and reliable conclusions.

Research structure

The remainder of this study is structured as follows: In the second chapter of this study the EU Emissions Trading System is analyzed, by giving emphasis on its brief history and the description of its features as they were developed through the different phases of the scheme. Specifically, we will present the main characteristics of Phase I, Phase II and Phase III, so that the European strategy to tackle climate change can be better understood. Following next, in the third chapter we will analyze the financial perspective of the EU ETS. Particularly, we will refer to the market structure

and regulations of the system as well as to the carbon price behavior through the years. We will then focus on inquiring into possible price determinants, on reviewing the modelling of carbon prices and derivatives and on the effort to evaluate the effectiveness of the financial aspect of the carbon market. In the final chapter, a critical assessment of the EU ETS will be presented by examining specific issues such as the "compliance or speculation" of market participants, certain market failures and some regulatory issues. Moreover, we will investigate whether there is a structural break between classic economic theory and the real world and at the same time we will express an "eco-socialist" critique of the pursued, "one way", market based policy. The paper closes with the reference of some conclusions and suggestions for further research.

2. The EU Emissions Trading System

2.1. A Brief history

The origins of carbon trading as a policy instrument designed to limit the greenhouse gases (GHG) emissions and as such to avert the catastrophic consequences of climate change can be found in the academic field of economics in the late 1960s. Ronald Coase[1], an economist at the University of Chicago, supported the idea of "pollution trading" as a viable mean to indirectly price pollution and as such to become a share of the cost of production. He argued that in this way pollution would be perceived as another cost that needs to be minimized and hence, businesses would have an incentive to reduce their pollution. This theory of "pollution trading" was further developed by economists Dales (1968) and Crocker (1966) who argued that overall pollution levels ought to be set by governments in order the pollution market to be effective. In other words, compliance of businesses with emissions targets set by the state would render pollution trading as a way of making it as cost effective as possible. Moreover, the price signal would procure a lasting incentive for businesses to innovate, in that way generating dynamic efficiency as well. Most importantly, this approach adhered to the "polluter pays principle" by design recompensing those who invested towards reduced emissions, and disciplining those who did the opposite (Kill et al. 2010).

The first attempts of applying this theory in practice were in 1976, when the US Environmental Protection Agency (EPA) introduced pollution trading of certain air pollutants and in 1990, when the US passed legislation for a nationwide sulphur dioxide (SO_2) trading system in order to tackle the issue of acid rain. Tietenberg (2006) delivers a notably review of the US project, which, in principle was a learning-by-doing endeavor, frequently acting as a practical reaction to unexpected conditions in which flexibility was of paramount importance, whereas all other alternatives were found to be unfeasible. Initially, these endeavors were generally fruitless mostly because markets were not of adequate size, liquidity was limited, restrictions on trading were in place, involvement was restricted and banking and borrowing was either not permitted

[1] 'The problem of social cost' (Coase 1960)

or highly restricted. Nevertheless, lessons were learnt and some successes were recorded. In fact, the US sulphur dioxide (SO_2) trading system, as well as the US delegation in the UNFCCC (United Nations Framework Convention on Climate Change), influenced the world community towards adopting pollution trading as the policy instrument of choice in order to tackle climate change and subsequently functioned as an exemplary for the design of carbon trading programs including the Kyoto protocol flexible mechanisms and the EU ETS (Kill et al. 2010).

Meanwhile in Europe a different approach was initially considered as an answer in the same problem, that of climate change and global warming. In this case, the competent authority to initiate the debate for new legislation, namely the European Commission, proposed an EU-wide carbon energy tax in 1992 but it was received with strong opposition and ultimately failed to win pan-European support. The resistance to the proposal came from two different sources. First, some member state nations regarded and maybe still regard fiscal autonomy as a core value of their sovereignty and thus tax harmonization even for this special case would be almost unattainable as it would require unanimity. Second, the main industry lobbies, represented mainly by UNICE (Union of Industrial and Employers' Confederations of Europe), were also against the proposed tax, mainly invoking reasons of lacking competitiveness. Eventually, the opposition proved too resilient and the proposal was officially withdrawn in 1997 (Ellerman et al. 2010).

Individual countries' initiatives towards reducing their GHG emissions, such as the initial US pollution trading system, are certainly essential and necessary but unfortunately not sufficiently enough. We are not in the 19th century anymore, where Europe and the US accounted almost for all the GHG emissions worldwide. Industrialization is now globally spread and our economies are still strongly dependent on fossil fuel energy. Eventually, the international community acknowledged the need for international cooperation and coordinated measures in order to limit the GHG emissions and address the adversities of climate change. To this end and after disturbing scientific reports urging for action, the UN, after a series of deliberations and preparatory negotiating committees, adopted an international environmental treaty, the United Nations Framework Convention on Climate Change (UNFCCC) on 9 May 1992. The UNFCCC opened for signature at the Earth summit in Rio de Janeiro in June 1992 and subsequently entered into force on 21 March 1994 after it was ratified by a

sufficient number of countries. Its main objective is to set restrictions on GHG emissions in order to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". Yet, the framework has no authority to set binding limits to GHG emissions for individual countries and therefore it includes no legally enforcement mechanisms. The real role of the UNFCCC is to outline the way particular international treaties may be conveyed so as to promote further action towards the main goal. Until recently (as of December 2017) the UNFCCC numbered 197 parties (almost universal membership) and that is why it shares broad legitimacy.

The parties of the Convention have met annually from 1995 in the so called COP (conferences of parties) in order to evaluate the development in dealing with climate change as well as propose and negotiate new potential measures so as to avert its ominous consequences. Two years later, in 1997, negotiations have ultimately culminated in the introduction of the Kyoto Protocol. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. The detailed directions for the enactment of the Protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords". The Kyoto protocol imposed legally binding obligations for developed countries (Annex 1 parties) to reduce their GHG emissions to specific targets (below 1990 levels) in the period 2008-2012, which was to become the first commitment period. More specifically, during the first commitment period, 37 industrialized countries and the European Community committed to reduce their GHG emissions to an average of five percent against 1990 levels. Prior to this, member nations were required to establish national GHG registries of GHG emissions and removals in order for the convention to determine the 1990 benchmark levels for accession of Annex 1 countries to the Kyoto protocol and for the commitment of those countries to GHG reductions. Annex 1 countries were also obliged to submit updated GHG registries annually. The reasoning behind setting heavier burden on developed nations (Annex 1 parties) is due to the recognition that developed countries were principally responsible for the current high concentration levels of GHG in the atmosphere as a result of more than 150 years of industrial activity. This fact reflects the protocol's principle of "common but differentiated responsibilities". Under the Protocol, countries must meet their targets primarily through national measures, meaning that each country could limit its GHG

emissions choosing their own policy. However, mostly due to the influence of the US delegation, the Protocol introduced certain market based mechanisms as additional means for parties to meet their targets by way of commercializing GHG emissions[2]. The so called Kyoto mechanisms are the following: International Emissions Trading, Clean Development Mechanism (CDM) [3] and Joint Implementation (JI)[4]. Their goal is to provide incentives for green investment and help Parties meet their emissions targets in a cost-effective way. Furthermore, to ensure compliance with the undertaken commitments under the protocol, monitoring and reporting procedures were entered into force. According to these, countries must monitor actual GHG emissions, keep precise records of the trades carried out under the Kyoto mechanisms and submit annual emission inventories and national reports in the legitimate authority responsible to ensure compliance. This authority, namely the UN Climate Change Secretariat (UNCCS) holds an international transaction log in order to verify that transactions are consistent with the rules of the Protocol. Last but not least, the Kyoto Protocol, like the UNFCCC, is also designed to assist countries in adapting to the adverse effects of climate change, hence it aims to facilitate the development and deployment of technologies that may help increase the resilience to these impacts. For that purpose, that is to finance such projects in developing member countries, the Adaptation Fund was established, initially financed with a share of proceeds from CDM project activities and later also from the international emissions trading and the JI mechanisms.

Following the Kyoto Protocol, parties of the UNFCCC kept meeting annually and after further negotiations they proposed and agreed upon new treaties and amendments to the previous ones. One such new treaty is the 2010 Cancun agreements,

[2] Emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units that they do not use to sell this excess capacity to countries that are over their targets. Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas this market became known as the "carbon market."

[3] The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO_2, which can be counted towards meeting Kyoto targets. This mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

[4] The joint implementation mechanism (JI), defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission reduction or emission removal project in another Annex B Party, each equivalent to one ton of CO_2, which can be counted towards meeting its Kyoto target. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer.

which declared that future global warming should be limited to a rise below 2 ^{o}C above the preindustrial levels. This treaty was based on scientific evidence from climate simulations showing with almost certainty that if average temperatures would rise above 2 ^{o}C the climate would transition into an irreversible state of continuous overheating, setting in jeopardy not only human activities but all life in general. Subsequently, the Kyoto Protocol was amended in December of 2012 in Doha, Qatar, in order to encompass the second commitment period from 2013 to 2020. The "Doha Amendment to the Kyoto Protocol" included new commitments for Annex 1 Parties who agreed to further limit their GHG emissions in the second period (2013-2020), a revised list of GHG to be reported on by Parties in that second period and amendments to several articles of the Kyoto Protocol which were specifically referred to issues of the first period that required updating for the second period. The composition of Annex 1 parties was also changed in the second period. During the second commitment period, Parties pledged themselves to reduce GHG emissions by at least 18 percent below 1990 levels. After the Doha Amendments, the Paris Agreement was adopted in 2015 and after sufficient parties ratified it entered into force on November 4, 2016. Its purpose was to regulate emission reductions from 2020 and onwards through undertakings of countries in ambitious Nationally Determined Contributions.[5]

Refocusing on the affairs in Europe we can deduce that the creation of the EU ETS had its origins in the necessity for the European Union to comply with the reduction targets committed under the Kyoto Protocol. Of course, matters in politics are much more complex than that. Besides, we should not forget that the EU ETS was the outcome of two failures. Firstly, the Commission's failure to win pan-European backing for the establishment of a carbon tax. Secondly, the miscarriage of European negotiators to obtain the inclusion of their desired policy initiatives in the Kyoto Protocol[6]. Eventually, six months after opposing emissions trading, the Commission incorporated it. This change of heart in the position of the European Commission was partly relied firstly, on the ever-growing academic literature regarding emission trading as a viable alternative for GHG emissions reduction and secondly, the US experience

[5] (https://unfccc.int/process/the-convention/history-of-the-convention#eq-1)

[6] Three features characterized the European Union's negotiating position at Kyoto: (1) a commitment to mandatory caps on emissions by developed countries; (2) an undifferentiated target of 15 per cent below 1990 emissions levels; and (3) an antipathy towards emissions trading as a mechanism for achieving these targets, on the basis that some participants whose caps included surplus emissions allowances, or 'hot air', would benefit without making an effort and would compromise the overall objective.

in such schemes (SO_2 emissions trading). It is noteworthy that advocates of the European single market, as well as some representatives from the industrial sectors, supported the inclusion of emissions trading in the Kyoto Protocol from the start. Eventually, creating a regional carbon market within the framework of the EU was envisioned by its prevalent leadership as a means of providing not only a price signal to motivate the abatement of GHG emissions, but also a practical opportunity to improve the effectiveness and unity of other EU policies as well as to promote the idea of European integration in general. Moreover, it would demonstrate global leadership, encouragement and a paradigm for the rest of the world to imitate and enroll in the struggle, especially after the fact that ultimately the US had not ratified the Kyoto Protocol, backing out from subsequent climate agreements as well. This European vision finally took actual form and became realized through the Emissions Trading Scheme Directive (Directive 2003/87/EC), which set the founding stones of the EU ETS (Ellerman et al. 2010).

The first sign that the EU was aiming to put into operation an emissions trading system was in 2000, when the European Commission issued the Green Paper on Greenhouse Gas Emissions Trading within the European Union (COM/2000/0087 final). This legislative initiative suggested whether the EU should enforce an internal EU-wide cap-and-trade system to limit GHG emissions in order to ensure effective compliance to the undertaken KP commitments, as well as to supplement other environmental policies and measures, regarding energy efficiency and renewable energy. The green paper set in place the main features of the system that would become the EU ETS, i.e. a pilot phase to run from 2005 up to 2007, followed by full implementation over the 5-year period parallel to the First Commitment Period of the KP (2008–2012). Essentially, this initiative from the part of the European Commission set in motion an extensive debate among the EU's institutions as well as other key stakeholders, such as business unions and environmental NGOs (non-governmental organizations). This legislative procedure concluded with the unanimous adoption of the ETS Directive by the European Council of Member States in October 2003. The details behind this procedure as well as the components that constitute the core of the EU ETS together with its subsequent amendments will be discussed in the following chapter (Ellerman et al. 2016).

2.2. Description of the EU ETS

2.2.1 The EU legislative structure

The first segment of this chapter refers to the political decision-making process within the European Union. This transnational structure with its multifaceted extensions and aspects became a reality through the constitution of the European institutions via certain pan European agreements and treaties[7]. One such agreement, the Single European Act (SEA) of 1986, which revised the Treaty of Rome (1957), formed the legal foundation for the EU ETS and European legislation in general. The SEA added new impetus for European integration and for the consummation of the internal market and extended the powers of the Community, also including on environmental subjects. In particular, it stated that the EU was authorized to propose legislation in order "to preserve, protect and improve the quality of the environment, to contribute towards protecting human health, and to ensure a prudent and rational utilization of natural resources" (European Commission 2015). As such, the EU ETS is an environmental regulation, intrinsically under the jurisdiction of European law and therefore decisions regarding it are made at the European level rather than the Member State (MS) level.

The main institutions involved in the legislative procedures of the EU are the European Commission (Europe's civil service, i.e. EU bureaucracy), the Council of the EU (national government ministers acting as representatives of each MS) and the European Parliament (the elected representatives of European citizens from each member state). The European Commission (referred also as the Commission or EC) is organized into a number of Directorates General, of which one is the DG for Climate Action (DG CLIMA). It has the singular right to initiate the procedures for new legislation, in the sense that it is the driving force that sets in motion all the other actors towards final resolutions. Moreover, it provides the evidence and logical basis to put policies forward, and it has the obligation of guaranteeing and facilitating their implementation, including, whenever it is required, taking violator member states to court. The second strategic actor is the Council of the EU, consisting of representatives of the member states, who, in the case of emissions trading, are normally ministers for

[7] The Treaty on European Union, signed in Maastricht in 1993, created new forms of cooperation between the member state governments, including the introduction of the euro. It and the Treaty of Amsterdam (1997) substantially enhanced the role of the European Parliament in the legislative process.

the environment. They are a key decision-making node since no legislation can be enacted without their approval. This does not mean that each member state has a veto, however. The qualified majority mechanism[8] entails that decisions can be taken without unanimity. Although the Council of the EU cannot commence processes for new legislation, it can appeal to the Commission to inspect a problem at hand and come forward with suggestions. The third key agent is the European Parliament, which is directly elected every five years by the EU citizens in each member state. Its role is essential, but rather insubstantial. Under the co-decision procedure (see Figure 2.1), the Parliament has the right to recommend adjustments to a Commission proposal over a period of two sessions. The Parliament can veto the approval of the whole proposal if it judges that its suggestions have not been taken into sufficient consideration in the final form of the text. Subsequently, it can adopt amendments rejected by the Commission only on the second reading, with the support of an absolute majority of its constituent members. Finally, it is worth noting that the whole operation is complemented and supported by other institutions and organizations, such as the European Environment Agency, and several committees within the Parliament and the Commission[9].

In conclusion, any EU legislation has to pass in accordance with the co-decision procedure (see Figure 2.1), in which, the Commission plays both the role of legislator and mediator between the two other institutional players. In a series of readings, the European Council and Parliament can suggest modifications to the legislative scheme, which the Commission can include in an updated legislative proposal. Finally, the Council and Parliament both are required to accept the proposed legislation before it becomes official law.

Once approved, legislation must be implemented primarily with the responsibility of the member states' goverments. At the same time, the Commission is

[8] In the Council of the EU, each member state is allocated a number of votes according to its population, with extra weight given to the smaller member states. Since 1 January 2007 the threshold for a qualified majority has been set at 255 votes out of 345 (73.91 per cent). A qualified majority decision also requires a favorable vote from the majority of member states (i.e. at least fourteen member states). In addition, a member state may request verification that the qualified majority includes at least 62 per cent of the European Union's total population.

[9] Examples of Parliament committees are the ENVI, the Environment, Public Health and Food Safety Committee and the ITRE, the Industry, Research and Energy Committee. Both committees together with the Climate Change Committee of the Commission play an important role in the legislative procedure in the EU ETS.

empowered to befittingly enforce the execution of legislation. For the EU ETS, the Commission had initially certain implementation powers over certain conditions requiring uniform application, such as determining the allocation of free allowances, monitoring, reporting and verification of emissions. Over the years we can observe a general shift of powers from the member states to the Commission regarding the planning and organizing the whole scheme. The explanation behind this concentration of powers by the Commission is that these rules and policies need to be implemented on an EU-level to ensure efficiency, harmonization and equivalence among the member states. Of course, there are always open communication channels (e.g. Climate Change Committee) in order to facilitate the cooperation between the Commission and the member states in implementing the adopted legislation. Nevertheless, should a MS fail to act in accordance with with EU law, the Commission has the right to commence infringement procedures. In that case the Commission can prosecute and impose sanctions (e.g. lump sum payments), in accordance with the legislation, against a MS. Ultimately, the Commission may submit the case to the European Court of Justice, which is the competent authority responsible for safeguarding that EU law is adhered (Ellerman et al. 2010, pp. 10–13).

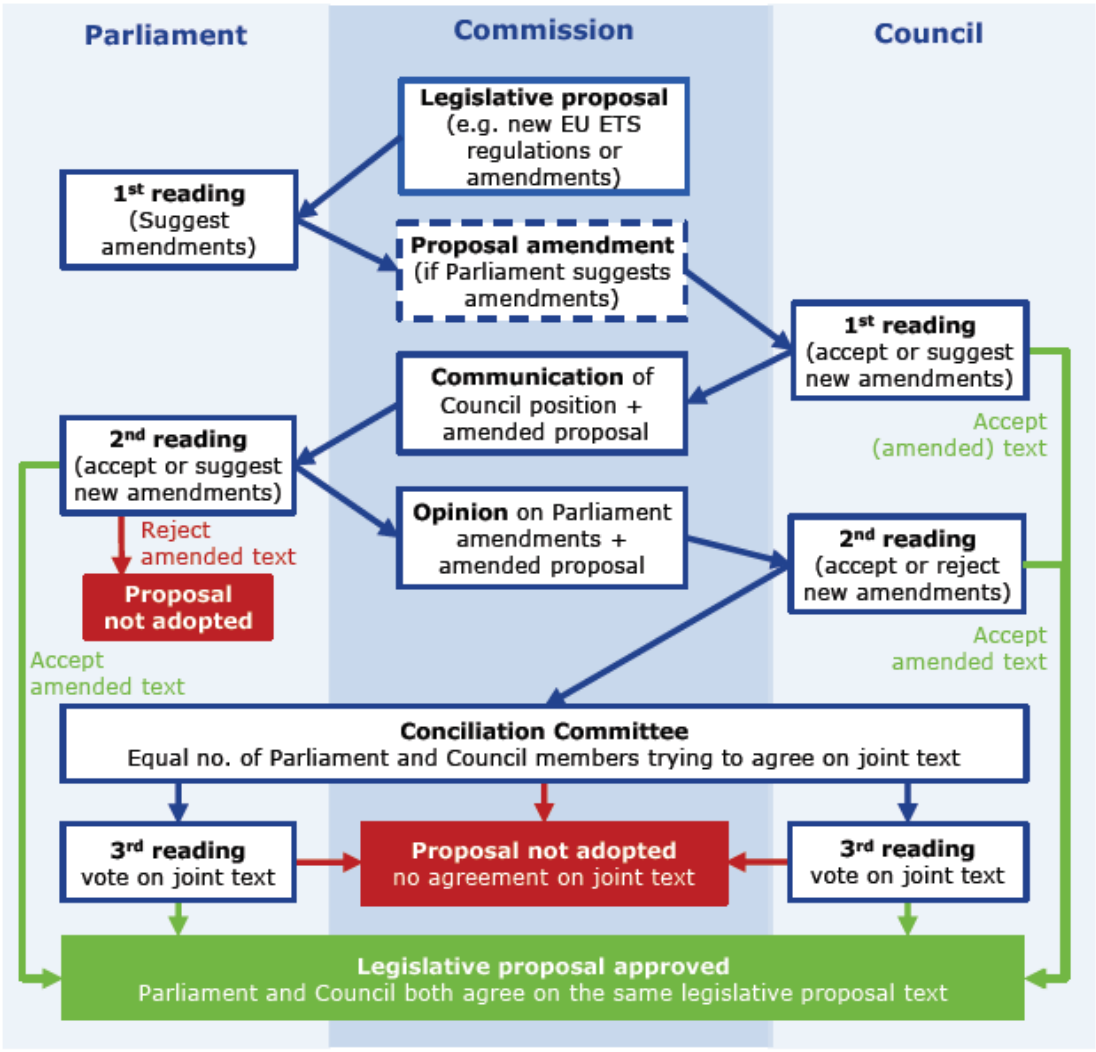


Figure 2.1.

Source: European Commission (2015), EU ETS Handbook.

2.2.2 The Green Paper on GHG emissions trading in the EU

In this section, after introducing how the EU decision making process works, we will summarize the key points of the Green Paper, which was the founding stone of the EU ETS directive.

As we already mentioned the Green Paper, which was brought forward by the Commission in 2000, was intended to launch a thorough dialogue on greenhouse gas emissions trading within the European Union, and on the association between emissions trading and other potential policies and measures to deal with the problems of climate change. In other words, the Green Paper was, in short, a communication from the

Commission to the Council and the European Parliament regarding the necessary preparations for the implementation of the Kyoto Protocol (KP). Emissions trading was firstly introduced as one of the policy instruments of the KP. Since, it was a new instrument for environmental protection within the EU, it was deemed important to gain experience in its implementation before the international emissions trading scheme actually started in 2008. Thus, the commission proposed to the European Community and its Member States to commence a pilot emission trading scheme by 2005 within the Community to prepare themselves. The Commission was of the opinion that a comprehensible and coordinated framework for applying emissions trading covering all Member States would provide an excellent assurance for a properly functioning internal emissions market as compared to distinct and uncoordinated national emissions trading schemes. Such a scheme would lead to one sole price for allowances traded by firms within the Community, whereas different independent national schemes would have resulted in diverse prices within each scheme. Furthermore, since the expansion of the internal market had been one of the main objectives behind the EU's past development, the Commission urged that this should be taken into account when creating new markets. Besides, climate change is one of the purest issues with transnational effects demanding coordinated action. In addition, the economies of scale generated at the level of the EU would permit substantial cost saving, while analogous regulatory provisions would ensure that administrative costs stay as low as possible.

Ultimately, Commission suggested that the fundamental policy options to be decided upon in forming such a framework would have to answer the following questions: Which countries, which firms and from which sectors will take part in this scheme? In what way, and by which authority, should the allowances be allocated to the sectors and companies involved in the system of emissions trading? How can emissions trading coexist and work with current policies and measures such as technical regulation, environmental agreements and fiscal incentives, and how can uniformity of effort be guaranteed amid installations involved in emissions trading and those who are subjected to other complementary policies and measures?

The Commission deemed that a collective Community approach was compulsory in order to prevent any distorting antagonism within the internal market. Different national emissions trading systems might also give rise to serious complications with respect to funding these individuals' projects and new companies

entering into the market. According to the Commission, if these distinct schemes were to be put forward it would certainly increase the uncertainty both for the Member States and the firms. Eventually, these problems were likely to further deteriorate in the context of the ongoing expansion of the Community. As a result, the potency and environmental reliability of any emissions trading system would chiefly rest upon its compliance mechanism and its implementation management. Certainly, an effective such system would require a definite degree of harmonization regarding the directions of monitoring, reporting and verification.

In conclusion, the Green Paper constituted from the part of the Commission the initiation of a process examining these concerns, as well as requested for comprehensive reactions and opinions from all other parties involved, concerning the whole proposal and the questions set.

2.2.3 The EU ETS directive and its main features

The Green Paper finally led through a series of deliberations and negotiations to the adoption of the EU ETS Directive in 2003 establishing a scheme for greenhouse gas emissions allowances trading within the Community and determining all the details regarding its structure and function.

The European Union's Emissions Trading System or Scheme was the first and largest GHG emissions trading scheme in the world. It was launched in 2005 and is considered as a cornerstone of the EU's climate policy. It imposes a cap in the total capacity of GHG emissions from installations and aircraft operators responsible, as of 2013, for around 50% of EU anthropogenic GHG emissions and covers more than 11,000 power stations and industrial plants in 31 countries (all 28 EU member states plus Iceland, Norway, and Liechtenstein), and flights between airports of participating countries.

The EU ETS is a "cap-and-trade" system, under which a maximum limit (cap) is set on the total quantity of GHG that can be emitted by all covered installations in a fixed amount of time, practically a calendar year. The common trading asset at the core of this system are the EU emission allowances (EUA) created by the EU ETS legislation. Essentially, they are rights to emit GHG emissions, each one corresponding

to the global warming potential of 1 ton of CO_2 (tCO_2e). Therefore, the height of the cap defines the total amount of allowances which are available in the system and as a consequence, it creates the necessary scarcity in order for a reasonable price to appear. Practically, this price per unit of pollution embodied in each allowance provides the motive to polluters in order to proceed in emissions' abatement, as well as it gives a sign to businesses to invest and come up with new and more effective means to reduce emissions. Within this cap limit, EUAs are allocated freely or auctioned each year and subsequently, participants can trade them as they see fit. For every period, installations must monitor and report their CO_2 emissions because they are required to surrender enough allowances to the EU authorities as an offset for their emissions. In that sense, should the verified emissions exceed the number of its available allowances, an installation must buy allowances from others to cover the difference. Conversely, if an installation has performed well at reducing its emissions, it can sell its remaining allowances for profit. This fact, in principle, allows the system to find the most cost-effective ways of reducing emissions without major government interference. Finally, compliance is ensured through the penalty and enforcement mechanisms. Thus, significant fines are imposed if companies fail to comply by surrendering sufficient allowances in time, set at €100/tCO2 and rising with EU inflation from 2013. Furthermore, companies are obligated to yield the allowances they still owe in order for the cap (i.e. the environmental targets) to be preserved successfully (Directive 2003/87/EC).

As we already mentioned, the operation of the scheme has been separated into different trading periods over time, also known as phases. The rules of the first two trading phases (2005-2007 and 2008-2012 respectively) of the EU emissions trading system (EU ETS) varied in vital aspects from those of the current third phase (2013-2020).

In the first and second trading periods, the EU ETS can better be grasped as a system for the compulsory connection of the individual member-state systems, each of which set its own separate cap and decided how the allowances were to be distributed to its own installations, subject to a 90-day review and verification by the European Commission. In particular, each member state established a National Allocation Plan (NAP) declaring the total number of allowances to be generated and the way that they would be allocated to the covered firms in the member state. These NAPs would then

be implemented unless the commission had any objections, for example because a NAP failed to comply with certain conditions or rules in the ETS Directive.

In short, the first phase of the EU ETS ran its course from 2005 to 2007 and had the nature of a pilot phase. In other words, this phase was a preliminary of the second and was used to examine the price development in the carbon market and to form the essential infrastructure and framework for monitoring, reporting and verification of emissions. The cap was set using estimated benchmarks since there were no reliable and consistent data available for the historical emissions. As we mentioned, the main purpose of phase 1 was to make certain the EU ETS operated well and effectively before 2008, allowing the EU Member States to meet their obligations under the Kyoto Protocol's first period. The so-called Linking Directive[10] permitted companies to use, up to quantified limits, certain certified emission reduction (CER) credits or emission reduction units (ERUs) generated under the Kyoto Protocol mechanisms—clean development mechanism (CDM) and joint implementation (JI)—to meet their commitments under the EU ETS. In particular, during the first phase, installations could only use units obtained under CDM projects for EU ETS compliance.

The second phase of the EU ETS ran from 2008 to 2012, the same period as the first commitment period under the Kyoto Protocol. From 2008 onwards, businesses could also use up to a specified limit emission reduction units generated under JI projects to achieve their requirements under the EU ETS. This made the EU ETS the main source of demand for CDM and JI emission reduction units. Towards the end of phase 2 the scope of the EU ETS was expanded by including the aviation sector from 2012[11].

The third phase of the EU ETS started in 2013, is still underway and it is due to end in 2020. It was designed to encompass all the lessons learnt from the previous two phases. Specifically, substantial endeavors were made so as to improve the harmonization of the system across the EU following a review of the EU ETS, agreed upon since 2008. This review resulted into the implementation of important modifications to the EU ETS in early 2009, which would apply to the system from the

[10] Directive 2004/101/EC of the European Parliament and of the Council amended the original Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms.
[11] Directive 2008/101/EC to amending the original EU ETS Directive to include aviation in the EU ETS.

third phase and onwards (i.e. in 2013) (Ellerman et al. 2016). The third phase of the EU ETS coincides with the Kyoto Protocol second commitment period, as agreed in Doha in December 2012. The EU is among the nations and federations that have committed to a target under the second commitment period and the EU ETS is supposed to be a key policy in fulfilling this target. Nevertheless, the EU ETS is defined by EU legislation and operates independently of the actions of other countries or the UNFCCC, in this way highlighting the commitment of the EU to confront and deal with the negative implications of climate change. This commitment is ensured by the fact that the EU ETS does not have an expiration date and will certainly continue to operate beyond 2020 with the phase IV (2021-2030) (European Commission 2015).

2.3. Phase 1 and 2 – key features and results

2.3.1 Key features

Phase I (2005-2007) of the EU ETS was a 3-year pilot of "learning-by-doing" to prepare for phase II, when the EU ETS would need to function effectively to help the EU meet its KP commitments. Some of the key features of phase I were the following: With respect to GHGs and sector coverage only CO_2 emissions from power generators and energy-intensive industries were included, partly due to the fact that CO_2 emissions from those sectors were easier to report, monitor and be verified. As for its geographical coverage, the EU ETS applied to all by that time EU25 member states and later in 2007 it applied to the two new members of the EU as well, Romania and Bulgaria. Another key factor was that almost all allowances were allocated to businesses for free. Besides, if that was not the case the strong opposition from the industry would probably have not been subsided at the end. Finally, the penalty for non-compliance was set at €40 per ton. Nevertheless, according to the Commission, the first phase proved successful in setting a price for carbon permits, as well as establishing unrestricted trade in emission allowances across the EU and the necessary bureaucratic structure and organization in order to monitor, report and verify emissions from the covered installations. However, in the absence of consistent past emissions data, phase I caps were founded upon the basis of ex ante (probably biased) estimates resulting in an over-allocation of the total amount of allowances issued that exceeded the verified ex post emissions. As a result, with the supply of EUAs significantly exceeding the

demand, in 2007 the price of allowances dropped to almost zero levels nullifying the environmental effectiveness of the project at that stage. Last but not least, in phase I, banking and borrowing allowances for later use in phase II was prohibited.

Phase II (2008-2012), as aforementioned, overlapped with the first commitment period of the KP, where the countries in the EU had tangible and precise GHG emissions reduction targets to meet. The key features of phase II were as in phase I but with certain minor and major updates and adjustments. For example, the total cap on allowances was lowered, some 6.5% lower compared to 2005. In terms of its geographical coverage, three new countries of the European Economic Area (EEA), i.e. Iceland, Liechtenstein and Norway joined the already EU27 member states. Concerning the GHG coverage, apart from CO_2, nitrous oxide (N_2O) emissions from the production of nitric acid was included by a number of countries. A key element was that the proportion of free allocated allowances fell slightly to the level of 90% of the total issued allowances. The rest 10% coming mostly from electricity generator installations was to be auctioned[12] instead. Moreover, the penalty for non-compliance was increased to €100 per ton. Another new feature included in the 2nd phase was the fact that businesses were allowed to use, up to a certain amount (totaling around 1.4 billion tons of CO_2-equivalent), international credits, i.e. certified emission reduction units (CER) generated from a CDM project activity or emission reduction units (ERU) generated by a JI project under the aegis of the KP. As for the monitoring, reporting and verifying procedures, the Union registry replaced the national registries and the European Union Transaction Log (EUTL) replaced the Community Independent Transaction Log (CITL). Last but not least, the aviation sector was brought into the EU ETS on 1 January 2012 (but application for flights to and from non-European countries was suspended for 2012). Regarding the total cap on allocated allowances in this phase, it was reduced based on actual emissions, since verified annual emissions data from the pilot phase were now available. However, the 2008 economic crisis resulted indirectly to emissions reductions that were far greater than expected due to a general fall of production. This in turn led to a large surplus of allowances and credits, which naturally had a negative impact on the carbon price throughout phase II, making the market unstable and insufficiently effective on its environmental reduction targets once again.

[12] See the link for more information about the auctioned allowances in the 2nd phase of the EU ETS, A brief summary and description of Phase 1 and 2: "https://ec.europa.eu/clima/policies/ets/pre2013_en").

2.3.2 Results

As the most noticeable result of the EU ETS market, EUA prices receive a great deal of consideration and are often regarded as indications of the system's performance in terms of its objective, i.e. emissions abatement. The purpose of this section is to provide a brief overview of price trends during the first two phases of the scheme, as well as to present data on the allocated supply of EUAs and the actual verified emissions and on the volume of emissions trading.

In Figure 2.2 we display the price trends of the December EUA futures prices in phase I and phases II. These futures have been operating as the basic trading instrument in the EU ETS. One thing we can deduce from the large gap of EUA prices between the futures with maturity in 2006 and those in 2007 is that in reality phase I and phase II constituted two separate markets, as banking of EUAs was prohibited between these phases. Emphasis must be given on the fall of carbon prices in April 2006, when "the rumours of 'over-allocation' hit the market a few weeks before the official audit report of verified emissions from the European Commission by May 15, 2006. In response, the price for both phase I and phase II allowances fell significantly, by 50 percent and 30 percent, respectively" (Alberola et al. 2008).

After 2009 EUA price has met a period of stability until the summer of 2011, when it has met another fall at the levels of €7–€8 in 2012 (Chevallier 2010).

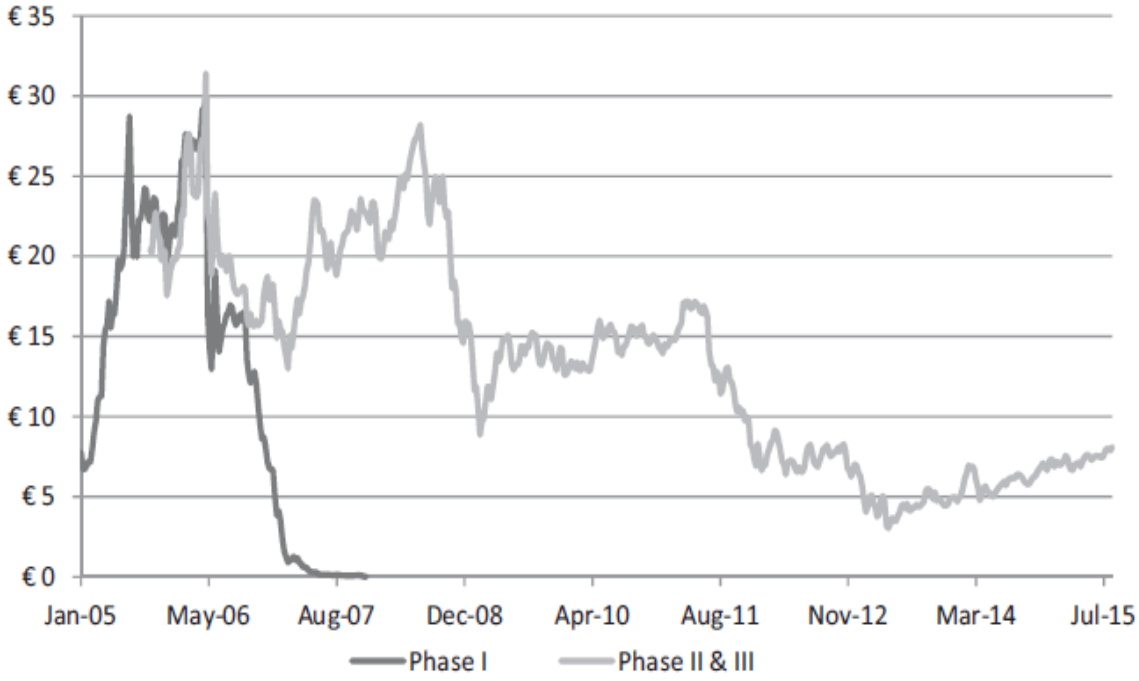


Figure 2.2 December EUA futures prices in phase I and phases II and III

Sources: Ellerman et al. 2016, p. 98.

Subsequently, we present Figure 2.3, which depicts the free allocated EUAs and the corresponding verified emissions in millions of tons of CO_2 equivalents aggregated for all countries and all installations participating in the first and second phases of the scheme. This chart highlights the negative impact that the over-allocation of free allowances had on the set goals of the EU ETS concerning the introduction of a high enough price on EUAs so as to stimulate cost effective emissions abatement. This over-allocation of EUAs together with the allowance of installations to use up to a certain quantitative amount—approximately 10 percent of the phase II cap (Ellerman et al. 2016, p. 101)— the much cheaper international credits as offsets (CERs and ERUs) indirectly raised the emissions cap substantially higher than the actual observed emissions throughout phase II, in this way sabotaging the system's capacity in motivating emission reduction through a scarcity of permits.

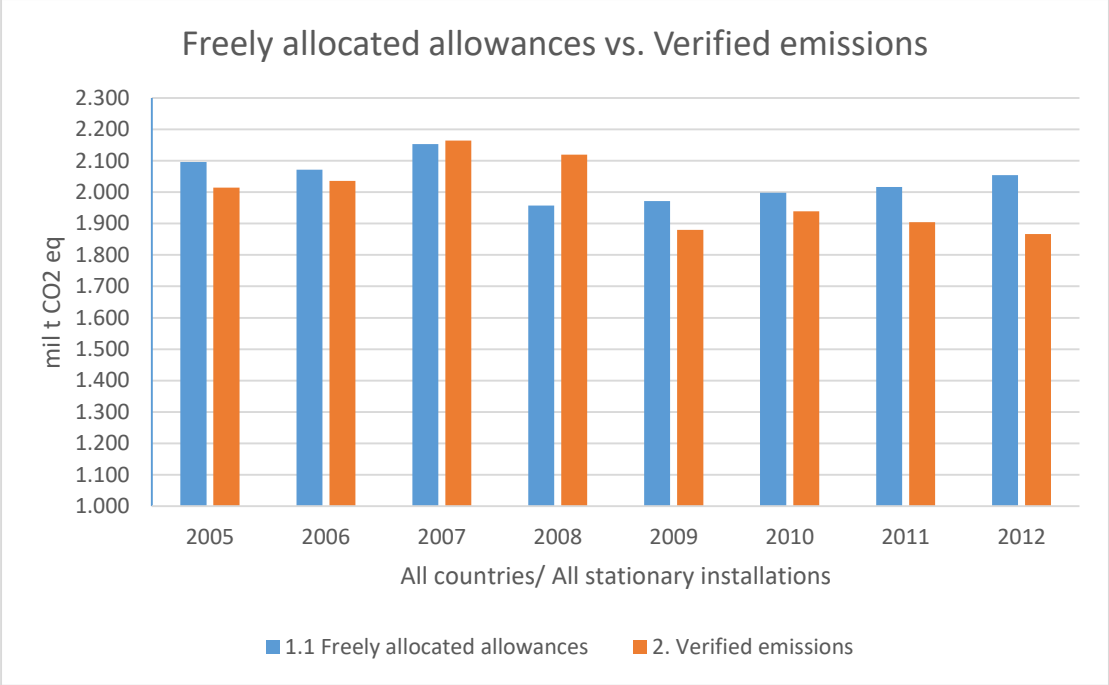


Figure 2.3
Source: European Environment Agency – last accessed 27-12-2017
"https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1"

Despite the fact that prices are certainly the most evident representation of a market, other elements of markets and market institutions, such as trading volume, the nature of allowance contracts, and the development of efficient trading platforms, are also important. These traits ensure the establishment of one fair price and in turn facilitate efficient abatement and product sales strategies (Ellerman and Joskow 2008, p. 16). Figure 2.4 depicts the steady increase in trading volumes in EUAs through the first and second phase of the EU ETS reflecting the growing confidence of participating agents in the newly developed market. An important element of the EUA market that differentiates it from the U.S. sulfur dioxide (SO2) trading market is the development of organized exchanges. Over-the-counter markets[13], which account for practically all U.S. allowance trading volume, were the first type of EUA trading platforms to appear and they remained the prevailing form of trading throughout the early years. However, trading on organized exchanges appeared timely and grew swiftly surpassing OTC trades during the second phase of the scheme. The first organized exchange, Nord Pool, started to operate trading EUAs as early as of February 2005, but by June of that year, four more exchanges had opened in Leipzig, London, Paris, and Vienna. These

[13] Over-the-counter (OTC) is transaction where a security is traded in some context other than on a formal exchange, usually referred to trade via a dealer network as opposed to on a centralized exchange.

exchanges do not all trade in the same financial instruments. The London Exchange, ECX, offered futures, options, and swaps, while the Paris exchange, Powernext (then Bluenext), started out offering only a spot contract. Each of the other exchanges offered some combination of spot, forward, and futures contracts (Ellerman and Joskow 2008, p. 17). The ICE (former ECX) is now by far the largest single platform for trading and it accounted for about 90 percent of the exchange volume in 2012 (Ellerman et al. 2016, p. 100). The appearance and the establishment of these exchanges provided that the law of one price materialized early in the EUA market boosting transparency and confidence in the market (Ellerman et al. 2016, pp. 99-100).

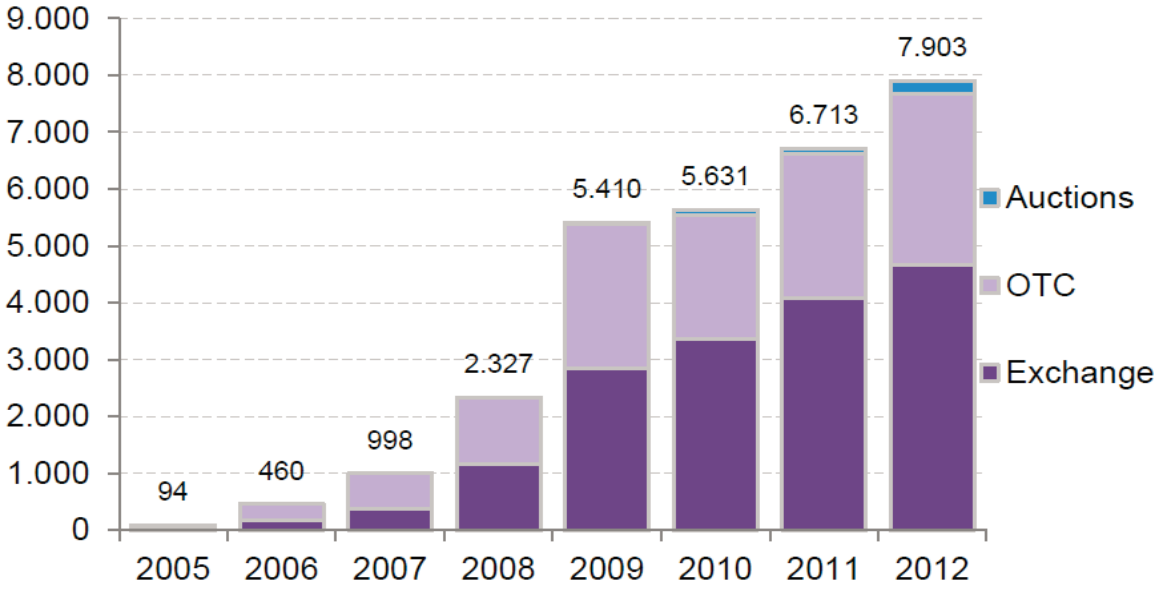


Figure 2.4
Trading volumes in EUAs (million tonnes)
Source: European Commission EU ETS factsheet, 2014. Originally from Bloomberg New Energy Finance, using data from Bloomberg, ICE, Bluenext, EEX, Climex, CCX, Greenmarket, Nord Pool, UNFCCC and Bloomberg New Energy Finance.

Summarizing the performance of the EU ETS in the first two periods (2005-2012), it is worth noting to review the literature so as to examine the impact it had on new investment and innovation as well as on the profits of the participating installations. Regarding investment, there were no quantitative studies with tangible results of investment due to the EU ETS, but qualitative inquiries suggested that the EU ETS had a positive effect in investment decisions, yet until now only in limited ways. These included mostly small-scale, efficiency related investment decisions rather than large and long term ones, as well as, fuel switching towards the less polluting natural gas. Nevertheless, it has been effective at getting the attention of corporations to climate

change as well as deterring major carbon intensive investments, which is a prerequisite in order to release capital that could be invested in low carbon technologies. As for innovation, there was evidence that investment and innovation initiatives were put forward a lot more in companies which had a shortage of allowances than in those with surplus allowances as the classical theory would suggest. However, these results are consistent with theories of behavioural economics, which give a rather higher emphasis at losses than gains, which in turn implies higher risk aversion than that of the classical theory. Finally, concerning the impact that the EU ETS had on profits of installations, it is arguably the case that free over-allocation of permits combined with trading created the potential for "windfall profits". According to Newbery (2009), the power generating companies included the price of EUAs in the final price of electricity passing the supposedly costs to the consumers, while at the same time they cashed in the free allocated permits at the EUA price resulting in high windfall gains. The evidence from Phase I and Phase II showed that significant windfall profits in the energy sector of the EU ETS was a real issue. But not for long, since the EU Commission and the other policy makers imposed auctioning of EUAs in the third period, especially in the power sector (Laing et al. 2013, pp. 25–26).

2.4. Phase III and future aims

Phase III (2013-2020) of the EU ETS focused on amending previously problematic designs of the scheme based directly on the earlier experience from Phases I and II. The main aim was to ensure that by 2020 all the covered sectors will have reached the targeted emission reduction of 21% lower than in the 2005 levels. For these purposes, the European Commission has proposed a revision of the EU ETS. We provide below an overview of the main approved modifications to the scheme that came into force in the beginning of 2013 and will apply throughout phase III.

First of all, the scope of the scheme was enlarged to include new sectors (petrochemical, ammonia, and aluminum sectors, as well as carbon capture and geological storage projects) and some additional gases (N_2O and PFCs). Also, Croatia joined the ETS at the start of Phase III ahead of its accession to the EU making the number of countries in the EU ETS 31. However, transportation, shipping, agriculture, and forestry remained outside of the scope of Phase III. Starting in 2013, an EU-wide

targeted cap replaced the former 28 separate national targets (and NAPs). Moreover, in order to reach the global EU target of reducing emissions by 21% below 2005 levels by 2020, the cap for 2013 was set at 2.084 billion allowances, accompanied by a linear reduction factor of 1.74% from the 2010 cap annually (i.e. 38.26 million EUAs per year)[14]. Furthermore, in Phase III, auctioning became the standard procedure for allocating allowances. In 2013, more than 40% of the total number of allowances were auctioned, and this portion is intended to grow progressively every year. Particularly, for the power sector, 100% of allowances are auctioned. The goal is a gradual reduction of the grandfathering practice in order to reach an aggregated 70% of allowances auctioned by 2020 and an 100% auctioning by 2027 (Chesney 2016, p.29). Since the January of 2013, auctioning has been taking place on a mutual EU-wide platform for most European member states (with the notable exceptions of Germany, Poland and the UK who decided to use national auction platforms). Nevertheless, some energy-intensive sectors that are at risk of carbon leakage will continue to receive their allowances for free (Chesney 2016, p.29). The following Figure 2.5, presents the recent and the estimated EUAs supply as well as the allocation methods with the necessary readjustment of the cap from the addition of international offsetting credits which are allowed under certain quotas.

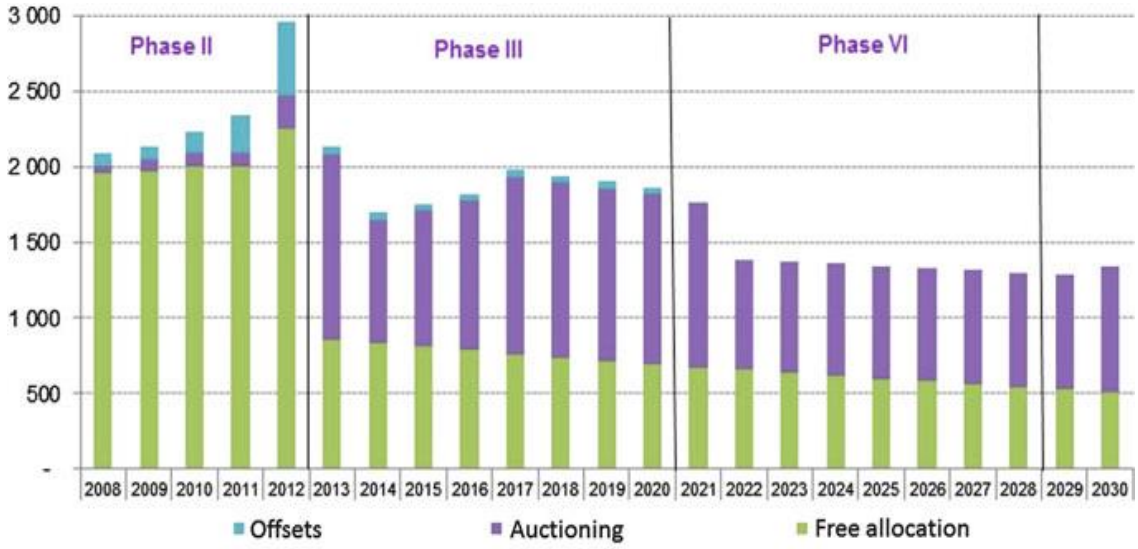


Figure 2.5. EU ETS emission caps and allocation 2008–2030

(Source: Chesney et al. 2016)

[14] 2013/448/EU: Commission Decision of 5 September 2013 concerning national implementation measures for the transitional free allocation of greenhouse gas emission allowances in accordance with Article 11(3) of Directive 2003/87/EC of the European Parliament and of the Council (notified under document C(2013) 5666)

The use of the flexible mechanism units (from CDM and JI) are subjected to qualitative and quantitative restrictions specified by EU legislation. However, in Phase III, Kyoto credits CERs and ERUs are no longer considered compliance units within the EU ETS and have to be swapped for EUAs rendering their interchangeability difficult.

Despite the amendments, the EU ETS continues to encounter a challenge in the form of a substantial surplus of allowances banked from the previous phase, as shown in Figure 2.6. This fact has substantially depressed EUA prices to very low levels. In the short term, this surplus threatens to sabotage the efficiency of the carbon market, in terms of a very low EUA price. In the long term, it could deter investments and obstruct the system's capacity to go through more demanding emission reduction targets in a cost effective way. As a means to reduce this cumulative surplus, the auctioning of 900 million allowances was suspended ("back-loaded") from 2013–2015 until 2019–2020. Additionally, a more structural program—a market stability reserve—was decided in 2015. This reserve, which started operating in January 2019, has as an objective to neutralize the undesirable effects of the prevailing allowance surplus and bolster the system's flexibility to future shocks. It was also agreed that the 900 million back-loaded allowances would be reassigned to the reserve rather than get auctioned in 2019-2020 as was initially intended (Chesney et al. 2016, pp. 29–30; Haita 2013, pp. 4–5).

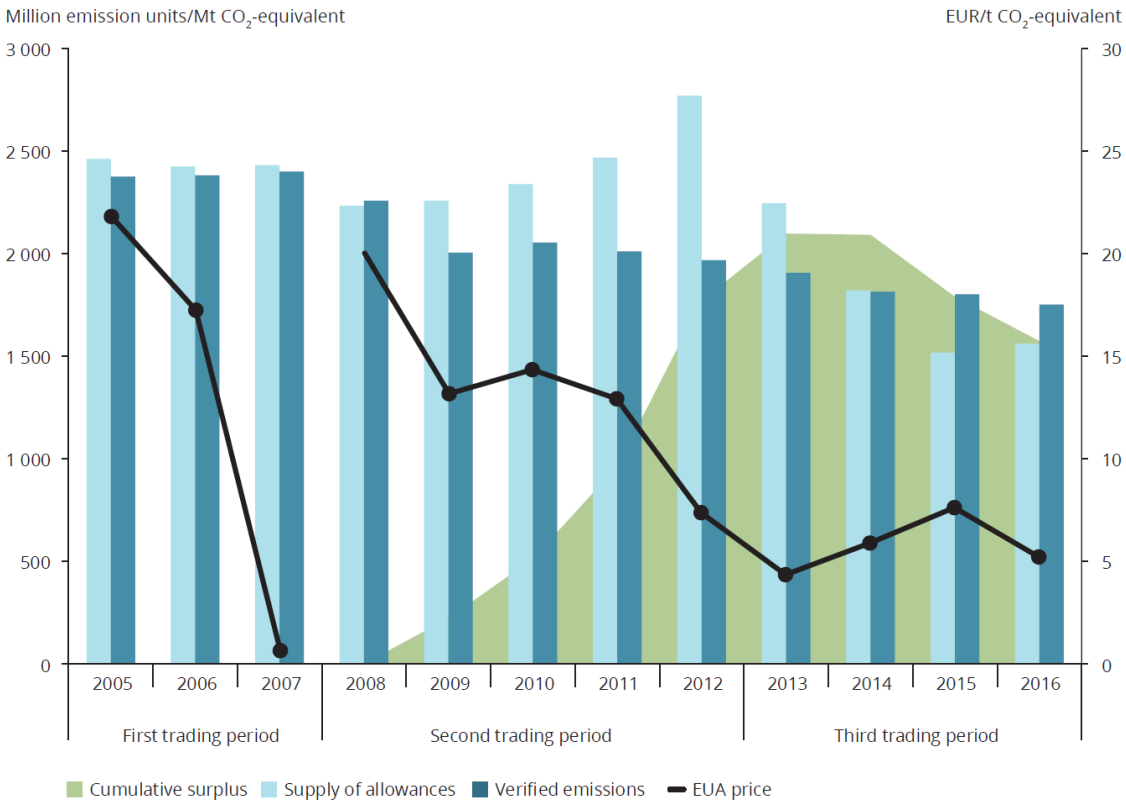


Figure 2.6. Emissions, allowances, surplus and prices in the EU ETS, 2005-2016

Notes: EUA: EU allowance (1ton CO_2eq.). Verified emissions and allocations shown in this figure for the years before 2013 were adjusted by the EEA to be comparable with those from the third trading period of the EU ETS (2013-2020).

The supply of allowances presented takes into account a redistribution, by the EEA, of annual volumes of allowances auctioned/sold on the primary market, from the year when they were released to the market to the years from which they arise. For example, the volumes of allowances relative to the second trading period (2008-2012) but sold/auctioned in the first months of 2013 are added here to the 2012 figures.

The average EUA price represents historical spot price data from the secondary market in the first and second trading periods. In 2008, only EUA spot prices for the second trading period are considered in the calculation of the average. In the third trading period, the EUA price refers to primary market auctioning clearing prices from the trading platforms EEX and ICE.

The break in the EUA price between 2007 and 2008 reflects the absence of banking provisions between the first (2005-2007) and second (2008-2012) trading periods. However, trade in future EUA contracts did take place during this period.

The cumulative surplus represents the difference between allowances allocated for free, auctioned or sold plus international credits surrendered or exchanged from 2008 to date minus the cumulated emissions. It also accounts for net demand from aviation during the same time period.

Source: European Environment Agency, 2017. Trends and projections in the EU ETS in 2017: the EU Emissions Trading System in numbers.

In spite of these efforts, prices in the EU ETS during phase III, as shown in Figure 2.7, were too low to motivate emissions' reductions or to promote the necessary investment towards building a thriving low carbon economy. The initial reaction of the market showed that the proposed reforms of the European Parliament ENVI

(Environment, Public health and Food Safety) Committee alone were inadequate. Additional reforms are required in order to form a more fitting supply and demand balance, so as to bring back prices to more effective higher levels, or regulate prices by instituting auction reserve prices. However, even if these extra actions were put forward, the still remaining cumulative surplus would probably avert any immediate price escalation. In conclusion, it is certainly a fact that prices at the levels of €5 per permit, which were observed during 2013-2017, were far too low to encourage either short term emissions' abatement or longer term investment in decarbonizing technologies, when it is widely acknowledged that prices needs to be at least €40/tCO_2 and even more likely in the range approximately €50 - 100/ton.[15]

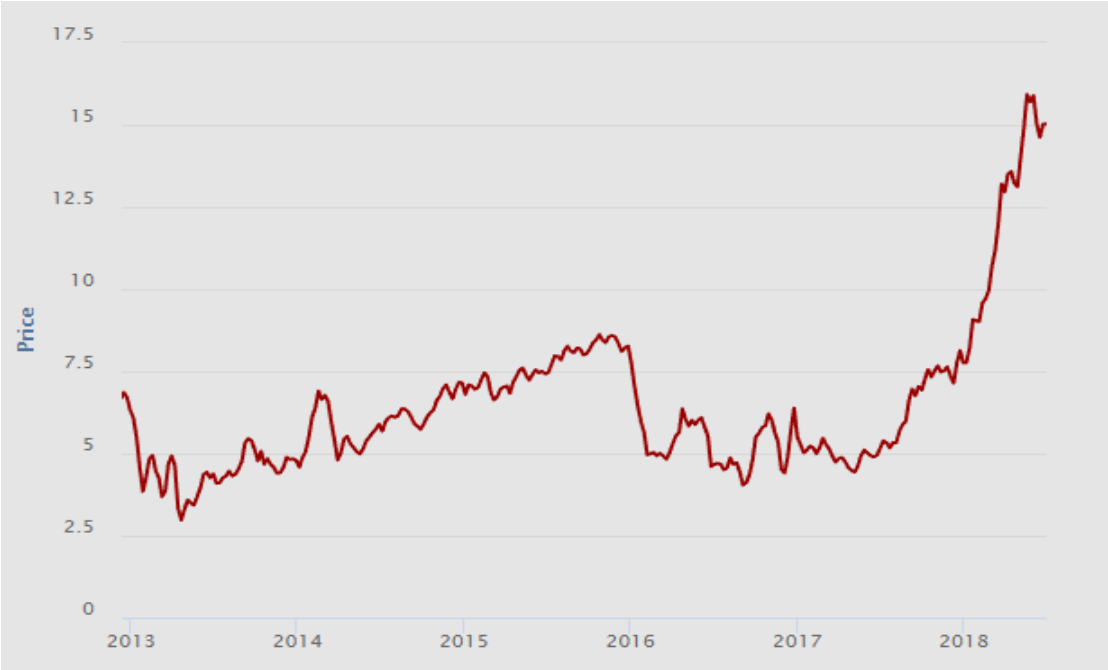


Figure 2.7. Price in €/tCO_2 of EU Emission Allowances | Secondary Market
Source: European Energy Exchange[16]

As for the forthcoming aims of the EU ETS, the EU Commission submitted in July 2015 a legislative plan to revise the EU ETS for the period after 2020. After wide ranging discussions, the European Parliament and the Council officially adopted the amendment in February 2018. The amended EU ETS Directive (Directive (EU) 2018/410) was put into force on 8 April 2018 and set the framework of the EU ETS for

[15] Source: "https://sandbag.org.uk/wp-content/uploads/2017/03/Prices-in-the-EUETS-Sandbag.pdf"
[16] "https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances"

the following trading period, i.e. phase IV 2021-2030. The purpose of this amendment was to ensure that the scheme would attain the EU's 2030 emission reduction objectives in correspondence to the 2030 climate and energy framework[17] and as part of the EU's contribution to the 2015 Paris agreement. The reforms focus on further solidifying the EU ETS emissions abatement potential by increasing the rate of annual reduction of the allowances supplied to 2.2% starting from 2021 and fortifying the market stability reserve mechanism. It was also agreed to continue the free allocation of allowances as a last resort for the international competitiveness of the industrial sectors at the highest risk of carbon leakage, while at the same time certifying that the guidelines for supervising free allocation are centered and exhibiting technological advancement. Additionally, another target of the revised EU ETS was to offer solutions to the industry and the power generating sector in order to meet the innovation and investment challenges of the low-carbon transition through several low-carbon funding instruments.[18]

Apparently, the news of the revised EU ETS had a considerable effect on market prices of EUAs, since we observe from figure 2.7 that prices in early 2018 surpassed the barrier of €10 for the first time since 2011 and even reached the levels of €15 after the new EU ETS directive was put into effect in April of 2018. As for how long this upward price trend will continue it remains to be seen.

[17] The 2030 climate and energy framework sets three key targets for the year 2030:
a)At least 40% cuts in greenhouse gas emissions (from 1990 levels),
b)at least 32% share for renewable energy and c)at least 32.5% improvement in energy efficiency.
[18] Source: “https://ec.europa.eu/clima/policies/ets/revision_en”

3. The Financial Perspective

3.1. Market structure and regulation

The European Union Emissions Trading Scheme (EU ETS) has been operating globally as the first large scale CO_2 emissions trading system. This system has been created in 2003, based on the EU Directive 2003/87/EC. In order to comprehend its general magnitude, it is imperative to comprehend and evaluate the structure and also the regulation governing the EU carbon market.

In this way, this chapter refers to the composition and regulation from a financial perspective of the EU carbon market for emissions allowances, i.e. the EU ETS, as well as how it developed throughout its consecutive periods. In the first section we make an introduction concerning the distinctive nature of the EUAs as new types of financial assets. Following next, we present the development of the market institutions such as the agents that are involved, the types of available transactions and the particular trading platforms that were developed to facilitate the transactions inside the scope of the EU ETS and the carbon markets in general. Finally, we focus on the financial regulation that oversees the EU ETS.

3.1.1. Market structure

By comprehending the innate characteristics of the CO_2 allowances we can better grasp the operation and dynamics mechanisms of the EU ETS carbon market. For this purpose, it is instructive to distinguish CO_2 allowances from regular commodities of financial markets such as stocks. For instance, emission permits can be considered as either an asset or a liability depending whether the covered firm has respectively a surplus or shortage of allowances relative to its actual emission levels.

Presumably, one may think that the carbon market is in general very similar to a traditional stock or commodity financial market. However, having a closer look at the special nature of the products of this market, i.e. CO_2 permits, yields the following important dissimilarities. For start, the value of a stock is founded upon future profit prospects of the firm that issues the shares. Whereas, the price of emission allowances is governed almost in every respect by the anticipated market scarcity caused by the at that time balance of demand and supply, which in turn is highly reliant on the regulations set centrally by the EU. Another significant difference is, that firms by themselves are able to substantial affect market scarcity and consequently the market

price by their abatement actions. Initiating for example emission abatement investments that can relatively cheap reduce large quantities of GHGs can have significant impacts on market liquidity and on price dynamics. Furthermore, as we have already made it clear, the annual supply of allocated emission allowances is predetermined by the EU Directive and its amendments for each trading period. Therefore, in the EU ETS all market participants must abide by these constraints. On the contrary, a company can straightaway change its stocks' liquidity at any time by issuing additional shares or retiring some of them. Last but not least, CO_2 emission allowances have a strictly specified validity period, since they must be surrendered by the installations for covering their verified CO_2 emissions of that particular compliance period. As a result, the value of permits expires after each commitment period, unless they are banked for future compliance periods (banking between phases has been allowed since phase II). Nonetheless, even in that case they will eventually be surrendered and lose their value too. (Benz and Trück 2006, pp. 32–33). This view, though from a more regulative perspective, is shared also by Hill et al. (2008) from the UK's FSA (Financial Services Authority). They consider that the most important dissimilarities in the CO_2 emissions market, compared with other financial markets are, firstly, that it is a politically made and highly regulated market and secondly, that the underlying asset is an intangible allowance certificate, as opposed to a physical commodity.

Also, there is a compliance aspect to the underlying market, in the sense that the covered installations must comply with the regulations of the EU ETS and surrender each year the necessary allowances that match with their actual emissions or else face penalties. However, they argue that none of these aspects make a considerable distinction between this market and other commodities markets or requires a rather distinct approach from the FSA to this specific market (Hill et al. 2008, p. 5). Furthermore, according to the suggestions of the International Accounting Standards Board (IASB), the EU accepted the legal classification of allowances as intangible assets. In other words, emission allowances are assets that exist only as digital accounts in registries. Hence, even if the permits are handled by market participants and regulatory authorities as regular commodities, the physical settlement of relevant derivative contracts can be deemed more secure than tangible assets which require actual delivery. This is explained since emission allowances only require a "book" entry of the transaction in the appropriate registry. Specifically, the Commodity Exchange Act issued by the Commodity Futures Trading Commission and the Banking Act

Implementation Regulation (Article 13-2) explains in an Interpretive Letter (No. 1039, Sept. 13, 2005) by the Office of the Comptroller of the Currency that: "An emission allowance is an authorization or license that gives affected entities the right to emit certain pollutants. It is not solely a license to pollute, however. Emission allowances may be bought or sold by any individual or entity that establishes an account at the relevant governmental authority." It continues clarifying that "for those entities that trade emission allowances or purchase allowances with the intent to 'retire' them (typically environmental groups), emission allowances are not used as administrative licenses, but rather are more akin to intangible contract rights. Thus, a hedge fund that purchases an emission allowance for investment acquires an intangible contract right that may be transferred or sold to other entities. There are no transportation, environmental, storage or insurance risks associated with possession of emission allowances" (Daskalakis et al. 2011, p. 54).

Turning our attention to the types of trading contracts in the EU ETS, there is in fact a wide range of spot, futures, forwards, swaps and options available for trade. Let us first though give some definitions and information about each kind of these financial instruments. When we refer to trading in the spot, we refer to a trade where the settlement (payment and delivery) is planned to take place "on the spot". Normally, the spot date is supposed to be within two business days after the trade date. Therefore, spot trading is reasonably considered as a risk-free transaction for those taking part, as it is unlikely to default on payments over such a short period of time. The settlement price (or rate) is called the spot price. Spot prices differ with each transaction in the market and can change swiftly and unpredictably with changes in information about supply and demand.

As a consequence, those participating in the market search for means to lessen the risk of buying too high or selling too low, which is why there is a hedging market as well. This is where dealers and brokers join the market introducing various buying and selling instruments, called derivatives and thus creating a derivatives market. A derivative can be defined as a financial security with a value that is conditional or derived from an underlying asset. The derivative therefore is a contract between two or more parties based upon the original asset. Naturally it has a price that is strongly affected by the oscillations in the underlying asset's price. Some of the most common kinds of derivatives are the futures and forward contracts, swaps and options.

The key difference of a forward or a futures contract relative to spot trading is that contract terms are settled at the moment of the trade but delivery and payment will ensue at a future date. In particular, a futures contract in EUAs is a standardized agreement between two parties to buy or sell a specified quantity of EUAs for a price decided initially (the futures price or strike price), with delivery and payment taking place at a stated future date, which is called the delivery date. These contracts are traded at futures exchanges, which function as intermediaries between the parties. This fact has two implications; firstly, that terms and conditions are determined separately by whichever futures contract is offered by that exchange and secondly that the intermediary exchange covers the counterparty default risk. A forward contract is analogous to a futures contract in the sense that the contract terms are arranged at the time of the agreement and delivery and payment happens at a later date also predetermined. However, forwards differ from futures in that they are not standardized and occur "over-the-counter", instead of being traded in an exchange, which means that there exists a default risk of the counterparty.

On the other hand, swaps are a type of contract which permits the parties to exchange with each other one security or cash-flow for another. In the commodities market, a swap allows a party to substitute its exposure or risk from "floating" prices to "fixed" prices, or the other way around. However, in the carbon market it usually takes the form of swapping a sum of EUAs for an equivalent amount of Kyoto carbon credits like CERs. As we have already mentioned, both types of units can be used for compliance in the EU ETS (at least for the second phase), but KP's credits (e.g. CDM credits) usually are sold at a discount to EUAs. The seller of the EUAs obtains not only the credits in return, but also the price gap between the two units, in that way decreasing the total cost of compliance in the scheme.

Finally, options are about giving buyers of the option the right, but not the obligation, to buy or sell a designated quantity of allowances at a fixed price and at a specified time in the future. The price of this right is often stated as the option's premium. It is up to the holder of the option to exercise this right or not. A call option gives the buyer of the call option the right to buy a specified amount of emissions allowances at an agreed price in a certain date in the future, which is called expiration date or date of maturity. In contrast, a put option allows the buyer of the put option the right to sell the underlying allowances at an agreed price in the date of maturity. On the

other hand, the seller of a call or put option is obliged to sell or buy the corresponding allowances if the holder of the option decides to exercise it. Options' fundamental purpose is to help stakeholders lock in a price in order to hedge against a potential risk of price movements in the opposite direction of their original expectations (European Commission 2015, p. 71). Nevertheless, they are most commonly used by speculators betting to the volatility of prices, due to the leverage they provide since the premium is an insignificant cost to pay compared to the potential returns.

Regarding the types of market players that are enrolled in the EU ETS, we can generally separate them into two core categories. Firstly, we have the accountable corporations, working largely in the energy and the industrial sectors and secondly the non-liable institutions, such as governments and financial mediators like banks and exchanges. With regard their part as supervisors, in Phases I and II of the EU ETS, national governments prepared and proposed to the Commission the allocation of emission allowances inside their jurisdiction. At the uppermost level, the European Commission (EC) examined and verified the suggested National Allocation Plans in the first two phases. However, from the third phase and on it assumed the authority of allocation planning for all participating countries. On a lower level, the EC Directorate-General for Climate Action (former General Directorate of the Environment and Climate) manages and directs the European Union Transaction Log and applies the designed reformations of the EU ETS.

As for the liable companies, the dominant market force is the electricity generating industry. In fact, owning to the ongoing liberalization development of the European energy producing and distributing sectors, most of the utilities have well-established trading desks already. Thus, the addition of emission permits in their trading portfolios was a reasonably expected outcome. The remainder of the industrial sectors covered by the EU ETS were initially less active on the market. Since permission of entry to the carbon market was not constrained only to liable firms, financial institutions joined the carbon market as well and took a rather active role in the EU ETS. Financial institutions included brokers, banks, insurers, and private carbon funds. The reasoning behind not confining the market only to the covered companies stemmed from the requirement for liquidity in the market in order to increase efficiency. Moreover, financial institutions were expected to act as intermediaries especially for a number of small emitters who were not accustomed with market trading and would prefer to

designate their allowance management to a specialized third party (Chesney et al. 2016, p.33). The only criterion was that the interested investors and financial institutions had to set up an account in the emission registry of any EU member state.

As we have already mentioned, market participants in the EU ETS can trade CO_2 emission allowances in spot, futures and options either over-the-counter or through certain exchange platforms. In the first two phases of the scheme most transactions were in the form of futures. In particular, according to Kossoy and Ambrosi (2010), during 2009 approximately 73% of the carbon trades were in futures, 22% in spot permits and the left over 5% in options. In addition, on average, approximately 70% of the carbon transactions during Phase I of the EU ETS were executed over-the-counter (OTC) (Kossoy and Ambrosi 2010). This means that only the remaining 30% were carried out through trading platforms. These were, the European Climate Exchange (ECX), Powernext, Nord Pool, the European Energy Exchange (EEX), Energy Exchange Austria (EXAA) and Climex Alliance. Most of the exchanged-based futures transactions in Phase I were performed through the ECX, followed by Nord Pool and EEX. As for the spot permits, these were predominantly dealt in Powernext, later Bluenext (Daskalakis et al. 2011, p. 56).

According to Daskalakis et al. (2011), the financial crisis of 2008 and its aftermath raised up fears amid stakeholders regarding the counterparty risk of default in OTC transactions. As a result, carbon trading in organized exchanges, which offered more security began growing comparatively to the OTC ones. In particular, according to data presented by Kossoy and Ambrosi (2010), by January 2010 OTC and exchange-based trades were approximately at the same level (ibid). It is worth noting that with respect to the market shares in Phase II, ECX, which has changed to ICE (Intercontinental Exchange) since 2010, remained the market leader with even increasing its market share to more than 90%. The EUA futures, and particularly those with December maturities, accounted for the most part of the market's liquidity and embodied the bulk of the volume of transactions (ibid., p. 57).

3.1.2. Market regulation

Market regulation refers to the methods and procedures the oversight authorities utilize to guarantee the security and reliability of the European carbon market. This primarily

incorporates a safe and well-organized trading framework and safety mechanisms to avert attempts of market manipulation. As regards to the regulation of the EU ETS, first of all, it is instructive to make a distinction between environmental regulation and policy on the one hand and financial regulation on the other. The prior is related with the market scheme that we have already discussed, while the latter with the operational functions and the reliability and consistency of the market once it has been established. (ibid., p. 58)

During Phase II of the scheme the financial regulation of financial markets in general and especially derivatives and energy markets attracted notable attention mainly due to certain developments in the global markets. Most importantly, this had mostly to do with the financial crisis of 2008-2009. The part that derivatives such as credit default swaps (CDS) and subprime mortgage loans in the form of collateral debt obligations (CDO) played in it, had forced policy makers across the world to undertake thorough examinations of the regulation and operation of financial derivatives markets. The emphasis of the reassessment was predominantly on the lack of transparency and accountability as well as the interrelated risks accompanying the OTC transactions. The financial crisis of 2008 – 2009 highlighted among other things the interrelationship and interconnections between the global financial markets. Thus underlined the need for reevaluating regulations in order to mitigate the potential dissemination of market risks across global markets and cause both energy security and macroeconomic risks. These incidents explained the considerable concern of the financial regulators and policy makers regarding the EU ETS, which of course could not have been remained unaffected by these events. (ibid., pp. 58-59)

As already mentioned, the greater part of carbon trading nowadays takes place in London through the ICE exchange. This puts the UK's Financial Services Authority (FSA) as the financial supervisory body with perhaps the highest overseeing of the carbon market. The Financial Services and Markets Act of 2000 (FSMA) assigns to the FSA five constitutional objectives. Firstly, market confidence, secondly, public awareness, thirdly, financial stability, fourthly, consumer protection and finally, the reduction of financial crime. Based on both the FSMA and the Markets in Financial Instruments Directive (MiFID), the FSA's controlling limits encompass the emission derivatives, but not their underlying EUAs (ibid., p. 59).

Regarding the underlying assets, according to the EU ETS Handbook, the emissions allowances are dealt similar with other standard commodities and financial assets, hence trading of EUAs is subjected to the same EU financial market regulation (European Commission 2015, p. 69). As we have already mentioned, the trading of EUA derivatives is under the regulations of EU financial markets, meaning the presently applicable Markets in Financial Instruments Directive (MiFID). Yet, on the spot trades were not initially included to the same rules and consequently were not overseen and regulated as much as they ought to. As a way to deal with this issue, many organized exchanges "packaged" emission allowances as financial derivatives (e.g. daily futures). This offered traders with the much sought safeties and advantages of trading in financial instruments (ibid).

Naturally emission permits accessible in such a fashion were much more favored by traders over on the spot traded allowances. To tackle this disparity, the reassessed MiFID that has been implemented since January 2018 brought spot transactions also under the EU financial markets regulation. In other words, the new MiFID, or MiFID 2[19], extended the old MiFID rules to also encompass spot trading in the previous framework of EU financial markets.

The rules of the reformed MiFID and the associated Regulation (MiFIR)[20] are applicable to all major parties who trade in emission allowances, i.e. the professional traders, financial institutions and naturally the EU ETS compliance installations. Furthermore, the modified regulations on market exploitation, i.e. the plans for a Market Abuse Regulation (MAR) and a Criminal Sanctions for Market Abuse Directive (CSMAD) are applied to all market partakers and aim to effectively restrain attempts of market manipulation. Rules also safeguard that examinations against money laundering are in position and that transparent information is easily accessible to all market participants. In a summary, these revised financial regulations were put forward in order to deliver a safer and more efficient trading setting so as to further improve confidence and transparency in the EU ETS (European Commission 2015, pp. 69–70).

Transparency is considered as a prerequisite for developing market confidence and eliminating information risk. As a highly politically influenced market, the

[19] Directive 2014/65/EU (MiFID II)
[20] Regulation (EE) 600/2014 (MiFIR)

effectiveness of emissions' trading markets is strongly reliant on the extent and quality of available information about the verified emissions and the allocation of permits. Much of this information is collected, organized and published by the authorities in charge with the operation of the emissions trading schemes (Hill et al. 2008, p. 8). All transactions and changes in ownership of emission allowances are documented by the registries that keep accounts of the allowances or credits, as well as by the EU Transaction Log, which archives all transfers in and out of the EU registry system. More specifically, the EU Transaction Log or else Union registry is an electronic accounting system that certifies and verifies the accounting of EUAs released and traded under the EU ETS as well as international credits from KP's projects. Since, the EU registry system keeps track of a lot of personal data and because it has been the target of thievery in the past, the Commission has put forward new safety instructions in order to prevent any such incident from happening again in the future.

The Union Registry is responsible to catalogue, first of all, the accounts of the Member States, legal entities and natural persons in possession of EUAs or qualified CERs and ERUs. Secondly, it has to keep track all the transactions in relation to those allowances or Kyoto's credits in or out of one of the existing accounts in the Union registry. Thirdly, it had to publish the national allocation plan tables demonstrating in detail the free allocation of permits to each installation and Member State during the phase 2 of the ETS (2008–2012), and also do the same for phase 3 (2013–2020) in harmony with the National Implementation Measure. Fourthly, it records the verified emissions of all compliance stationary installations and aviation operators, as well as the total of allowances submitted by the installations and aircraft operators to cover their verified emissions. Last but not least, the Union Registry documents the annual settlement of allowances and verified GHG emissions as well as the compliance status for each company covered by the EU ETS.

One significant reformation regarding the monitoring and registering procedures, was brought forward by the amendment of the EU ETS Directive in 2009. In particular, this amendment constituted the centralization of the EU ETS operations into a single European Union registry managed by the Commission. This actually started operating in 2012, when the Union registry supplanted all national EU ETS registries that were previously located separately in each Member State and EEA EFTA (European Economic Area - European Free Trade Association) State. Nevertheless,

many organizational affairs such as managing the partakers to the EU ETS and their accounts or carrying out the allocation of permits are still conducted by the competent authorities of the different Member States and the EEA EFTA States. The Kyoto Protocol (KP) distinct national registries have also been combined into the Union registry. According to the Commission, the shift towards the Union registry has accomplished and provided market participants with greater and harmonized security standards. Last but not least, it is vital to remark that the Union registry only keeps records of the EUAs and Kyoto units. This means that it does not track the bulk of financial trades which take place outside the registry, but only the ensuing transfers of allowances or Kyoto units between accounts (ibid., p. 72).

As for the operational and technical characteristics of the Union registry, these are stated in a Commission Regulation (known as the Registry Regulation[21]). Apart from the Union registry, the European Union Transaction Log (EUTL) mechanically examines, records and finally gives permission for every transaction that occurs between accounts in the Union registry. This confirmation procedure makes sure that any transfer of permits is in harmony with the EU ETS regulations. The EUTL is the successor of the Community Independent Transaction Log (CITL), which had an analogous responsibility before the initiation of the Union registry. The EUTL safeguards the integrity of the Union registry and retains records of every transfer into and out of the accounts. For transparency reasons, it is worth to note that all transfers in the Union registry older than 3 years are published on the EUTL public website[22]. The EUTL public website also issues in detail updated information on the free allocation, verified emissions, compliance status and allowances surrendered per unit type on installation level (European Commission 2015, pp. 73-78).

3.2. Carbon price behavior

In this section we present an overall review regarding the development of the carbon prices from the beginning of the scheme until mid-2018. An overview of price trends has already been presented in figure 2.2 in paragraph 2.3.2 but for reasons of

[21] Commission Regulation (EU) No 389/2013. *Details on functioning of the Union registry and the EUTL.*

[22] (http://ec.europa.eu/environment/ets/)

convenience we will again present it here. As we already mentioned, EUA futures prices differed significantly during the first two phases of the EU ETS, especially in late 2006 and during 2007 as shown in figure 2.2, when the prices of phase I and phase II allowances deviated entirely. Since banking of EUAs was not allowed between the two phases, surplus allowances from phase I could not be banked for later compliance years in phase II, signifying that phase I and phase II consisted two separate markets.

When the EU ETS was initiated, it was estimated that the price of EUAs would be between €5 and €10, and the prices in early 2005 proved this expectation to be true. In the following months, the EUA price climbed rapidly to record levels potentially because of the speculative activity from brokerage firms and investment banks and also due to risk-averse behaviors from installations which after all did not know what to expect about actual emission levels since it was the first year of the scheme. Against this initial enthusiasm, the carbon prices came upon a striking downward trend beginning in April 2006 when the word of 'over-allocation' spread in the market a few weeks before the official assessment report of verified emissions from the European Commission by May 15, 2006. Consequently, the futures prices for both phase I and phase II allowances plummeted, by 50 percent and 30 percent, respectively, as explained by Alberola et al. (2008). For instance, during the summer of 2006, the phase I EUAs' price was fluctuating around €15, but when autumn began it became all the time more clear that the phase I verified emissions would be below the cap in the next year too. When this was realized in the market, the prices for phase I EUAs fell to nearly zero levels, while the futures prices of phase II EUAs endured generally in high levels between €15 and €20.

As phase II began, the phase II price increased for a second time in high levels, almost €30, yet once again it fell sharply by about 50 percent as a consequent side effect of the international financial crisis of late 2008. The EU parliamentary Committee on Climate Change (CCC 2009, p. 67) reported two major causes for this drop in prices. Firstly, the reduced output in energy-intensive sectors as a result of the recession that followed the financial crisis and the lack of liquidity and credit in the market. As a direct consequence, less abatement was necessary in order to comply with the cap. Thus, the lower demand for permits had eventually a decreasing effect to the carbon price. Secondly, the market expectations for future fossil fuel prices probably have been readjusted downwards as was to be expected since the price drop was not exclusive to

the EU ETS, on the contrary, many other asset values (e.g., stocks, bonds, natural gas, and crude oil) underwent similar negative shocks. Despite the previous crash of EUA prices, estimations made in 2009 indicated that similar to Phase I, Phase II would encounter an excess quantity in allowances. As a result, 2009 carbon prices would be maintained in lower than normal levels due to the expected banking of allowances in order to be surrendered in the tougher third phase. These projections came out true, since, after gaining some ground in early 2009, the EUA price went through a 2-year period of relative stable prices fluctuating around €15. This continued up until the summer of 2011, when prices fell once more by approximately 50 percent, to a new low of €7–8 in 2012, before falling yet again to around €4 as phase III began (Ellerman et al. 2016, pp. 98-99; Chevallier 2010, p. 4.).

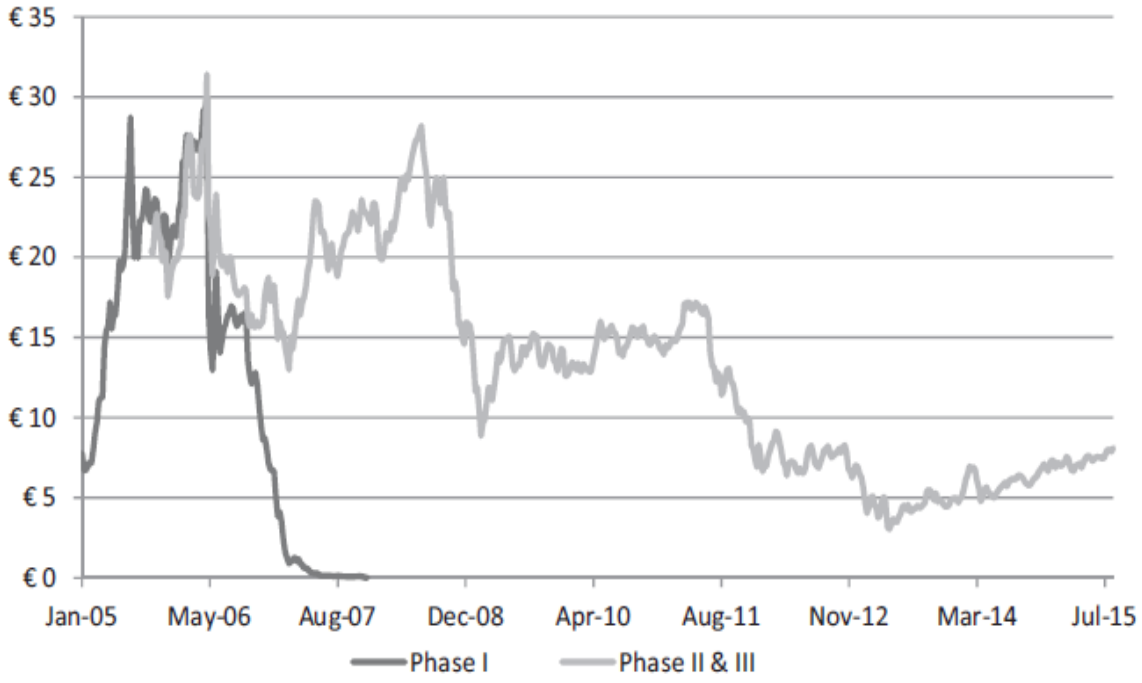


Figure 2.2 December EUA futures prices in phase I and phases II and III.

Sources: Ellerman et al. 2016, p. 98.

Like we mentioned in chapter 2.4, concerning the current phase III (2013-2020), prices remained relatively low at the levels of €4-€8 until the end of 2017 when the news of new more ambitious reforms from the EU commission hit the market. With the adoption of the amended EU ETS Directive (Directive (EU) 2018/410) in April of 2018

EUA prices begun trending upwards through the whole of 2018, as we can observe in figure 3.1.

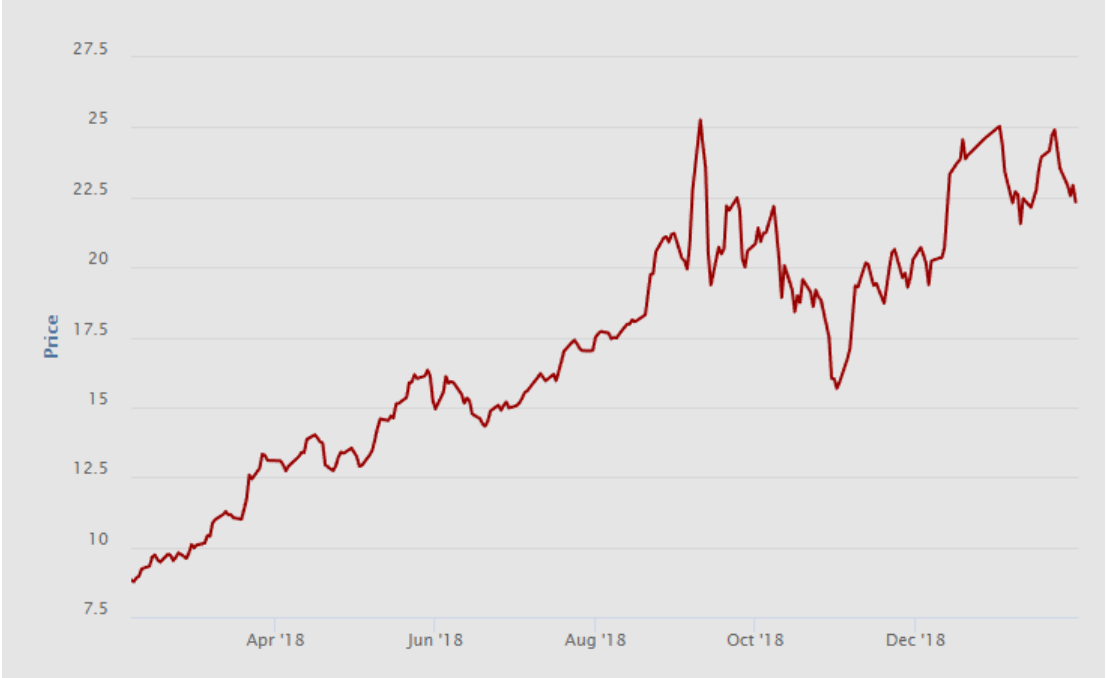


Figure 3.1. Price in €/tCO_2 of EU Emission Allowances | Secondary Market

Source: European Energy Exchange[23]

Until now we have been referring to the most common trading instrument of the EU ETS, i.e. the EUA futures. Following next, we present some insights regarding the options markets for carbon prices, which have been initially launched by the ECX in October 2006 for EUA futures. As for any financial market, the development of liquid options markets constitutes yet another derivative instrument that can be used by the covered installations or the other market participants in order to protect their portfolios against undesirable price movements. Thus, option prices indirectly can imply the different levels of risk-aversion that each market participant represent. In other words, risk-averse agents will be disposed towards covering themselves against high levels of carbon price volatility. On the other hand, risk-lover traders will act in the opposite way, namely they will have a tendency to bet in favor of sudden price shocks, especially

[23] "https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances"

around compliance events, so as to make high net profits. As for risk-neutral agents, such as public sector's utilities regulated by the scheme, they may also prioritize offsetting the effects of carbon price variations during compliance events by using call or put options in advance fixating the price in accordance to their expectations and position in the market at that time. It is worth remarking Chevallier (2010) who reports that call options are more actively traded than put options for ECX EUA and ECX CER futures contracts. Chevallier et al. (2009) explained this behavior due to the fact that the foremost fear of most market agents on the carbon market is that of increasing prices. On such markets, there is a high demand for buying call options by risk averse agents and therefore the easiest way for risk seeking agents to speculate against this behavior is by selling call options. (Chevallier 2010, pp. 12-15).

3.3. Inquiry into possible price determinants

In this chapter we focus on presenting a review of the literature which is concerned with inquiring into possible EUA price determinants, so that the changes in prices can be better understood. Naturally, being a market-based instrument, the EU ETS price reflects the equilibrium between the demand and the supply of emissions. Therefore, an over/under-supplied market has to be reflected in a low/high price respectively. By default, the supply side of the market is determined by EU policy decisions such as the level of the emissions cap, linkages to other emission markets, allocation of permits and rules about banking and borrowing between phases. In this section, though, we focus on the elements that affect the demand for allowances. We begin by presenting the fundamentals that characterize the EUA price and then we proceed to demonstrate the empirical literature that intends to quantity the magnitude to which variations in these fundamentals influence the allowance price.

The fundamentals that in principle govern the allowance price can be separated to those that affect the actual emissions and to those that determine marginal abatement costs. Starting with the former ones, as we have already mentioned, one primary driver of the demand for permits are the actual verified emissions in the industries covered by the EU ETS. These emissions are in turn propelled mainly by economic growth, industrial activity, the economy's energy efficiency and carbon emission intensity (i.e. emissions per gross domestic product [GDP]). In the short term, emissions are also

affected by weather conditions through their effect on the demand for energy for heating or cooling as well as on power generation from renewable sources like wind and solar energy. The second driver of allowance prices are the available abatement opportunities and their respective costs. Based on survey data, Heindl and Löschel (2012) found that during phase II the most popular abatement options were those of process and operational optimization and investment in energy efficiency. Because these investments affect the price level of allowances but not daily fluctuations, the literature focuses on fuel switching between coal and gas as the most applicable short-term abatement option (e.g., Christiansen et al. 2005; Kanen 2006; Bertrand 2014). Therefore, the cost of carbon emissions (i.e., the allowance price) should induce fuel switching between all available generators as long as the implicit abatement cost does not exceed the allowance price (Hintermann et al. 2016, pp. 109-110).

According to Christiansen et al. (2005), the robust explanation of EUA price can be based on the growth of solar and wind electricity production and also on variations in economic activity. We must say that energy variables are considered the most natural determinants and we can understand that by the magnitude of the electricity sector, which accounts for almost 39% of the European CO_2 emissions that are covered by the EU ETS regulation. However, institutional determinants have shown equal importance especially during Phase I where price patterns have been strongly impacted by institutional regulations, news and reforms. Among many researchers, Alberola et al. (2008) examined this impact between the so called "compliance break" (i.e. in May 2006 when the verified emissions of 2005 where announced and the over-allocation of permits by the NAPs were evident) by using sub periods, one before the event (June 2005–April 2006) and the other after it (May 2006–April 2007). The results suggested that policy proxies were the main driver of carbon prices before the aforementioned event, while energy fundamentals accounted mostly for the carbon price variations henceforth (Creti et al. 2012, p. 328).

The research of Creti et al. (2012) extended this field of research, meaning that of investigating into possible price determinants for the first and the second phases of the EU ETS. Firstly, they decided to use as data the prices of daily futures contracts which were more traded and less sensitive to the initial policy and the relative frequent structural changes that have occurred on the spot market over the whole period under their examination, i.e. from the June of 2005 to the December of 2010 (Mansanet-

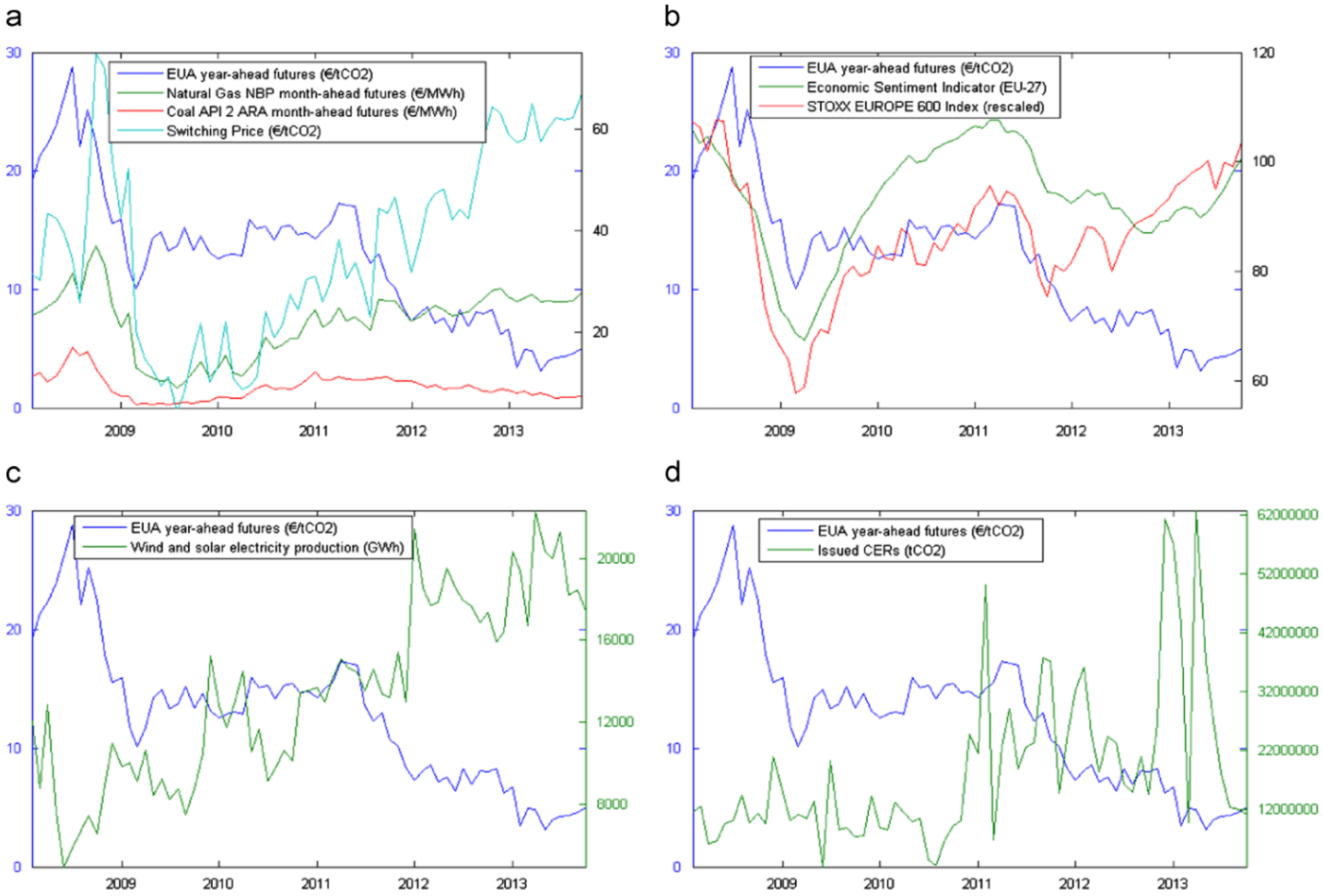
Bataller and Pardo 2008). Secondly, they aimed at explaining the dynamics of these futures carbon prices, based on their main determinants according to the related literature such as energy prices and economic growth. They used a European equity futures index in order to proxy the economic environment. As for the Energy prices they considered two variables. The first one utilizes the oil price and is represented by the ICE Brent futures index, taken from the European Climate Exchange database. As for the second, they quantified the abatement opportunities through fuel switching by calculating the price of allowances that equalizes the marginal costs of gas and coal-fired power plants, i.e. the switching price from coal to gas. Hence, assuming that each installation has the possibility to switch from high to low cost fuel inputs, differences in the fuel prices affect directly the technology for electricity production, thus fuel demand and consequently the demand of EUAs too. To put it more clearly, if the EUA price is below the switching price, there is an economic advantage to use coal-fired power plants even in the context of a carbon-constrained system like the EU ETS. Moving forward, the researchers employed the cointegration methodology to investigate the existence of a potential long-term, equilibrium relationship between the carbon price and its determinants. Moreover, they aimed to evaluate the presence of the same carbon price drivers in Phase I and Phase II and also their relationship. By using as we stated, cointegration techniques in their research, they came to the result that "while a cointegrating relationship exists between the carbon price and its fundamentals during Phase II of the EU ETS, such an equilibrium relationship can be obtained for Phase I only if the 2006 structural break (compliance break) that occurred on the carbon market is accounted for" (Creti et al. 2012. p. 328). Furthermore, they emphasized that on the whole, equilibrium relationships were presented in both phases, although the nature of this relationships was different for the two sub-periods, since for example the switching price was not statistically significant for the first phase. Apart from that, all the included explanatory variables, namely, oil price, equity futures price index, and the switching price between gas and coal were significant determinants of the carbon price in the second phase of the EU ETS.

Lastly, we focus on the work of Koch et al. (2014), which tried to shed light on the sudden and persistent decline of the EUA prices in Phase II and early Phase III of the EU ETS, i.e. from mid-2008 until mid-2013. In their paper, Koch et al. (2014) argued that this price drop might had been justified by three commonly identified

explanatory factors: the economic recession, supplementary EU renewable energy sources (RES) policies and the use of international credits (CERs) as offsets. These factors presumably led to an unexpected decline in verified emissions, thus lowering the demand of EUAs significantly. However, they suggested that it is difficult to determine to what extend each of these factors separately was responsible for the actual reduction of emissions. More importantly their research results concluded that the EUA price dynamics could not be solely evaluated and explained by fundamentals of the marginal abatement cost theory, such as the aforementioned, since the explanatory variables of their model accounted only for a 10% of the total carbon price variations. Nevertheless, among this 10% the most significant explanatory variables were those representing economic conditions especially in the form of the Economic Sentiment Indicator (ESI). Secondly, they found that the growth of solar and wind electricity production is the next most important determinant of EUAs price drops. As was expected the coexistence of RES deployment targets and the EU ETS work at cross – purposes, i.e. they are overlapping policies and therefore there is a negative competitive relationship between the two. However, the magnitude of this relationship was much less than the previous literature suggested. As for the use of CERs as offsets, the relationship with the EUA price was of minor importance. Finally, they urged for further inquiries in order to find the true EUA price determinants suggesting "that a key issue for future research is to verify whether structural weaknesses – and a lack of credibility in particular – are at the root of the inefficient carbon pricing mechanism." (Koch et al. 2014).

One thing is certain though, that the lack of flexibility at the supply of EUAs, i.e. in the determination of the EU ETS cap and the free allocation of EUAs, and furthermore its inability to adjust to the radically changing economic environment, threatens to undermine the project's efficacy in providing incentives for actual emissions abatement.

Figure 3.4 - Evolution of EU Allowance (EUA) prices (on the left y-axis) jointly with (a) fuel (switching) prices, (b) indicators of economic activity, (c) the deployment of electricity from renewable energy sources and (d) the amount of issued Certified Emissions Reductions (CERs) (on the right y-axis, respectively).



Source: Koch et al. 2014.

3.4. Review on modelling carbon prices and derivatives

In this chapter we focus on reviewing the recent literature regarding the modelling of carbon prices and derivatives. For this reason, we will present the research scope, as well as, the main findings and conclusions of some recent researches, so that we can have a general picture regarding the predictability and the uncertainty of the EUA prices in the future.

In their research, Paolella and Taschini (2008), carried out an empirical analysis on the returns of the CO_2 market in EU ETS, using the data of daily spot prices of the

EUAs from the early pilot phase. They argued, that the main factors one needs to have in mind in order to create risk management and hedging strategies are the forecastability and also the knowledge of the underlying distribution that characterizes the prices of EUAs. The purpose of their research was therefore to investigate what kind of model could best explain the variations of the data and also provide accurate predictions for the future development of EUA prices and their volatility. For this reason, they employed several conventional GARCH-type models with certain alterations in order to deal with the unique characteristics of the data. Subsequently, they tested the goodness of fit of these models as well as the quality of the forecasted risk measurement in the form of value at risk (VaR). Nevertheless, no model resulted in adequately accurate forecasts. Some may argue that the data set used—which covered only the period of the first year of the scheme—is not large enough for any reliable econometric estimation of GARCH-type models. However the authors suggested that the problem might have something to do with some kind of misspecification of the models. Consequently, they tried to address this issue by using another parametric model which put more weight on the short term and on the negative returns. The insight behind this alteration was that the EU ETS was a rather new market, which was highly influenced in the short term by the announcements of the regulatory authorities and due to its high uncertainty, market participants reacted stronger to negative rather than positive shocks. The results of this final model were overall much better than the previous non-weighted ones and specifically its forecasting ability was improved significantly (Paolella and Taschini 2008).

Next, we refer to the study of Daskalakis et al. (2009), who also undertook an empirical analysis on the returns of the EUA prices, using the data of both spot and futures prices from the most liquid market exchanges of that time, i.e. the European Climate Exchange (ECX), Nord Pool and Powernext. In their analysis they focused on explaining the implications incurred in the futures prices from the prohibition of banking of EUAs between Phase I and Phase II. Evidently, one may observe these implications from the gap of futures prices between the contracts that matured in December 2007 and those that matured in the next phase as shown in figure 2.2. Driven from these grounds, Daskalakis et al. (2009) structured their own empirical and theoretical models in an effort to explain the pricing of EUAs and their derivatives which are tradable either inside a period or in between two distinct periods.

Subsequently, some of the key findings of their research are presented. Regarding the spot prices, the analysis had showed that they were characterized by jumps and non-stationarity and they were better estimated and predicted by the application of a Geometric Brownian motion amplified by jumps. As for the futures pricing, like it was expected, the prohibition of banking of EUAs between the different phases of the scheme yielded serious negative implications. Particularly, the intra-phase futures were adequately explained by the classic cost-of-carry model with zero convenience yields. However, in the case of interphase futures a two-factor model that uses a jump diffusion process for the underlying asset and a stochastic, mean reverting convenience yield should be employed. Hence, the pricing mechanisms of intra-phase and inter-phase futures vary significantly. More importantly, the complexity in inter-phase futures market due to the restrictive banking rules, implies very high uncertainty and hedging costs, thus hindering the primary goal of the EU ETS, i.e. the inducement of efficient emission abatement at the lowest possible cost (Daskalakis et al. 2009).

Last but not least, we present the research of Cetin and Verschuere (2009), who in turn proposed a model for trading in EUAs and their derivatives in the EU carbon markets. They carried out an approximation of the spot prices of carbon allowances by utilizing the arbitrage relationship that was presented in forward prices due to the banking restrictions between the two periods. They also assumed an exogenous price process for the forward prices. Since they used data from the first period only, they decided not to include any kind of assumptions in their model regarding the banking of permits between periods. Nevertheless, they provided certain modifications that can be applied to the original model in the scenario that banking of allowances is permitted. The main methodology employed comes from filtering theory, which they use in order to estimate the spot prices of EUAs and also to propose hedging formulas by the use of a local risk minimization approach. They also took into account the effect of intermediate announcements regarding the net position of the EU ETS had on the prices in the form of jumps (Cetin and Verschuere 2009).

3.5 Evaluating the effectiveness of the financial carbon market

In the last section of this chapter we will proceed in a brief overview of the literature which focuses on the assessment of the effectiveness of the financial carbon market.

Based on all of these reports and research material of the literature it is understood that much ink has been spilled regarding the issues of the carbon market and most importantly its under question effectiveness. After all, the development of a new global financial market, which concerns CO_2 emission allowances goes hand in hand with the very important and necessary scientific and political dialogue.

Moving forward, according to the research of Daskalakis and Markellos (2008), several relevant research papers have been published in the economics literature on the alternative emission allowances market mechanisms, policies and their implications. However, very little research has been undertaken from a financial market perspective. Specifically, an important question that has not been addressed yet is whether the chosen mechanics of the EU ETS have allowed the market to operate efficiently during the first two years of its life. In other words, the authors endeavor to test whether the emission allowance prices reflect all available information to the extent that no investor can systematically gain excess returns. Investigating this issue is crucial, since the prime aim of the EU ETS is to allow the participating countries to achieve environmental compliance in a cost-effective and economically optimal manner, both of which implicitly require that the market itself is efficient. Moreover, the liquidity of the EU ETS depends substantially on whether the system manages to establish a reputation as a well-functioning and efficient market.

Concerning their methodology, the efficiency of the European market for CO_2 emission allowances has been examined by analyzing different trading strategies and econometric testing procedures based on naïve forecasts (random walk forecasts and buy-and-hold approach) and also technical analysis rules. By their empirical results it is demonstrated that the market is inconsistent with weak form efficiency. One of the most important factors for this inconsistent character is found to be the restrictions imposed on banking of emission allowances and also on short-selling. These results are considered crucial for carbon hedge funds, passive or active investors in the emerging sector of energy and also for risk managers, policy makers and emission intensive firms (Daskalakis and Markellos 2008).

More specifically, in their research, Daskalakis and Markellos (2008) concluded that their empirical analysis entailed that the emission allowance returns were serially

predicable and that simple trading strategies could be used so as to take advantage of these predictabilities and to produce substantial risk-adjusted profits. The main factor for this was argued to be the infant status and in this way immature character of the market. Also, they highlighted specific problems, which concerned the liquidity of the market and the reduction of the number of participants, due to the regulatory framework for speculators, arbitrageurs and hedgers. Another serious factor for the reduced liquidity was the presence of complications by the prohibition of banking allowances. Last but not least, they highlighted that the lack of liquidity is in favor of the largest market players of the EU ETS, i.e. the electricity generator companies, for two possible reasons. First, they were in a better position to calculate more accurately the overall market position and therefore to exploit any potential inefficiencies. Second, they might have been able to exert market power either individually or through tacit collusions and therefore to manipulate the market with serious negative implications.

Eventually, their presentation of the performance of the EU ETS in its early years can be viewed in a critical way on the lack of ability to establish a reputation as an efficient and also a well-functioning market. It can be understood that the EU ETS is considered a very young market, but very important differences in terms of pricing, information, liquidity and stakeholders may exist between regional exchangers and in many cases between futures and spot markets. The growth of liquidity is very important for market efficiency according to Daskalakis and Markellos (2008), and that is why individual investors and non-emitting firms have been allowed by the EU ETS to engage in carbon trading.

In a subsequent paper, Daskalakis (2013), continued his previous research regarding the efficiency of the EU carbon market using the same methodology as before and drawing on new evidence from phase II of the scheme. The main findings of his research for the years 2008 and 2009 coincide with the results of his previous paper regarding phase I (Daskalakis and Markellos 2008). However, the results from 2010 and onward suggested that the EU carbon market is becoming more mature, due to the fact that the data were consistent with weak market efficiency.

4. A Critical Assessment of the EU ETS

4.1 Compliance or speculation

It is common knowledge that the EU ETS is presented as the most prominent tool in the arsenal of the European policy in the fight against climate change and the necessary transformation of the European economies into environmentally sustainable ones. However, its poor results and controversial performance as well as the regulatory issues of the original design of the system has led, even before the beginning of the project, to a serious debate regarding its capacity and its actual impact in the targeted transition of the European economies to be less dependent on fossil fuels. That is why many researchers try to answer if it actually led to more compliance or speculation.

As we have already discussed, the cap-and-trade program functions as a market system where the supply of the product, i.e. the emission permits, are constantly decreasing. This is supposed to create an increasing deficit of allowances and thus leading to higher compliance prices in order to motivate abatement and fuel switching away from coal. In spite of the critic against the EU ETS, it is a fact that since the entry into force of the ETS, Europe responded to its emission reduction targets. The big question however is whether the EU ETS played the decisive role in this endeavor, especially when we have observed that for the most part of the scheme the prices were too low to give incentives towards emission reduction. Many proponents of the scheme have argued that the relative low coal prices can be explained, at least to an extent, by the achievement of the targets and the switch from carbon to other energy sources. In other words, when the demand for coal decreases while its supply does not adjust as quickly, then the price falls. However, many in Europe want higher and faster results. Many politicians, analysts and academics are not satisfied with the simple approach to just stay below the cap of the target, which is also as many of them argue really conservative. They would prefer a higher price for coal as well as for carbon allowances which would most probably lead to major changes in the energy market, resulting in turn in the necessary emissions reduction not only for the EU but for the whole world.

Coming back to our topic, we can definitely argue that there is a compliance and a speculation aspect to the underlying market of the EU ETS. This can be attributed to the foundations of the market itself and the two distinct types of market players

related with the EU ETS. Firstly, there are the regulated heavy emitting installations, which are obligated to comply with the annual delivery of allowances equal to the amount of their verified emissions, and then we have the non-liable financial institutions and agents, which are not bound with any such obligations. As we have already stated, the reasoning behind not restricting the market only to the under compliance agents is due to the much required liquidity in the market in order to have more competition in the development of a fair price. In other words, the participation of as many financial institutions and other unrestricted agents was viewed as a necessary requirement in order for the carbon market to operate efficiently.

Characteristic for the purpose of this chapter is the research of Berta et al. (2017), in which the authors analyzed the transactions in the European carbon market in respect with the question in hand, namely, whether the EU ETS led actually to compliance of the covered installations or rather to mostly speculation. As it is presented, the main aim of the EU ETS is to help regulated installations in the effort to cover their CO_2 emissions, with the use of trading of allowances. Moreover, they argue that the EU ETS is mainly a financial market used for hedging and speculation. They highlight though, that this financial feature which is regarded as the solution (hedging and liquidity) to the problem (the price risk and volatility imposed on installations) is actually fueling the very same problem by itself. In other words, the problem of high price volatility and uncertainty is caused by the supposedly solution of the derivatives financial market, hence leading to more speculation rather than compliance.

Berta et al. (2017) have tried to estimate the true needs of the covered installations for transactions in allowances in the first two phases in order to achieve compliance with the set of regulations of the scheme. Through their analysis they have deduced that the transactions made solely for compliance reasons stayed rather constant while the volume of market transactions grew rapidly as time went by. On the contrary however, speculation transactions grew exponentially and with them grew the carbon price volatility, sabotaging in this way the theoretical justified role of the carbon price as a signal for cost effective emissions abatement. Inspired by Keynes' (1936) famous analogy[24] and paraphrasing to match their context, the authors very well stressed that,

[24] 'Speculators may do not harm as bubbles on a steady stream of enterprise. But the situation is serious when enterprise becomes the bubble in a whirlpool of speculation' (Keynes 1936, p. 159).

"compliance transactions have become a very light bubble, drowned entirely in a whirlpool of financial speculation" (Berta et al. 2017, p. 589). Therefore, in contrast with the thesis of the proponents of the scheme, that the increasing volume of carbon trading is a considerable positive sign of success, Berta et al. (2017) argue through their evidence that this general increase actually exposes the rising disconnection with its original reason of creation.

Their critique did not stop at this point though, i.e. the "wrong" usage of carbon trading for speculation rather than compliance transactions. Instead they dived much deeper and suggested that even if the market was set up "right", so as to promote mostly compliance transactions, it would have provided at best short term incentives for emissions abatement through cheap solutions, rather than the necessary long term investments for cleaner and sustainable forms of energy. In this way, Berta et al. (2017), share the opinion of other scholars (e.g. Lohmann 2010; Lawson 2012; Vlachou 2014) who are critical towards the EU ETS as the appropriate policy instrument that will facilitate the required structural changes to switch to a low carbon economy, even more so from the fact that it produced distributional injustice and generated large windfall profits for some of the biggest emitters.

Moving on, we refer to the paper of Spash (2010), in which a comprehensive critical assessment of ETSs in general is presented. Amongst his overall critique towards the ETS he also highlights that due to inherent design flaws and speculative trading we observe high price volatility, which in turn compromises the aim of stability of the market. According to Spash (2010), price volatility is inherently generated by the short term economic and market trends in other interrelated markets, such as coal and gas, as well as by other unstable variables like weather and political uncertainty. This uncertainty is enhanced by the speculators who thrive in such situations seeking purely to gain quick profits by exploiting the large price volatility. Therefore, we can definitely affirm that the EU ETS did not provide the regulated industry with the required certainty about future carbon prices in order to promote cost efficiency in emissions abatement. On the contrary, it actually led to more speculation, short term profiteering and instability undermining by itself the advocated true hedging and compliance behavior by the actual stakeholders of the scheme.

4.2 Market failures

As we have already stated at the beginning of this paper, the conception of international carbon trading and the EU ETS in particular, as a means to reduce GHG emissions in the most cost effective way, was based upon the ideas of the influential economist Ronald Coase. According to Coase "pollution is doing something bad and good. People don't pollute because they like polluting. They do it because it's a cheaper way of producing something else. The cheaper way of producing something else is the good; the loss in value that you get from the pollution is the bad. You've got to compare the two. That's the way to look at it."[25] To put it in other words, Coase's idea is that pollution is just a factor of production necessary in the production process in order to produce other goods efficiently and thus it should be treated as another resource or commodity with the appropriate price attached to it. Exercising the right to pollute naturally involves that some losses (social cost) will be suffered not necessarily from the one who utilizes this right but in most cases by many others. But if we want to measure in some extent these losses the best way to achieve this according to Coase, is just like with all the other goods and services, that is by letting the market forces to decide the appropriate level of pollution and its associated compensation in order to be allowed to be exercised. Hence, if the market is a perfect market, if it has no transaction costs and is populated by properly calculating and utility maximizing economic agents with perfect information, the pollution level and the price of it will be determined in the way that encompasses the highest augmentation to society's total product. The most interesting part in Coase's theory is that the concept of responsibility is of no economic use at all, in the sense that, in a perfect market with zero transaction costs it does not matter whether the agent who causes damages is held liable for them or not because the broader economic result at the end would be the same.

The big question however is whether in reality markets in general appear to be consistent with the perfect and abstract structures that most economic theories present them to be. The answer of course is no, and Coase himself who always had a pragmatic point of view rightly stressed that a perfect market is only a figment of the imagination. Because all the necessary assumptions of zero transaction (bargaining) costs, perfect

[25] 'Looking for Results: Nobel Laureate Ronald Coase on Rights, Resources and regulation', *Reason* magazine, January 1997, https://reason.com/1997/01/01/looking-for-results.
Coase, The Firm, the Market and the Law, op. cit. supra note 68, p. 155

information, no market power differences, and efficient markets for all related goods and factors of production, are actually too utopian to ever exist in the real complex world. In reality transaction costs are pervasive, information is never perfect and complete, market power is the norm, and most markets for final goods and productive factors do not meet the requirements for perfect competitive efficiency. In short, there is seldom any reason to suppose that letting the market deal with externalities like pollution will produce a good outcome. Definitely, government imposed solutions, such as restriction laws and limits on emissions have their disadvantages, too. As Coase pointed out back in 1960[26], the only sensible way ahead is to look at the individual case carefully and decide which approach is likely to work best. If it is a big, complicated dispute that involves thousands of different parties, regulation or taxation, or a mix, is often the best remedy. If it is something smaller, with fewer people involved, the parties themselves might be able to work it out more efficiently. [27]

Coase's "successors", such as the economists J. H. Dales (1968) and T. Crocker (1966) modified pollution trading theory further. While continuing to emphasize the importance of giving polluters rights to pollute, they bypassed the theory of Coase about "optimizing" pollution through merely trading. According to them, it should be up to the government, not an imaginary "perfect market", to set the best overall level of pollution in the first place. In their hands, pollution trading took the form of finding the most cost effective way to reach an emissions reduction goal that had been already set in advance.

However, according to Lohmann (2006), the advocates of carbon trading in their effort to demonstrate all the "efficiencies" that it supposedly entails tend to hide under the carpet a lot of its "inefficiencies" as well. For instance, few have tried to estimate the costs that follow the setting of such a scheme as the EU ETS. That is the costs for all the necessary bureaucratic infrastructure, for setting up a legal framework, for measuring, reporting and verifying the actual emissions and so forth. Trading might sometimes be the single slowest and inefficient way of attaining goals, such as drastically reducing GHG emissions, which require sweeping structural changes in society and in the production process. It is also inefficient when the necessary

[26] 'The problem of social cost' (Coase 1960)
[27] https://www.newyorker.com/news/john-cassidy/ronald-coase-and-the-misuse-of-economics

conditions for trading which in our case are measurement instruments, legal institutions and so forth are at best inadequate. Lohmann (2006) also stresses that those who claim that carbon trading is the more efficient way of reaching environmental goals do not clarify for whom exactly and in which way it is exactly more efficient. (Lohmann 2006, pp. 55-57, 72)

Nevertheless, the EU ETS was created in the aftermath of these theories and the previously ongoing international debate regarding the best way to deal with the consequences of climate change and particular of global warming. Its actual operation though resulted in many market failures among which the most prevalent perhaps was the inadequacy to establish a stable and reliable enough price in order to incentivize the advocated cost effective emissions abatement and more investments in low carbon technologies. Of course the responsibility for this failure falls at the hands of the regulatory authorities which did not manage to impose a strict enough cap at least bellow the actual emission levels. As a result, the oversupply of permits in the first years caused carbon prices to sink. Generally, carbon trading has not had a steady course all along as it has suffered from volatile carbon prices; systematic fraud; unreliable and unverifiable reporting and monitoring; profiteering and windfall profits; and most importantly, EU's GHG emissions have inadequately reduced and at the same time global GHG emissions have continued to rise.

More specifically, regarding its emission abatement objectives and the set of a realistic cap in emissions allowances, the outcome of the first trial phase of carbon trading in 2005-2007 was not encouraging. This can be better understood by presenting certain facts from official data. For instance, the cap of emissions and therefore the allocated allowances in 2007 was at 2,298 million tons of CO_2 which was 8.3% higher than the verified greenhouse gas emissions of 2005. This of course, together with the fact that banking of allowances was restricted only for the first period translated quickly in the crash of carbon prices in the first phase of the scheme as we have already presented. As a consequence, companies of this period were free to increase emissions, or in most cases sell them to gain large and quick profits. The reasons behind this divergence can be attributed partly to the non-existence of preceding reliable data regarding the actual emission levels of the covered installations and the free allocation of permits in the basis of what is called "grandfathering" of allowances to the business as usual levels. This fact though, could only be held accountable just for the first years.

It certainly could not justify the overestimated cap of the next periods. Most scholars agree that one of the main reasons behind this divergence between the cap and the verified emissions was the industry's lobbying efforts that put pressure to the European and national political establishments against setting higher and effective targets in order to avoid short-term investments in emission reductions. The lobbying was apparently so effective that at the end they did not achieve only that, but they managed to convince the authorities to allocate them all the permits for free which ultimately turned out with the previously mentioned expected results. The free allocation of allowances meant that power generators received windfall profits since they passed their compliance costs to consumer prices and sold the permits in the secondary market gaining huge revenues without making any emissions abatement. According to UBS Investment Research, the first phase of the EU ETS "has probably contributed to €10–20/megawatt-hour higher power prices with a very significant redistribution of value from consumers to producers and between companies." The results of the EU ETS were apparently so contradictory with those that were advertised that even financial analysts stated that the "competitive advantages bestowed by handouts of assets under the EU ETS simply cannot be justified from a climate policy point of view." (Lawson 2006, pp. 92-93).

In addition, at the second phase spanned in the period of 2008-2012, the average CO_2 emissions cap was inadequately only 2% lower than the 2005 emission levels. Because of this and the fact that free allocation continued to transpire, with only few exceptions, there were so many unused allowances banked from the over allocation of previous years that most industries covered by the EU ETS could legitimately avoid carrying out any cuts at least for several years in the future. Moreover, the linking directive allowed the use of Kyoto Protocol's flexible mechanisms, like the Clean Development Mechanism, to be used as offsets by the covered installations against domestic emission abatement. Therefore, the EU covered companies could invest in such projects outside Europe and earn the analogous certificates (CERs) which gave them the right not to actually reduce their emissions in Europe or to even increase them in some cases, as long as they surrendered the required amount of certificates to cover for their overexposure. This offsetting option most certainly failed to deliver domestic cuts but often even failed to reduce emissions to developing countries, where the investments were made, due to the controversial design, function and inadequate

measurement and verification standards of these mechanisms (CDM). Instead in many cases led to serious environmental and social problems in those countries.

We should of course not forget about the financial crisis that hit global markets in 2008 and it definitely affected carbon markets too. During the financial credit crisis of 2008-09, most covered companies used their EU ETS allowances to raise cash that was otherwise hard to obtain due to the unavailability of bank credit and lack of liquidity in the banking sector giving them a significant but unfair competitive advantage versus the businesses outside the EU ETS, such as the renewable energy industry, which did not had that option. Summarizing, due to a combination of continued over-allocation at the start of Phase II, inflexible cap setting and the economic downturn since 2008 which naturally had a negative effect to emissions, companies managed to bank up a massive amount of surplus permits by the end of Phase II and carried them over to Phase III. Also by using almost to the maximum extent the allowance of offset credit purchases during Phase II, they effectively managed not to make any significant abatement and to carry even more permits in the next period. In full, a large proportion of Phase III reduction effort for at least many years would be achieved solely by using the spare surplus permits and credits from Phase II and would substantially reduce the requirement to actually cut emissions within the EU.

With regards to several other issues concerning the financial markets, the UK's FSA in a series of reports has identified a range of risks related to commodity markets in general but very much apply to carbon markets too. These include the: (1) market foundation risk, (2) market abuse risk, (3) market infancy risk, (4) information risk, and (5) liquidity risk. The problem is that most of these risk factors relate strongly to the underlying markets of EUAs but have the potential to disseminate in the emission derivatives markets (Hill et al. 2008). Furthermore, the FSA observes that the price collapse of the EUAs that occurred in April 2006 highlighted not only the "market foundation risk" from the overly generous caps and over allocation of free permits but also, underlined the potential "market confidence risks" of disorderly release of information from both the administrators of the EU ETS and the politicians responsible for the market design for the future phases of the market. Another serious issue concerned financial crime, in particular, tax evasion through the so called "Missing Trader Intra-Community" or "Carousel" fraud. This practice involved charging VAT

on transactions but not passing it on to authorities and has been observed in various contexts. One of the latest occurrences of this fraud involved EUAs trading through the EU ETS, costing the EU member states around €5 billion (Daskalakis et al. 2011, pp. 58-60).

We should finally come back and close by restating the advocated primary goal of the EU ETS. In short, that was to create a scarcity of allowances of pollution and consequently by creating a price for carbon, the covered installations would be motivated to reduce their GHG emission in the best cost effective way possible by using the market for trading these intangible assets. The efficiency of the permit market, both in terms of reducing the problem of climate change, and reducing the cost of achieving the environmental objectives depended on many factors concerning the design of the license market and its operation but most of all as we already highlighted depended on the cap of permits and ultimately the price of EUAs. Eventually then, the most important problem of the EU ETS, which is stressed all across the literature by most scholars, is no other than the high price volatility. The continuous changes in the regulation policies had definitely augmented the price volatility with negative effects in price stability and caused an important deterrent for people investing in renewable energy sources and energy efficiency technologies. We can also argue that this volatility is in addition self-sustained by speculative trading. Ultimately, the long-term price of tradable emission allowances is too uncertain to be a sufficient driver of systemic technological change in an industry which requires long term investments in order to transition out of fossil fuels.

4.3 Regulatory issues

According to Lohmann (2006), at the start of the creation of any trading system, the basic requirement in order for it to work is some major regulation issues concerning who will have the right to trade within the system, what will be traded and who will own it. The EU decided that private companies burning fossil fuels would be considered, for the purposes of the scheme, the only right holders. In choosing to give rights to the world carbon dump away to corporations, European governments decided

at the same time not to give rights to others, including ordinary citizens. In choosing to give rights to corporate "downstream" energy users, it chose not to give them to "upstream" producers of oil, gas and coal. The problem with this decision was the expense involved in distributing rights to thousands or hundreds of thousands of "downstream" energy users rather than a manageable handful of "upstream" suppliers of fossil fuels. Therefore, for the sake of convenience, only big energy users could be included. The domestic, transport and small-business sectors had to be left out. Even so, there are so many industrial users that the costs of attempting to monitor and administer the scheme are huge. In addition to being inefficient and expensive, the decision to make energy users the owners of emissions allowances failed to address the global warming problem closer to its root. In short, the main current threat to climatic stability is the flow of fossil carbon out of the ground. It would be both more economical and more logical to curb this flow at the relatively few points that it takes place than to attempt to impose centralized control over millions of separate users of coal, oil and gas.

According to Lohmann (2009) the crises over the last years regarding climate change and also the financial markets have in our era concentrated the dialogue of authorities and economists on basic issues of regulation policies like never before. The debate on how to regulate or not various financial derivatives is generally parallel with the widening of the debate regarding the regulation of the carbon markets. Both markets are based on attempts of commodification, which is to create intangible tradable assets. In the case of financial markets, the commodification of a great deal of uncertainty and, in the case of coal markets, commodification of the climate benefits or the capacity of earth cycling carbon. Many support the idea that these intangible externalities if internalized properly can be effectively regulated and then traded like normal commodities. Another approach suggests partial or complete decomposition as a way of addressing the problems posed by the new markets.

In his research, Lohmann (2009), emphasizes the presence in many cases of advantages in considering hand to hand the problems of financial markets and of carbon market regulation because generally, carbon markets are developed in a parallel way to financial derivatives markets and therefore solutions can be derived and implemented analogously. Lohmann (2009) also mentions that "while no consensus exists about the extent to which they are regulatable, it is widely acknowledged that they are not now

being regulated effectively, and there are very powerful arguments that portions of them could never be effectively regulated". Finally, the advantages of laying economic orthodoxies aside have also been suggested in the effort the regulators to determine the problems and the possible solutions in each situation separately.

Summarizing, the basic regulatory aspects that determine the incentives and the costs for the covered installations are the following. Firstly, who is allowed to trade. Secondly, whether those permitted to trade can import extra allowances from outside the scheme, without the ability to breach the cap. Thirdly, whether there is a use-by-date for the allowances and finally how the allowances are allocated to the participants of the system (Kill et al. 2010). In this way we can understand the very important role of regulatory issues, which need further research and evaluation, so that various problems of the scheme can be answered.

According to the Economist magazine[28]: "Under a cap-and-trade system, an invention that reduced the cost of cutting carbon emissions could itself push down the price of permits, reducing investors' returns". Similarly, higher than expected energy efficiency investments—to lower industrial production costs, for example—could cut energy use and CO_2 emissions but reduce demand for permits. Hence a "good" (cutting CO_2 emissions) can be "bad" for permit prices, killing the incentive for further green investment. In that sense, the ETS is a counter incentive to the very goal of emissions reductions that it is designed to achieve.

Eventually, do carbon prices directed business's attention and ingenuity toward the climate crisis or away from it? As reported above, the European market for carbon so far has not pushed corporations into creative long-term investments to do something about global warming. Instead, it has taught them how to lobby for more emissions permits, find ways of passing on costs to customers, game the system, locate cheap carbon credits abroad, present a green face to the public, keep gas as an option, and make marginal efficiency improvements. Responding to carbon prices is one thing; taking practical long-term action on climate change quite another.

[28] The Economist, "Doffing the cap": https://www.economist.com/finance-and-economics/2007/06/14/doffing-the-cap

4.4 The gap between economic theory and reality

In his very influential paper for the science of economics Friedman (1966) states that truly important and significant hypotheses have "assumptions" that are wildly inaccurate descriptive representations of reality, and, in general, the more significant the theory, the more unrealistic the assumptions (in this sense). To put this point less paradoxically, the relevant question to ask about the "assumptions" of a theory is not whether they are descriptively "realistic", for they never are, but whether they are sufficiently good approximations for the purpose in hand. And this question can be answered only by seeing whether the theory works, which means whether it yields sufficiently accurate predictions. The question whether a theory is realistic "enough" can be settled only by seeing whether it yields predictions that are good enough for the purpose in hand or that are better than predictions from alternative theories.

According to Sartzetakis (2004) it is typical for economists and policy makers alike to presume that competitive markets allocate emission permits efficiently. In his paper though, he demonstrates that competition in the emission permits market cannot assure efficiency when the product market is oligopolistic. In other words, by changing the assumptions of the theory and hence the theory itself, he manages to achieve better predictive results. Particularly, he provides the conditions under which a bureaucratic mechanism is welfare superior to a tradable emission permits system. Price-taking behaviour in the permits market ensures transfer of licenses to the less efficient in abatement firms, which as soon as they gain more market power become more aggressive in the product market, acquiring additional permits. As a result, the less efficient firms end up with a higher than the welfare maximizing share of emission permits. Moreover, if the less efficient in abatement firms are also less efficient in production, competitive trading of permits may result in lower output and welfare.

Moving further, Spash (2010), mainly argues that there is an unbridgeable gap between the complicated reality of carbon markets and the rather simplistic assumptions of classical economic theory behind the concept of cost effective abatement of emissions. Spash (2010) conclude that the focus on such markets is creating a distraction from the need for changing human behavior, institutions and infrastructure. Based on the research of Spash (2010), we can say that climate change is a very multi-faceted and complex problem at global and national level and that is why we urgently

need regulatory solutions. In financial theory, pollution is conceptualized as a limited aberration with a market system, which functions perfectly. Also emissions trading, as it has been already mentioned, is presented as a favoured government strategy and carbon permits are presented as an important financial tool in modern markets. However, the pervasiveness of Greenhouse Gas emissions, strong uncertainty and complexity combined have prevented economists from substantiating their theoretical claims of cost effectiveness of carbon trading (Spash 2010).

Very important is also the research of Andrikopoulos (2013), in which the methods and objects of science in the sector of financial economics are analysed. In addition, we can mention the mainstream theory of finance, which can influence the nature of financial markets and in most cases shapes the decision making process in most economic decisions, especially those regarding investments. Explanatory problems of financial economics present an association with the respective method of inquiry and financial reality. In an alternative finance theory that is proposed by the author, financial markets can be considered as social institutions and also can be comprehended by theorists and investors through transitive contexts of perception. In this way we can understand that there is a gap between theory and reality in the operation of carbon markets, which can explain the problems and the prediction failures.

Closing this chapter, it is worth referring to an exceptional analogy from the work of Lohmann (2006) that illustrates brilliantly the futility of preserving a destined to fail system. In his analogy, Lohmann, parallelizes the carbon market with the epicycles of the Ptolemaic geocentric astronomical model which astronomers invented in order to save the phenomena of their biased model. From about the second century onward, the European astronomical model that placed the earth at the center of the universe had to add more and more complicated mathematical formulations and refinements ("epicycles") in order to account for observations of planetary movements. Only in the 16th century was the whole complex model and all its epicycles finally abandoned in favour of a simpler and more elegant sun-centered model. The carbon market is like one of the epicycles added to the earth-centered model to preserve it. It helps to conserve the obsolete fossil-centered industrial model at a time when society should already be abandoning it.

4.5. An eco-socialist critique

In this chapter we make a direct reference to the critical assessment of the EU ETS from a value-theoretic and class-based point of view of A. Vlachou. According to Vlachou (2014) the EU ETS is marked with various systemic setbacks, such as, limited environmental effectiveness, windfall profits from the biggest emitters of the energy sector as well as distributional injustice of the allocation of permits. However, these drawbacks are not coincidental or random but rather premeditated and stemming from the innate integration of the scheme in the EU capitalist economies. Thus, following a dialectical value-theoretic and class-based methodology is helpful in order to identify these failures and moreover to understand the link between the intensification of climate change and the historical patterns of capitalistic development. It is easy to understand that the fundamental motives and mechanisms of capitalism, i.e. profit maximization and market competition, have led in increasing demands of energy use, deforestation and changing land use, which are essentially the key reasons behind the increasing GHG emissions.

Furthermore, let us not forget the central role that fossil energy played in modern economies by fueling their rapid growth and transforming radically the structures, systems, networks and relations of the capitalistic societies internationally. In a way, globalized economic growth is very much dependent and interwoven with "locked in" fossil fuel structures making global warming and climate change more and more unavoidable. Under these circumstances, it is apparently easy to comprehend the immense lobbying pressure from international capitals with high stakes in maintaining and protecting fossil fuel markets in order to impede and slow down climate and environmental policies which threaten their profits. A good example in an international level is the case of the Kyoto Protocol and the policy mechanisms that were ultimately adopted after a great deal of negotiations between nations, corporations and organizations. Apparently, carbon-intensive capitalist companies and also developed economies exerted great influence on the shaping and also on the implementation of flexible practices which would allow them to comply with the lowest possible cost for them. Other probably more important goals like environmental justice and effectiveness and in addition equal sustainable development were supported and also claimed by

developing countries, local communities, social movements and worker-citizens have not been secured. Therefore, flexible practices have not yet presented a real challenge to the establishment's mechanisms and current institutions for sustainable climate conditions for the majority of workers-citizens of the world (Vlachou and Konstantinidis 2010).

Global warming is still aggravating due to the increasing GHG emissions despite all the efforts and the international agreements to prevent and reduce them. This fact, highlights the inability of policy makers to tackle the problem at its root the moment it appears. They seem not eager to reduce new extractions of fossil fuels and they are unwilling to implement any other solutions apart from market based instruments. Currently, carbon-trading policies, practically, even promote in many cases the further exploitation of fossil fuels like natural gas in the basis that it is cheaper and "cleaner" than coal. Other than that, utilizing Kyoto Protocol's flexible mechanisms like for example the planting of new tree plantations, which can be used as a sink of GHGs, in many cases destroy biological diversity and drive people out of their traditional living grounds (Lohmann 2006). This impromptu measures which tend to ostensibly solve one problem while at the same time creating various others, possibly worse, ought not to be acceptable as sustainable solutions.

It is self-evident that climate change has been producing and is expected to cause even more negative and inevitable effects on capitalist firms and economies. According to Vlachou (2014), the labour theory of value, combined with the theory of surplus value, can assist us in determining these effects and their inescapable consequences as well as in providing a unique systemic/class interpretation of them.

To start with, natural resources and the necessary conditions of production are sustained and determined by climate conditions like sunlight, rainfall, temperature levels, etc. Hence, their utility is crucial for firms on preconditioned qualities and quantities in order to carry out all their profit-making enterprises. More importantly though, climate conditions sustain human life, which is after all, the labour power which in turn is a necessary component for the production of firms. But when climate conditions change for the worse, there are negative implications on the constant capital, i.e. the produced means of production and the natural means of production, and on the variable capital, which is the cost of labour power. Subsequently, these changes will

result in increased costs and selling prices directly affecting profits, rents and wages. Certainly the negative consequences of climate change is not at all experienced in an equal way by capitalist firms and worker citizens. As a result, climate change instigates various class, environmental and other social conflicts and tensions between emitters and the different victims of climate change. Climate policy like the EU ETS emerges under those struggles and every aspect of it reflects primarily the dominant social groups and their interests. It is worth noting however, that these conflicts are not restricted between firms and workers alone, but also between nation states and between different agents and firms that are disproportionally affected by the alternative policies to mitigate climate change like the EU ETS.

Regarding the EU ETS, the basis of the arguments of the consultation process was that it provides flexibility to the participating emitters to comply with the abatement goals in a cost-effective and environmentally effective way. However, the proclaimed scientifically efficient way of operation of the domineering mainstream climate change solutions in general, and of the EU ETS especially, is not socially or ethically neutral, but rather, it should be understood as the product of a class-biased approach because "efficiency" is based on measuring certain benefits and costs while ignoring others depending on who is dictating the objectives. This can be explained by the way free initial allocation of permits was assigned to large emitters with the known method of grandfathering, which eventually resulted in passing all the extra costs of compliance to the final prices of goods and services. This fact contradicts the "polluter pays" principle which lies at the core of the EU environmental policy, exposing the class implications of endorsing the polluting firms and raising deep ethical issues. Particularly, regarding the energy sector the costs of shifting to a low carbon economy are more or less financed by the increased electricity prices, which translates to reductions in the income of all citizens, as if the workers were to blame exclusively for the climate change and global warming. Moreover, according to Lohmann (2006), the idea of targeting behavioral change from the bottom and individual responsibility by appealing to new green ethics are likely to fail. Vlachou (2014), argues that from a Marxian perspective these notions are bound to be unsuccessful simply because they underestimate the deep rooted systemic origins of the climate change problem and additionally the systemic creation of the self-interested, antagonistic and consumerist behavior and at the same time the social withdrawal of the disenchanted. At the end,

the class based approach allows us to illustrate that despite the dominant capitalist class is responsible primarily for the climate change the real costs of the EU ETS and the social implications are expected to burden unfairly more the less privileged people of the lower classes.

Moving on, we can say that the EU ETS does not seem to influence by itself innovation towards carbon-free or low-carbon technologies. This was shown in previous chapters as a result of allowances surpluses and low and volatile carbon prices. But even if the markets were stable there is another deeper reason that hinders the necessary systemic technological change. This is that fossil fuel technologies have been entrenched in every aspect of modern economies, from agriculture and industrial production to energy and transportation networks and grids making any alternative technologies appear more expensive because they lack all the necessary infrastructures.

Finally, the value-theoretic and class-based approach followed in the paper of Vlachou (2014), has helped us realize that the fundamental deficiencies of the EU ETS for a socially just and in many cases sustainable solution to the climate change problem are inseparably intermixed with the patterns of contemporary capitalist economies. From an ethical point of view of an eco-socialist perspective, it is not acceptable or desirable that the shift to a low-carbon economy should occur at the expense of poor people and countries that have been in such a vulnerable position because of the workings of environmentally destructive capitalism. The eco-socialist alternative should be that of a democratic society where collective non-exploitative production relations would characterize the production, appropriation and distribution of surplus. It is reasonable to expect that people living in solidarity in such a society would care for climate sustainability to secure life on the planet (Vlachou 2005). Such radical changes in all aspects of society can be brought forth only by a large and sustained coalition of labor and environmental political forces. Hence, democratic political organizing is indispensable for a sustainable climate and sustainable economies.

5. Conclusion

The high concentrations of greenhouse gases in the atmosphere cause global warming and climate change, thus leading to serious consequences for the societies, economies and also for the environment. That is why emissions' abatement is considered as a top priority in our era in the political agenda of the EU. The flagship of EU environmental policy towards this endeavor is the EU ETS, which was created in the aftermath of the Kyoto Protocol agreement, in order to help the EU countries meet their emission target reductions in a cost efficient way.

In a summary, this study was about conducting a review of the literature regarding the European Union's Emissions Trading Scheme. This methodology was preferred in order to comprehend the ongoing debate concerning the main characteristics of the EU ETS as well as its performance so far. Beginning with chapter 2, we presented in brief the history of its precursor, namely the Kyoto Protocol, in order to better comprehend the reasons EU came up eventually with the EU ETS as a policy instrument that would facilitate it meeting its binding targets under the protocol. Subsequently, we referred to the EU decision making process and the various deliberations that took place before the EU ETS took actual form. Soon after we described the major characteristics of the initial scheme along with its amendments that followed after the first two phases. As it has been mentioned, the operation of this system is based mainly on three factors. The first is an annual cap, i.e. a limit on overall emissions, which decreases every year and affects all the covered industry sectors in the EU and some countries of the EEA. The second is the issuance of emissions' permits, each one corresponding to a right to emit 1 ton of CO_2 equivalent (tCO_2e). In the beginning of every compliance period the allowances are allocated or auctioned to the covered installations and subsequently they can be traded among all market participants in order to achieve, in theory, emissions' abatement in a cost effective way. The third factor is that, all facilities must measure and report their CO_2 emissions in order to be verified by the competent authorities and subsequently surrender an allowance for every ton of CO_2 they emitted during each annual compliance period.

Alongside the key features of the EU ETS the initial results of the scheme were presented in terms of data about the price trends and trading volumes of the EU allowances, as well as, data about the allocation of permits. Overall, the results were

disappointing since prices were in very low levels in order to induce adequate emissions' abatement. The reasons behind this were mainly due to an overallocation of permits and the restriction of banking allowances between the first and second phase, as well as the financial crisis in 2008, which led to mass liquidation of financial assets. The low prices remained almost throughout the 3rd period until the EU authorities revised the EU ETS Directive and put forward some changes for the next period that made the framework stricter.

Following in chapter 3, we examined the carbon market from a financial perspective in order to better comprehend how the EU ETS and particularly carbon trading actually works and also if it performed according to plan. First, we referred to the structure and the regulation of the financial market. Second, we made an overview of the development of carbon prices showing data from the beginning of phase I in 2005 since the early of 2018 in phase III. Afterwards, we presented a review of the literature concerning the inquiry of possible price determinants, the modelling of carbon prices in derivatives' contracts and the assessment of the effectiveness of the financial market.

Finally in chapter 4, we presented an overview of the most significant issues and failures of the EU ETS according to the literature, as well as, a summary of some more critical arguments that question the EU ETS in a more profound way. First of all, we referred to the issue of market speculation and how the high level of price volatility undermines the stability of the market and overshadows the compliance aspect of the scheme, in the sense of cost effective emissions' abatement. In subsequence, we presented certain market failures and regulatory issues, such as the relative low prices and high volatility, the windfall profits, the overallocation of permits, etc. Those issues, as well as, the lack of flexibility of the competent authorities to respond to the highly unstable and unpredictable economic environment undermine the purpose of the EU ETS and as a consequence the goals of EU for emissions' reduction. Following next, we presented the views of some scientists who suggest that there is a distinct gap between the classical economic theory, in which the EU ETS and the concept of carbon trading in general is based upon, and the real world. Last but not least, we demonstrated in short a critique from an ecological and socialist perspective, which suggests that the problems and setbacks of the EU ETS lie deep within the foundations of the whole system that defines our economies.

To sum up, as it is understood the EU ETS is an important tool for the European Union in its effort to achieve the emission reduction targets in the future. We can say, that many consider the whole scheme as a success from the fact that under this program for the first time and within a coordinated way, a price of carbon has been introduced motivating business involvement towards emissions reductions. The mainstream economic narrative of the EU ETS, is that it contributes to combat climate change in theory in a cost-effective way. The initial challenge was to establish a system that would demonstrate that GHG emissions could have a price and to provide the signal of what constitutes appropriate short-term and long-term actions to limit GHG emissions. In this, the EU has done more with the ETS, despite all its faults, than any other nation or set of nations. However, others disagree with this view arguing that, while trading schemes can in theory save participating private firms money in reducing emissions of specific substances to a particular degree over specified time periods and within a particular technological system, the same schemes are unlikely to be the best choice if the objective is to save resources for the society or industry as a whole, or make more drastic reductions with long-term goals in mind, or bring about a greater shift towards a carbon-free technological system.

Eventually, the EU ETS will likely never become a fully efficient—and therefore idealized—market but rather a compromise between economic theory and political reality. Market efficiency critically depends on the attention firms devote to optimizing their abatement and trading decisions in response to allowance prices. The past price levels of permits may not have made the effort worthwhile, but apparently this is changing recently in light of the stricter future emission targets and regulations that were put forward in order to achieve the overall EU's climate goals for 2020 and 2030 after. One thing that is certain though, is that the only way to address the adversities of climate change is via international cooperation and coordinated actions directed towards reducing GHG emissions and building new foundations for sustainable economies in cleaner energy forms.

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