CAP-AND-TRADE AND PROJECT-BASED FRAMEWORK: HOW DO CARBON MARKETS WORK FOR GREENHOUSE EMISSIONS REDUCTION?

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Introduction

Climate Change is the most pressing environmental concern that humanity has faced in recent decades. Scientific research on climate offers increasing evidence that human activities are largely responsible for increasing concentration of greenhouse gases (GHG) in the atmosphere, leading to climate change (IPCC, 2008).

While there is still disagreement within the scientific community, the thesis that prevails, especially in international forums, is the "precautionary principle," which recommends that, although there is no absolute certainty about a certain phenomenon, the world should take measures to protect against the possible damage that may occur. The decision about which are the most appropriate actions to minimize the effects of climate change is a controversial issue, hotly debated by the parties involved.

Despite uncertainties, increased consciousness of the effects of higher GHG levels has resulted in public and private policies which aim to reduce emissions of gases, such as the creation of carbon markets. In this context, it is possible to highlight two examples: emission permit trade, following the principle of cap-and-trade (European Emission Trade Scheme); and carbon credit from deployment of emission reduction projects, with a focus on emission reduction (Clean Development Mechanism). These two systems are attempts to solve environmental problems using economic tools, as opposed to tax policies.

Carbon trading is relatively innovative, but the concept is usually couched in technical language based on international law, which is consequently not always easily understood. As a result, studies generally incorporate ideas and concepts in a discrete manner, which hinders applicability. From this background, the aim of this paper is to

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present the dynamic evolution of carbon markets, analyzing the main existing structures worldwide and their performance, comparing different carbon markets. Furthermore, this work seeks to analyze greenhouse gas emissions reduction by country and compare to targets.

The theoretical basis of this work is Institutional Economics, since one of the central points of this theory is focused on the importance of institutions and organizations in establishing an efficient market. The article surveys the theoretical contribution to carbon markets, presenting an introductory approach related to some theories of carbon markets and economic theories; it also presents a comparative, mainly of carbon markets; and analyses global GHG emission reduction against goals.

Economic theories and carbon markets

Nobel Prize-winner Ronald Coase proposed a new way to analyze this problem in the 1960s, through the critique of the Welfare Theory contained in his article "The social cost problem" (Coase, 1960). The author argues that GHG emission rights should be treated as property rights, and that those rights could be transferred using market tools. Property rights are intended to internalize externalities when the gains of internalization outweigh the costs. Market certificates for reducing emissions of greenhouse gases through a clear definition of property rights proposes to internalize this externality (Mueller, 2002).

Addressing imposed environmental taxes, Coase argues that the public authority is not without its flaws, such as corporate interests, lack of information, and political pressure. The author contrasts market failures with government failures. In the same line as the Chicago School - and contrary to classical economic models - the author states that private solutions usually involve lower costs.

Negative externality is a market failure related to the degradation of natural resources, defined as costs to others that result from particular actions, even if they have not contributed to the harm. Emissions of greenhouse gases are an example of negative externality, as they cause harm to others, even if they are not responsible for the emissions. According to some Economics theories, the resource allocation deviation justifies government regulation, through command and control measures and taxation (Varian, 1994). Pigou (1920) presents the creation of taxes as a solution to negative externalities (Pigouvian taxes) in an amount equivalent to the cost (benefit) of the externality generated. Such a solution - the principle of paying polluter - has been adopted by the Organization for Economic Cooperation and Development (OECD).

This logic gave birth to a theoretical line called the New Institutional Economics, which proposes that the state should create conditions, through the definition of property rights, for economic agents to freely negotiate so-called "environmental goods," such as air pollution reduction. Carbon trading has at its core the logic advocated by Coase, insofar as it enables a tool aimed at the ownership of a free asset, based on transactions of emissions permits or carbon emissions reduction certificates.[1]

Transaction costs are resources allocated to coordinate the production of goods, such as: drafting of contracts; obtaining new information on the product and competitors;

bargaining; conducting negotiations; and process monitoring. When property rights are not well defined, there may be a loss of benefits, and externalities may not be efficiently internalized, and if transaction costs are zero it is preferable that agents negotiate the goods freely (Coase, 1960; North, 1994; Williamson, 1985).

Transaction costs are present in every deployment stage of an emission reduction project, such as in the preparation of the initial presentation of the project contract; validation; approval; registration; monitoring process; certification; and in the issuance of emission reduction certificates. These costs are consequences of uncertainty, asymmetric information, the need for drafting contracts, and bureaucratic costs.

Considering the different theories on direct government intervention versus the free market, some authors propose to incorporate both. One example is a pollution control policy including emission permits, with a limited number of emissions assigned to a specific group (or groups) within a sector (or sectors). This system avoids the imposition of a regulatory authority, to set emission levels on business and industry or to determine the most appropriate technology to be used (Nusdeo, 2008).

Historically, creating a market for certified emission reductions of GHG stems from the concept of tradable emissions permits (cap-and-trade), initially formulated by Dales in 1968 and later developed by Montgomery (1972), Tietenberg (1985), and Baumol and Oates (1988). But the concept of emissions trade as a strategy for pollution control was first proposed by Crocker (1966) and further developed by Montgomery (1972).

The academic literature presents three basic systems of tradable emissions: the environmental permit system (focused on the exposure to emissions at the reception point), the emissions permit system (focused on emissions sources), and the pollution offset system (combining features of the previous two). With respect to regulating the sale of certificates, four programs stand out: offset policy, bubble policy, netting policy, and emission banking (Almeida, 1998; May, 2003).

The offset policy, created by the Environment Protection Agency (EPA) in the 1980s, is a new program that allows polluting plants to settle in regions where air quality does not meet appropriate environmental standards. However, this is possible only if the new emissions are offset by a reduction of existing pollution sources in other regions. Rather than impose a rigid zoning law barring expansion of activities in the area, the entry of new firms is permitted, provided that local environmental quality is not undermined.

The bubble policy, also created by the EPA in the 1980s, is a mechanism that treats multiple emission points of existing polluting plants in a given area as if encased in a bubble. The total gas emitted in a particular region is controlled, and as long as values remain below this limit companies can still pollute. Participants can negotiate emissions reductions among themselves.

The netting or net emissions policy sets both a limit and a fixed number of certificates that participants can acquire to achieve their goals. From these boundaries, companies are free to increase or decrease their emissions as long as the net growth of emissions does not exceed the pre-determined ceiling. Emissions banking, in turn, enables companies to store or sell reduction certificates or permits for use in reductions in the offset, bubble, and netting policies (Almeida, 1998; May, 2003; Pindyck & Rubinfeld, 1994).

Global carbon markets

There is no carbon market defined by a single commodity, by a single contract. What is commonly called the "carbon market" is a collection of various transactions through which volumes of GHG emission reductions are traded, and which differ with respect to size, shape, and regulations. These transactions can also be separated into Kyoto compliance and non-Kyoto compliance: that is, whether the carbon credits meet the parameters set by the Kyoto Protocol or not.

Clean Development Mechanism

The Clean Development Mechanism stems from the establishment of the Kyoto Protocol, which introduced economic tools to help compliance parties meet the objectives and principles established under the United Nations Framework Convention on Climate Change (UNFCCC). Based on first Intergovernmental Panel on Climate Change (IPCC) in 1990, the General Assembly of the United Nations established the Intergovernmental Committee of Negotiation, responsible for development of the UNFCCC. A document was presented on the Convention in 1992, during the United Nation Conference on the Environment and Development (UNCED), known as Rio-92.

Following negotiations, the member countries of the Organization for Economic Cooperation and Development (OECD), and economies in transition (Russian Federation and other countries in Central and Eastern Europe) agreed to adopt national policies and measures to reverse greenhouse gas emissions to about 5 percent below 1990 levels by the year 2000. After the initial commitments on reducing greenhouse gases was agreed at UNFCCC, an ongoing process and regular discussions were established to exchange information about scientific research, including technological progress and possible new interest in making policies and agreements. This continuous process led to the creation of the Conference of the Parties (COP), the supreme body of the Convention and highest decision-making authority, whose meetings have occurred annually from 1995 to the present day. The 3rd Conference, held between December 1 and 12, 1997 in Kyoto, Japan, gave rise to the Kyoto Protocol (UNFCCC, 1997).

To facilitate compliance with these reduction targets, the Protocol established flexibility mechanisms, by which an Annex I country can exceed its emissions limit without increasing global net emissions, provided that there is an equivalent reduction in another country.

An Annex I country has two alternatives for achieving the targets and using them according to its cost-benefit analysis: invest in more efficient technologies in terms of GHG emissions in their own countries, or use the flexibility mechanisms, leveraging the lower costs of deploying projects in other countries. However, countries with commitments under Kyoto Protocol must meet their targets primarily through national measures.

There are three flexible mechanisms: Joint Implementation (JI), Emissions Trading (ET), and the Clean Development Mechanism (CDM).[ii] Joint Implementation allows industrialized countries to offset their emissions and sinks by participating in projects in

other Annex I countries.[iii] The Emissions Trading policy delineates transactions relating to GHG emissions among Annex I Parties. Finally, and directly affecting developing countries, is the Clean Development Mechanism (CDM), through which industrialized countries can meet their reduction commitments by investing in low-emission projects in developing countries (UNFCCC, 1997).

The first commitment period of Kyoto Protocol ended in 2012. However, during COP 17, in 2011, a new compromise was agreed to establish a second Kyoto Protocol stage based on the following assumptions: the establishment of a formal provision for a second commitment period of the Kyoto Protocol (post-2012); the launch of the Green Climate Fund to expand long-term financing to developing countries; and the establishment of a formal clause for an action plan that results in a global agreement on climate change (Durban Platform for Enhanced Action), to be defined in 2015 and enter into force in 2020.

The last meeting, in Doha, 2012, saw the adoption of the "Doha Amendment to the Kyoto Protocol," including new commitments for Annex I Parties, establishing a second commitment period from January 2013 to December 2020, and other measures updating some articles of Kyoto Protocol.

According to these new specifications established for the second commitment period, Annex I countries agreed to reduce emissions of greenhouse gases by at least 18 percent below 1990 levels in the period between the years 2013-2020. On the downside, Japan, Canada, New Zealand, and Russia said they would not participate in the next Kyoto commitment period, which jeopardizes the success of the second period but did not derail the continuity of established rules.

European Union Emissions Trading Scheme - EU ETS

The first large emissions trading market, the UK Emissions Trading Scheme (UK ETS) was developed in 2002, through an auction of 4,028,176 tCO2e. In 2007 this program ceased its activities, but it led to the creation of the EU Emissions Trading Scheme (EU ETS), which began operating in January 2005. The first phase of compliance with reductions lasted from 2005 to 2007; the second from 2008 to 2012, coinciding with the first commitment period of the Kyoto Protocol; and the third will span from 2013 to 2020 (DECC, 2012; Defra, 2005; UK, 2005).

The European market initially emerged to help countries meet the targets set by the Kyoto Protocol. The EU ETS Commission created a Linking Directive, which functions as a regulatory regime that determines the relationship between Kyoto Protocol and EU ETS. The Linking Directive allows institutions included in the EU ETS to use Clean Development Mechanisms (CDM) carbon credits to meet their commitments (Ieta, 2005; Point Carbon, 2005c; World Bank, 2005b).

Each European member state develops a National Allocation Plan (NAP) that establishes the amount of GHG emission allowances (EUAs), which are permits distributed to their industries and power plants. It is up to each company to adjust its polluting profile to remain within the established quota; if it exceeds this limit, it can buy permits,

and if it is below, it can sell them. Covering about 12,000 facilities in the first phase, the scheme included the energy, metal and steel, pulp and paper, cement, and ceramics and glass sectors.

Since 2012 some changes were incorporated into the program, such as the inclusion of the aviation sector, and the entrance of Norway, Iceland, and Liechtenstein. Other greenhouse gases are being proposed, such as CO2 from petrochemicals, ammonia, and aluminum; Adipic N2O, nitric and glycolic acid; perfluorocarbons from the aluminum sector; CO2 capture, transport, and geological storage. Another set emission limits for countries, aiming to reduce these by 1.74% per year until 2020. There will also be a substantial increase in the number of licenses to be auctioned (from below 4% in 2013 to a goal of over 50%) (DEFRA, 2012; World Bank, 2012).

Table 1 shows the main differences and similarities of the EU ETS and Clean Development Mechanism.

Table 1. Comparative characteristics in CDM and EU ETS.

EU ETS	CDM
European developed countries.	Developing countries.
Shared by sectors: Cement and lime, paper, iron, ceramics, chemicals, hospitals, universities, aviation.	Shared by sectors: Energy, transport, fugitive emissions from fuels, solid fuels, oil and gas, industrial processes, mineral products, chemical industry, production of halocarbons and sulfur hexafluoride, consumer halocarbons and sulfur hexafluoride, agriculture, land use, land use change and forestry, and sewage treatment.
Emission limits passed on to governments; designs change according to countries' policies.	Emission reduction targets are passed on to governments and project implementation is in accordance with countries' policies.
Target until 2020.	Target until 2020.
Annual limits.	Goals in the period and passed on to governments.
Three phases (2005 to 2007; 2008 to 2012; 2013 to 2020).	Two phases (2008 to 2012; 2013 to 2020).
Participation in the EU ETS is currently mandatory for certain sectors.	Still voluntary.
Emission limits (permission to emit, emission licenses, allowances).	Emission reduction targets (reduced emission reduction).
GHG converted to CO2e	GHG converted to CO2e

Annual monitoring	Annual monitoring
Based on "learning by doing" principle with updates and modifications needed over time.	Based on "learning by doing" principle with updates and modifications needed over time.
European countries participate in the program.	Interested developing countries can participate.
Stages in the EU ETS process: preparation, approval, emission permit transfer, monitoring, crediting, verifying.	Stages in the CDM: preparation, approval, validation, register, monitoring, certifying, carbon credit issuance.
Taxation: national policy.	Taxation: national policy.
Regulatory committee: Commission of EU ETS.	Regulatory committee: CDM Executive Commission.
Methodologies of calculations of emission reductions are more generalized.	Methodologies of calculations of emission reductions are more detailed.
Legal nature of documents, arising from the DIRECTIVE 2003/87/CE and other amendments, are based on this initial document.	Legal nature of documents, arising from the Kyoto Protocol of 1998 and other amendments, are based on this initial document.

Source: UNFCCC, 2012; WORLD BANK, 2013; UNFCCC, 1997. Data developed by authors.

Other markets

The Certified Emission Reduction Unit Procurement Tender (CERUPT) results from the Dutch government's interest in investing in CDM projects through the purchase of Certified Emission Reductions. They also created the Emission Reduction Unit Procurement Tender (ERUPT), similar to the CERUPT program, but directed at the Joint Implementation projects (CERUPT, 2005).

In 2011, new initiatives for regional and domestic carbon markets gained strength in both developed and developing countries. Three new cap-and-trade schemes were approved in national laws, and two in state laws. Mexico is laying the foundation for a future cap-and-trade scheme, as are Quebec and China. A successful example is New Zealand, which was the first country outside the EU to approve and implement its own emissions trading scheme, active since 2010, and is a rapidly growing market, whose carbon value has tripled to US $351 million in 2011 (World Bank, 2012).

In 2011, the cap-and-trade regulation in California was adopted by the California Air Resources Board (CARB). It shall come into force in 2013 and, with a coverage expansion scheduled for 2015, will cover 85% of annual emissions. In late 2011 the Australian Parliament passed its Clean Energy Act, establishing a national cap-and-trade system in 2015. The program should cover about 60% of the 600 million tonnes of CO2e emitted annually in the country. Quebec, accounting for 12% of GHG emitted annually in Canada, approved its own cap-and-trade plan, and aims to link it to the California plan.

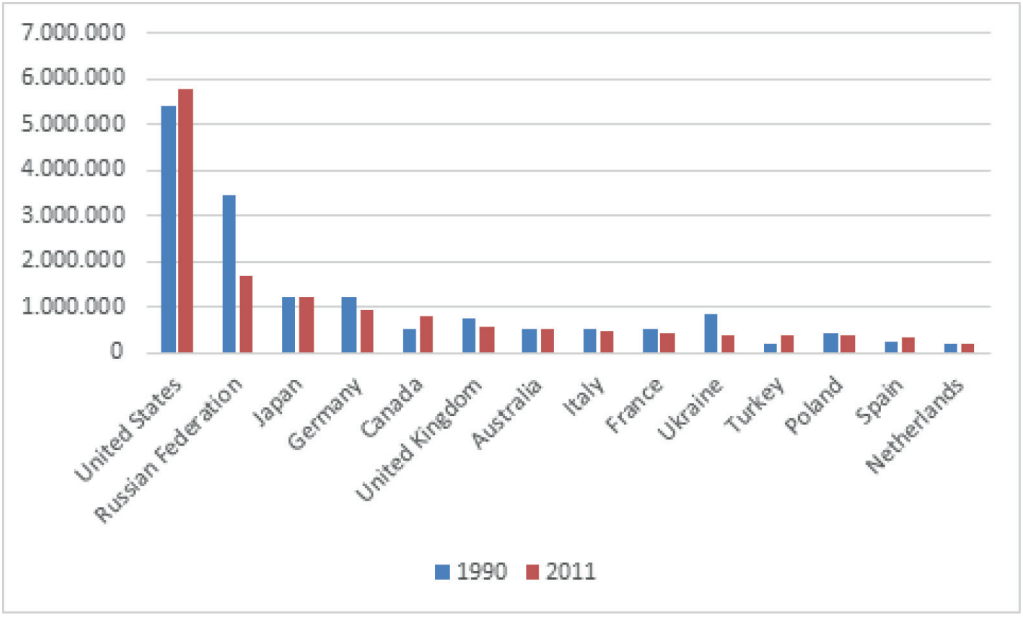
The large number of programs around the world demonstrates that there is a worldwide mobilization to use the market as a tool for solving the GHG emission problem. Many reduction schemes have more aggressive targets than Kyoto, but they follow precepts defined in the Protocol.

GHG countries, and carbon markets overview

The 1990-2011 inventory of CO2 emissions from Annex I countries showed a decrease of 13.61% in total emissions (from 17,693 MtCO2e to 15,284 MtCO2e), including the Land Use, Land Use Change and Forestry (LULUCF) sector.[iv] The largest reductions were observed in Eastern European countries, probably influenced by the modernization of their formerly obsolete and inefficient industrial plant, but also by the poor performance of world economies in recent years.

Despite the overall drop, many countries showed a significant increase in emissions, such as Turkey, Canada, Australia, and Spain (including LULUCF). Countries showing the highest reductions were: Russian Federation, UK, Poland, and Germany (Graph 1). What can be concluded is that global emissions were reduced overall, but mainly due to the economic crisis of recent years (WORLD BANK, 2012; UNFCCC, 2013).

Graph 1. Anexo I countries with higher emissions in CO2e between 1990 and 2011 (CO2e)



Source: UNFCCC (2013).

Carbon Market performance

Carbon credit buyers (or buyers on behalf of buyers) can basically be divided into categories: multilateral institutions; agencies that act as intermediaries, buying on behalf of governments (as in the case of Austria, Belgium, and Denmark); development banks, such as those in Japan and Germany, also buying on behalf of buyers; and other commercial enterprises. Some of the major carbon credit participants are investment funds, such as the ones financed by the World Bank and the Netherlands Government.

Reflecting the global crisis and uncertainty about emission reduction actions, carbon credit prices have fallen in recent years, especially in 2011 and 2012 (Table 2). The drop in certificate prices resulting from CDM projects was higher than that observed on the EU ETS market, especially by virtue of lower risk to investors in European Market (World Bank, 2012).

The estimated average price of certified emission reductions (CERs) fell from $11.8 in 2010 to US $10.9 in 2011. In addition, the difference between the certificate price of the EU ETS and the CDM increased, mainly due to uncertainty about the resulting acceptance of carbon credits from CDM implementation after 2012 (Table 2).

Table 2. Average of carbon credit price, secondary market (US $/tCO2e)

Year	2005	2006	2007	2008	2009	2010	2011	2012
Price	3-7	6-24	12-25	25	17	16	18	4

Source: CCX (2012); WORLD BANK (2005, 2007, 2010, 2012); ICE (2012); POINT CARBON (2007).

China tops the ranking of countries that sell CERs (87% of the primary market), while Latin America, which in 2005 had 20% of CER contracts in the primary market, represented only 2% in 2011 (equal to 2010). African countries stood out in 2011, with an increase in their share to 21% of issued CERs, influenced mainly by increased interest in claims by buyers of CDM projects in LDCs. Organizations in the United Kingdom (followed by Switzerland) dominated the purchase of primary CER market in 2011, accounting for 26% of transactions (World Bank, 2008, 2012).

An important fact to note is the decreased demand for carbon credits, a result of oversupply in the market, uncertainties about the future of the carbon market, and the global economic crisis. Even in this context, there was an increase of 17% in the total volume of carbon credits traded from 2010 to 2011 (Table 3). This growth was influenced by increased hedging and portfolio adjustments by participants benefitted from the fall in the prices of carbon credits.

Table 3: Value and volume traded in carbon markets

Carbon Market	2010		2011	
	Volume (MTCO2e)	Value (M$US)	Volume (MTCO2e)	Value (M$US)
Emission Permit				
EU ETS	6,789	133,598	7,853	147,848
Other	'373	1,336	228	1,033
Total	***7,162***	***134,935***	***8,081***	***148,881***
Emission reduction carbon market				
Secundary CDM	1,260	20,453	1,734	22,333
Other	16	184	88	917
Total	***1,276***	***20,637***	***1,822***	***23,250***
Primary CDM	224	2,675	264	2,980
Voluntary market	69	414	87	569
Other primary market	41	530	28	339
Total	***334***	***3,619***	***379***	***3,888***
TOTAL	**8,772**	**159,191**	**10,282**	**176,019**

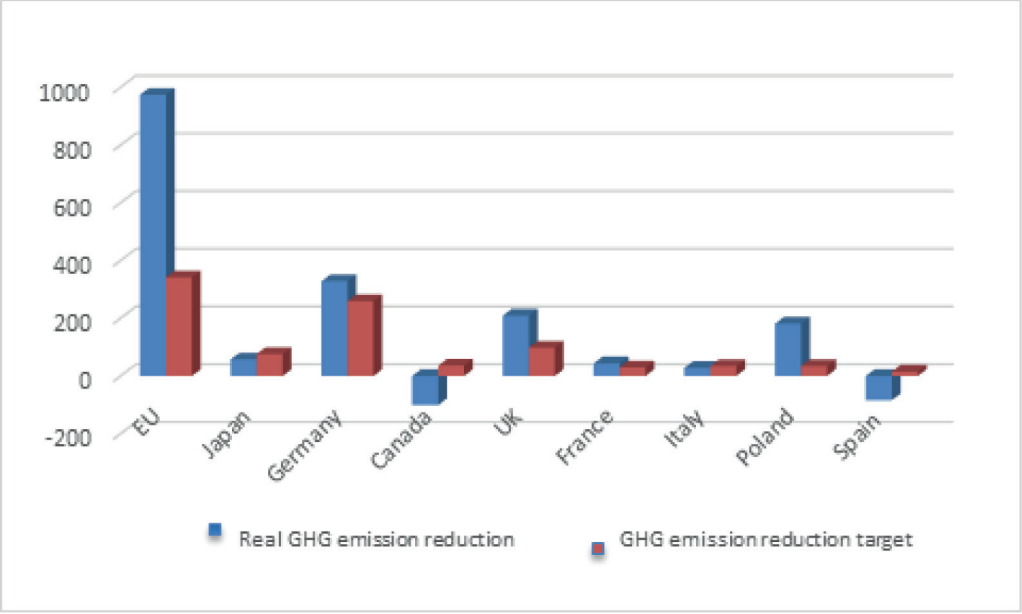
Source: WORLD BANK (2012).

The EU ETS remains the main global carbon market, reaching a volume of US $148 billion in emission permits sold in 2011, an 11% increase over 2010. In terms of trading volume, the increase was 27 % (Table 3). The lower growth in value can be explained by a drop in prices. It is important to note that global emission reduction targets that were achieved, including EU ETS and Kyoto, were probably more as a result of weak global economic performance than effective actions to reduce emissions adopted by countries (Graphic 2). The fact that reduction targets of GHG emissions have been achieved demonstrates the necessity to increase reduction targets of countries involved (EU ETS, 2012; UNFCCC, 2012, World Bank, 2012).

Despite the growth of the carbon market resulting from the implementation of CDM projects (Graphic 3), which also reflects an increase in overall volume of carbon trading (Table 2), there are many difficulties in implementing a Clean Development Mechanism project. Researches related to the carbon market, such as the World Bank (2012) and Point Carbon (2012), indicate that as a result of excess carbon emissions credits buyer interest outweighs that of sellers, leading to the imposition of clauses restrictive to sellers, who bear most of the risk of the project. Another problem is related to the lack of carbon credit buyers in the early stages of the CDM cycle, mainly due to the fact that many governments are gradually migrating to the secondary carbon trade instead of primary markets.

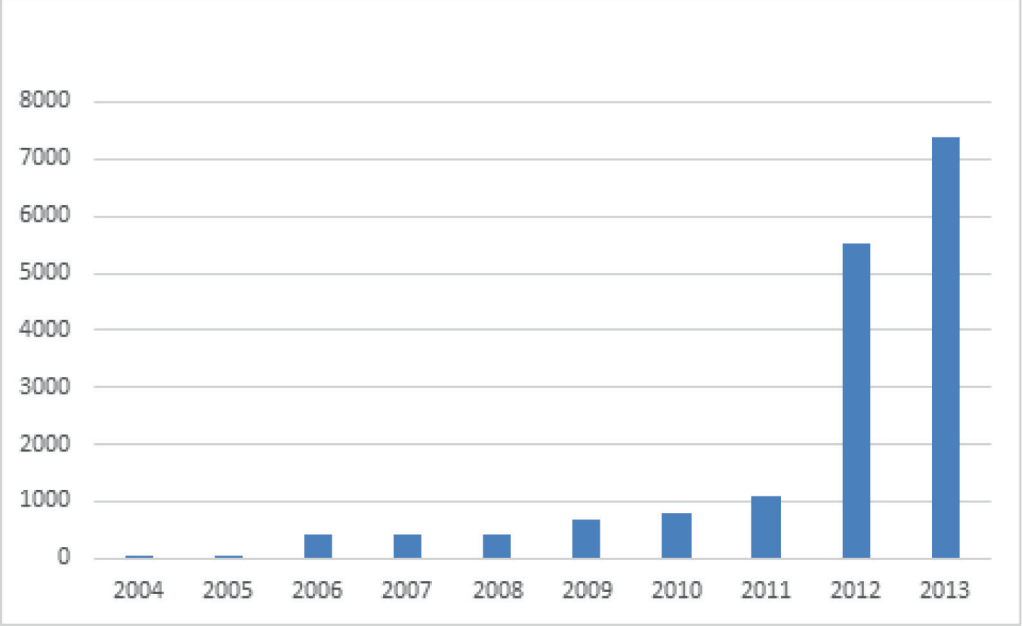
CDM also faces difficulties from a micro point of view. Barriers related to markets that have been noted by holders of CDM projects are: failures in the calculations required to determine the emission reductions; difficulties in drafting contracts; problems of poor choice of definition of methodology employed in the project; and excessive requirements to implement a CDM. Other barriers are financial costs related to the CDM cycle such as registration fees and audit costs (Godoy, 2011).

Graph 2: Emission reduction targets, and real emission reduction as of 2012 (Kyoto Protocol)



Source: UNFCCC (2012). Data managed by authors

Graph 3. Number of CDM projects registered (global)



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In an attempt to reduce the transaction cost problems in CDM implementation and simplify the deployment process, UNFCCC has created a mechanism called programmatic CDM, or Program of Activities (PoA). Through these programs, it is possible for different projects to have only one contract and one request for registration with the Executive Committee, provided that have some common features (like similar activities, region, or project type). Despite the progress reflected in the number of ongoing projects (240 registered in 2013), the mechanism is still incipient (UNFCCC, 2013, World Bank, 2012).

Conclusion

Global warming is part of a complex field of understanding, covering different and often conflicting interests, both in terms of understanding and combating climate change. Fulfilling GHG emission reduction targets requires international cooperation, taking into account political, social, and economic factors related to every interested country. The issue of global warming raises many questions, because of the uncertainty about the measurement of its effects and the real damage they can wreak on societies.

Even now, some researchers within the global scientific community - albeit a minority -reject the existence of global warming. Others reject the argument that the warming is mostly caused by human activities rather than natural factors, and some even argue contrary to the IPCC reports.

Despite the lack of consensus, studies on climate change have intensified in recent decades, with a huge breakthrough in climate science research in the areas of observation, modeling, and in the treatment of uncertainty. Discussions on global warming have begun to take on wider dimensions: environmental, economic, political, and social. As a way of dealing with the problem of growth in greenhouse gas emissions, carbon markets have emerged as an attempt to define emissions property rights. Carbon credit trade is a tool that allows countries to comply with the fulfillment of their emissions reduction targets.

The existing carbon markets have many points in common with institutions, rules, and similar organizations, but they also have different characteristics. The first definitions of the emission reduction market were mostly set in the 1970s, and refer to economic logic inherited from Institutional Economics, which indicates the need to define property rights when externalities exist. Markets are influenced by many factors, and although there are basic assumptions common to all, some are more relevant than others. Despite the emergence of different programs, the CDM resulting from the Kyoto Protocol and the European Trade Scheme are highlighted, both in trading volume, visibility, and institutional structure. However, despite the importance of these two programs, recent years have seen increasing growth of national and regional policies in order to reduce GHG emissions.

Although the trading volume of carbon credits from Kyoto is not so relevant, the Protocol has created unique tools to achieve emission reduction objectives, known as flexible mechanisms, which allow the joint participation of various stakeholders with or without emissions reduction targets. These instruments can serve as an incentive for international cooperation, by promoting investment and joint action between developing and developed countries. Although there is criticism related to Kyoto and other carbon markets, it is important to highlight an important feature, that before any decision is made or a new rule is amended, it is necessary to have consensus among all signatory countries. Thus, agreeing on emission reduction targets and other proposed reduction rules is a broad and complex challenge given the large number of participating countries.

Market mechanisms are adversely affected by different factors, resulting in lower effective trading volume compared to the potential. These reasons could be summarized as low prices of carbon credits in the short term, uncertainty, and economic crisis. On the other hand, some measures could benefit these markets and contribute to greater efficiency, such as: adoption of more ambitious reduction targets reaching a larger number of countries; improvements in market regulations; decrease of transaction costs; and spreading existing information. Despite not having reached its full growth potential, carbon market mechanisms are now established and continue to develop. With a growing number of regional emission reduction programs a new paradigm emerges: how to standardize different carbon markets in order to reduce information asymmetry and uncertainties.

Notes

i Carbon credit, carbon certificate, and emissions reduction certificate is the nomenclature used in this work to generally designate the certificates resulting from the reductions of CO2 emissions, encompassing certified emission reductions (CERs) from the Clean Development Mechanism (CDM) and other emissions reduction certificates from other markets. Carbon credits are mesured in tCO2e (tonnes of carbon gases equivalent).

ii Certified Emission Reduction (CERs) are carbon credits earned by eligible CDM projects. Emission Reduction Units (ERUs) are carbon credits earned by eligible JI projects.

iii Sinks are defined as any process, mechanism, or activity, including the biomass and in particular forests and oceans, which have the property of removing greenhouse gases, aerosols, or GHG precursors from the atmosphere. They may be also other terrestrial, coastal, and marine ecosystems (UNFCCC, 2004).

iv LULUCF—Land Use, Land Use Change and Forestry—covers projects related to carbon sequestration by forests, including afforestation and reforestation.

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Submitted on: 26/09/2013
Accepted on: 21/08/2014
http://dx.doi.org/10.1590/1809-4422ASOC795V1812015en

CAP-AND-TRADE AND PROJECT-BASED FRAMEWORK: HOW DO CARBON MARKETS WORK FOR GREENHOUSE EMISSIONS REDUCTION?

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Abstract: There are two examples of carbon market mechanisms: i) trading based on the cap-and-trade principle establishes Greenhouse Gases (GHG) emission limits for companies that can negotiate allowance to pollute (as in European Union Emission Trading Scheme, EU ETS) , and ii) carbon credits, project-based emission reductions of GHG (such as the Clean Development Mechanism of the Kyoto Protocol, CDM). Given the importance of these two, this paper presents the dynamics of the evolution of carbon markets evolution by analyzing different markets (including other examples) and their framework, performances, potential and barriers. Besides these two programs, other national and regional systems are being developed, bu EU ETS and Kyoto stand in terms of volume and visibility. Despite existing criticism, in some countries volume of GHG emissions decreased between 1990 and 2011, probably influenced by the modernization of some formerly obsolete and inefficient industrial plant, and also by the poor performance of world economies in recent years.

Key words: Clean Development Mechanism; Kyoto Protocol; Carbon Market; EU ETS; Institutional Economics.

***Resumo*:** Existem dois exemplos de mecanismos de mercado de carbono: i) *cap-and-trade*, que estabelece limites de emissões de Gases de Efeito Estufa (GEE) às empresas, e baseia-se em licenças para poluir (*European Union Emission Trading Scheme* - EU ETS), e ii) projetos de reduções de emissões de GEE, que baseia-se em certificados de carbono com base em reduções (Mecanismo de Desenvolvimento Limpo do Protocolo de Kyoto - MDL). Este artigo apresenta a dinâmica da evolução dos mercados de carbono, analisando comparativamente diferentes estruturas de mercados existentes, desempenhos, barreiras e potencialidades. Outros sistemas de redução de emissões nacionais e regionais estão sendo desenvolvidos, no entanto, o EU ETS e o mercado decorrente de Kyoto ainda se destacam, tanto em vo-

lume quanto em visibilidade. Apesar das críticas existentes, o volume global de emissões de alguns países decresceu comparativamente entre 1990 e 2011, principalmente afetado pela crise econômica global, e pelas melhorias de tecnologias obsoletas.

Palavras-chave: Mecanismo de Desenvolvimento Limpo; Protocolo de Kyoto; Mercado de Carbono; EU ETS; Economia Institucional.

Resumen: Hay dos ejemplos de mercados de carbono: i) *cap-and trade*, con establecimiento de límites a gases de efecto invernadero (GEI) para empresas, con comercio de Permiso para Emitir (*European Union Emissions Trading Scheme*), y ii) créditos de carbono basados en proyectos (Mecanismo de Desarrollo Limpio del Protocolo de Kyoto). Este trabajo presenta la dinámica de la evolución de los mercados de carbono mediante el análisis de las estructuras de los mercados existentes, actuaciones, y los posibles obstáculos. Otros sistemas nacionales y regionales para reducir las emisiones se están desarrollando, pero sin embargo, el EU ETS y el mercado de Kyoto todavía se destacan, tanto en volumen como en visibilidad. Además, pese a las críticas existentes, el volumen total de emisiones disminuyó en entre 1990 y 2011, afectado principalmente por la crisis económica mundial, y las mejoras en la tecnología.

Palabras clave: Mecanismo de Desarrollo Limpio, Protocolo de Kioto, mercado de carbono, EU ETS, Economía Institucional