NBER WORKING PAPER SERIES

CARBON MARKETS: PAST, PRESENT, AND FUTURE

Richard G. Newell
William A. Pizer
Daniel Raimi

Working Paper 18504
http://www.nber.org/papers/w18504

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2012

Carbon Markets: Past, Present, and Future
Richard G. Newell, William A. Pizer, and Daniel Raimi
NBER Working Paper No. 18504
November 2012
JEL No. Q48,Q54,Q58

ABSTRACT

Carbon markets are substantial and they are expanding. There are many lessons from experiences over the past eight years: fewer free allowances, better management of market-sensitive information, and a recognition that trading systems require adjustments that have consequences for market participants and market confidence. Moreover, the emerging international architecture features separate emissions trading systems serving distinct jurisdictions. These programs are complemented by a variety of other types of policies alongside the carbon markets. This sits in sharp contrast to the integrated global trading architecture envisioned 15 years ago by the designers of the Kyoto Protocol and raises a suite of new questions. In this new architecture, jurisdictions with emissions trading have to decide how, whether, and when to link with one another, and policymakers overseeing carbon markets must confront how to measure the comparability of efforts among markets as well as relative to a variety of other policy approaches.

Richard G. Newell
Nicholas School of the Environment
Duke University
Box 90227
Durham, NC 27708
and NBER
richard.newell@duke.edu

William A. Pizer
Sanford School of Public Policy
Duke University
Box 90312
Durham, NC 27708
and NBER
billy.pizer@duke.edu

Daniel Raimi
Duke University
101 Gross Hall
140 Science Dr., Box 90467
Durham, NC 27708
daniel.raimi@duke.edu

1. Why Carbon Markets?

The 1980s and 1990s witnessed a growing awareness of climate change risks and the associated need to reduce greenhouse gas emissions. Beginning with the first World Climate Conference in 1979, attention culminated with the signing of the UN Framework Convention on Climate Change (UNFCCC) at the 1992 Earth Summit in Rio de Janeiro. In that agreement, 166 (now 194) nations acknowledged the need to limit the accumulation of greenhouse gases (GHGs) in the atmosphere to a level that will "prevent dangerous anthropogenic interference with the climate system."[1]

During that same period, emissions trading began emerging as a practical and increasingly popular policy tool to address pollution control, particularly with the successful phasedown of lead in gasoline and creation of the acid rain trading program in the United States (Tietenberg 1985; Stavins 1998). On the international scene, the Montreal Protocol on Substances that Deplete the Ozone Layer, signed in 1987, laid clear groundwork for the idea of "targets and timetables" for emission levels in different countries, and it included a limited amount of emission trading. It is therefore not surprising that there was considerable enthusiasm for using this tool to address climate change as countries grappled with how to design the 1992 UNFCCC and then meet its objectives in the 1990s. Indeed, advocacy for international GHG emission trading began in the late 1980s and early 1990s, with the US initially promoting "emissions trading" in the UNFCCC treaty negotiations, and the idea of "joint implementation" as an informal version of emissions trading ultimately appearing in the UNFCCC (Wiener 2001).[2]

This enthusiasm for emissions trading ultimately overcame various objections and led to the signing of the Kyoto Protocol in 1997.[3] The Kyoto Protocol was the first vehicle for emissions trading in greenhouse gases—or what we will call carbon markets.[4] Kyoto set up a system of emission limits for a basket of six GHGs for developed countries, mechanisms for those developed countries to trade their emission limits, and mechanisms for developed countries to offset their emissions by financing emission reductions in developing countries. While the Kyoto Protocol itself has led to a very small number of trades directly among countries, the European Union and a variety of other jurisdictions have since pursued emission trading to reduce their regional GHG emissions. Carbon markets are now the largest class of environmental or emissions trading markets in the world in terms of both volume and market value, by a very wide margin.

But how effective has emissions trading been at addressing climate change? What are the distinguishing features of trading in emissions of greenhouse gases compared to, for example,

---

[1] See Article 2 of UN Framework Convention on Climate Change.

[2] Joint implementation refers to one nation financing (partly or in whole) an emission reduction project in another nation.

[3] Objections included an early focus on emission taxes in the European Union (Barrett 1998) as well as more general issues related to emissions trading (e.g., Sandel 1997).

[4] We use the term "carbon market" because carbon dioxide is the dominant gas in terms of its overall contribution to global warming and because the units of trade are denominated in terms of carbon dioxide equivalent.

conventional air or water pollution? What have we learned as carbon markets have been designed, implemented, and operated? The purpose of this paper is to answer these questions, as well as to highlight new emerging issues that now need to be confronted. After eight years of carbon market experience following the creation of the EU Emission Trading System in 2005 (see Figure 1), experience that includes growing market volumes, market value, and emissions coverage, at least part of that answer must be, yes, carbon markets can work effectively. However, we have learned a lot and there are important lessons for current and future policymakers, analysts, and researchers.

The next section provides an overview of the normative theory of carbon market design, beginning with a description of some of the relevant attributes of GHGs. Section three discusses actual experience with existing and proposed emissions trading program design, while section four describes and draws lessons from operational experience in those markets. Section five looks forward and describes key issues facing emissions trading policies.

2. Normative Theory of Policy Design for Carbon Markets

There are a number of distinguishing attributes of the climate problem that are relevant to the design of carbon markets and that differentiate them from most other emission or resource markets. The first is the global nature of the climate problem. GHGs are one of the few examples of a "globally uniformly mixed pollutant" where emissions throughout the world have the same consequences regardless of where they are emitted.[5] Put another way, GHG emissions have exactly the same externality properties across countries that many conventional emissions have within a local jurisdiction. It is insufficient to control the GHG emissions from a particular source or region to reduce the risks to that region. This feature of the climate problem requires that, ultimately, an internationally coordinated approach must be taken, with implications for carbon markets that make them unusual if not unique among environmental markets.

Second, GHGs are long-lived "stock pollutants," remaining in the atmosphere on the order of decades to centuries. It is the accumulated global atmospheric concentration of GHGs that is linked to global warming and climatic change, rather than the GHG emissions at a particular point in time. Along the same lines, the capital stock that produces, distributes, and consumes GHGs also tends to be long-lived; cars and major appliances can last over a decade, while power plants and buildings last several decades. It is therefore important to keep in mind a long-term global perspective when addressing the climate problem, even when considering particular near-term regional policies.

Third, while carbon dioxide is the major GHG, there are numerous GHGs of varying potency (quantified in terms of the amount of heat energy trapped by a given amount of each gas) and longevity, from methane with a lifetime of 12 years to sulfur hexaflouride with a lifetime of 3,200 years.

Fourth, GHGs are pervasive in the economy, rather than being identified with a particular set of sources, sectors, or technologies. Carbon dioxide, the dominant GHG, is a fundamental

[5] Ozone depleting substances are one other example.

product of the combustion of fossil fuels (coal, oil, and natural gas) for energy production. Energy is used everywhere, and fossil fuels are the source of over 80 percent of U.S. and global energy consumption. As a consequence, the potential market size is much larger than other existing environmental markets. For example, in 2008 there were about 30 billion metric tons of carbon dioxide emissions globally from fossil fuel combustion (Boden *et al.* 2011). The market value of one year of allowances for these emissions at $10 per metric ton would be $300 billion; at $25 per metric ton it would be $750 billion. For higher allowance prices or when aggregated across several vintages of allowances, the value is easily in the trillions of dollars. As another example, the estimated market value of allowances that would have been created, just in the United States, by proposed Senate legislation in the 110th Congress was $6-7 trillion (Samuelsohn 2008).

A related point is that while stabilization of GHG concentrations in the atmosphere eventually implies driving net greenhouse gas emissions to near zero, the foreseeable future likely entails significant continued emissions. The pervasive economic role of fossil energy use coupled with limited alternatives and continued global economic growth means that GHG emissions will not be reduced in the same way that ozone-depleting substances were virtually eliminated in the 1980s and 1990s (Sunstein 2007). In scenarios with limited to moderate emission reductions, total mitigation costs tend to be a small fraction of the allowance value (Burtraw & Evans 2009). This leads to different distributional consequences than more typical situations where mitigation is a significant share of total emissions.

A fifth important feature is that options exist for offsetting GHG emissions, thereby negating or at least significantly reducing their impact on the atmosphere. Generally speaking, offsets include any approved methods for either reducing emissions or removing GHGs directly from the atmosphere (e.g., through forestry), that are not otherwise covered under a particular cap. In principal, offsets can come from both within or outside of the jurisdiction covered by an emissions cap. On a related note, carbon capture and storage (CCS) technologies offer an end-of-pipe solution to the avoidance of atmospheric emissions, involving capture of carbon dioxide from process or combustion gases, and then its storage underground. While end-of-pipe approaches are quite common in conventional air and water pollution control, CCS is considered a relatively advanced approach in the climate context and is still in the development stage. Nonetheless, well-designed policy would need a mechanism for crediting CCS, similarly to offsets.

Given the degree of complexity and long timeframes inherent in the climate problem, uncertainty along several dimensions—including the effectiveness of different approaches, the cost of mitigation, the evolution of technology, and the climate risks themselves—tends to be an overarching and pervasive aspect of policy analysis, construction, and implementation.

When placed in the context of the economic paradigm, the above attributes of the climate problem have a number of implications for carbon market design. We discuss the most important of these in this section, including the importance of compliance flexibility for cost-effectiveness; the significance of benefit and cost features for efficient instrument design; and the link between allowance allocation, government revenue and use, distributional impacts, and international competition. For further detail on several of these design issues, Aldy et al. (2010) provide a thorough review of the literature on designing climate mitigation policy.

2.1 Cost-effectiveness, Comprehensiveness, and Flexibility

Cost-effectiveness, or achieving a given aggregate GHG mitigation target at the lowest possible cost, tends to be a top-tier concern for market-based policy design. To theoretically enable cost-effectiveness (although not empirically guarantee it), the above characteristics tend to point to the design of carbon markets that have comprehensive coverage (i.e., across all gases, sectors, sources, and technologies), that can take advantage of mitigation opportunities at a global scale, and that have a long-term time horizon and structure that supports integrated decision making across time. This is sometimes referred to as "what, where, and when flexibility", which underpins a normative tendency toward comprehensiveness and minimal barriers to trading opportunities across space, time, and mitigation activity.

"What flexibility" relates to the comprehensiveness of any carbon market, with theory guiding design toward inclusion of as many types of GHGs (e.g., carbon dioxide, methane, fluorinated compounds), sectors (e.g., electricity, transport, industry, agriculture), and technologies (e.g., fuel switching, CCS, forestry and other biosequestration) as is feasible. One caveat is that it is important to consider what happens outside of a global trading system, when only some jurisdictions are pursuing emission trading. In particular, "leakage" can occur when regulation within one jurisdiction leads to increased imports from another, unregulated jurisdiction. Leakage tends to be concentrated in energy-intensive, trade-sensitive sectors and has both emissions and economic consequences, as economic activity shifts across regions. There are a variety of ways to address these concerns (Fischer & Fox 2009).

"Where flexibility" speaks to the significant variation in the costs of GHG mitigation across regions and countries. When focused on designing a carbon market for any specific region, it is therefore important to consider the extent to which allowances and/or offsets from other regions will be permitted to be used for compliance. So long as the validity of such allowances can be established, cost-effectiveness would tend to point toward open trade in allowances across jurisdictions. However, this type of "linkage" can face practical and political hurdles, in part due to the associated resource transfers, as we will discuss below (see Section 5.1).

Finally, given the stock pollutant nature of GHGs, emissions on any particular day, month, or year are not consequential for climate impact. As a result, allowing "when flexibility" through banking or borrowing of allowances across time tends to increase cost-effectiveness without additional harm to the climate. So long as the full range of mitigation options across space and time is available to the market system, trading will in principal lead to a cost-effective allocation of pollution control actions, through the elimination of opportunities for arbitrage.

2.2 Efficiency and Instrument Design

In addition to cost-effectiveness, which implies equalization of marginal pollution control costs, overall economic efficiency requires balancing the marginal benefits and marginal costs of GHG mitigation. One of the advantages of a market-based cap-and-trade approach to pollution control is that—for a given emission target—it does not require any ex-ante knowledge of pollution control costs or benefits. However, if there is interest in balancing the marginal cost and benefits of the policy, then economic information is required for both sides of this ledger.

This raises additional issues related to estimating the costs of mitigation, the monetized value of climate damages (Interagency 2009; National Research Council 2010), and the design of policy instruments that are efficient in the face of uncertainty over costs and benefits. The early economic literature on climate policy instrument choice under uncertainty (Pizer 2002; Newell & Pizer 2003) pointed to the advantage of price-based (i.e., a carbon tax) over quantity-based instruments (i.e., cap-and-trade) based on a modified Weitzman-type argument (Weitzman 1974) and assuming compliance had to be achieved on an annual basis. This earlier work also showed that price-like modifications within a cap-and-trade program—ceilings and floors on the allowance price or otherwise adjusting the cap to accommodate cost shocks—could achieve the same outcome as a carbon tax (Newell *et al.* 2005; Murray *et al.* 2009). Moreover, recent work has shown that ordinary banking provisions—which are included in virtually all emission trading programs—may come close to the efficiency of a carbon tax without further modifications (Fell *et al.* 2012).

One of the thorny issues raised by the potential movement of allowances across time is the trading ratio that should be applied to banked or borrowed allowances, and how this rate should be applied. Theory suggests that the optimal trading ratio between periods is equal to one plus the discount rate minus the desired rate of change in permit prices (Leiby & Rubin 2001). In addition to this *formula*, the discount rate itself is required, which raises a distinct set of analytical challenges for both the estimation of damages and the rate at which the carbon price should rise (Interagency 2009; Aldy *et al.* 2010; National Research Council 2010).

Due to the long-term nature of the climate problem, incentives for technological innovation in GHG mitigation technologies are also important for efficiency (Newell 2010). With respect to carbon market design, a key issue for technology innovation and deployment is setting carbon market stringency at a level that generates "the right amount" of incentive through the price mechanism. In the presence of innovation spillovers, one might be tempted to boost stringency beyond the level dictated simply by the climate externality. However, a more economically efficient approach is to recognize the need for more than one policy instrument to address these multiple market imperfections, and include direct innovation policy (Jaffe *et al.* 2003). Instrument design in the context of multiple market imperfections and multiple policy instruments can become complex, as the optimal level of stringency of any particular instrument depends on the levels of the others (Fischer & Newell 2008).

2.3 Allowance Allocation: Distributional Impacts and Efficiency

As with other market-based programs, GHG allowances can be auctioned, allocated for free, or some combination. There are both distributional as well as efficiency consequences to allowance allocation, and these can be large given the sizable economic rents that can be at stake – on the order of hundreds of billions of dollars. As noted above, because of the relatively small ratio of mitigation to emissions in most carbon trading regulation to date, payment of these rents tends to be the dominant distributional cost.

In many key carbon-emitting sectors, we would expect competitive pressure to lead product prices to reflect carbon content, regardless of any free allocation.[6] Consequently, end

[6] Exceptions to such pass-through could include utilities under cost-of-service regulation (where such pass through is prohibited) and industries facing strong international competition (and thus world prices).

users of energy would ultimately end up paying these rents. As a consequence, there can be significant distributional impacts to alternative free allocation approaches and formulas that distribute these rents, with implications for feasibility and equity across firms, income groups, regions, and generations. Unless regulation by utilities or others intervenes, free allowance allocations tend to accrue to firms and result in higher equity values to the benefit of higher income groups at the expense of lower income groups (Dinan & Rogers 2002).

Even without the potential equity impact of free allocation, it is fairly well-established that carbon pricing (through either an auctioned allowance market or tax) disproportionately harms low-income households (Hassett *et al.* 2009). While higher-income households tend to spend more on energy than do low-income households, they spend less as a fraction of income. A number of mechanisms have been proposed to ameliorate the regressiveness of carbon pricing, including lump-sum rebates (e.g., so-called "cap-and-dividend"), allocations to electricity distributors, and parallel offsetting changes to income or social security taxes (Burtraw *et al.* 2010). From an efficiency point of view, better compensation mechanisms tend to avoid lowering energy prices (to preserve appropriate incentives) and take advantage of opportunities to lower other distortionary taxes.

Absent a global trading program, free allowance allocations for energy-intensive industries are often a key mechanism to address political feasibility as well as to avoid emissions leakage. For moderate policies, some research on this issue has found that *on average* only about 15-20 percent of free allowances are need to compensate energy intensive industries for their loss of producer surplus (Bovenberg & Goulder 2001). However, other research has shown that there is significant variation in compliance costs *within* energy intensive sectors—creating both "winners" and "losers" under a carbon market—so that it can require a several times higher fraction of allowances to compensate the "losers" than would be indicated by the average loss in producer surplus (Burtraw & Palmer 2008).

Efficiency issues arise principally with respect to how much revenue is raised through auctions, and how much of this revenue is recycled to offset other distortionary taxes, or used for other purposes (e.g., technology programs, adaptation, energy efficiency programs). The literature tends to support the view that there is a significant potential efficiency gain from revenue-neutral full auctioning, and use of the proceeds to lower other distortionary taxes, relative to free allocation or lump sum redistribution of revenues (Aldy *et al.* 2010).

There are any number of other ways that carbon allowance auction revenues could be used, and the potential need for resources to support complementary GHG mitigation efforts—such as funding technology research, development, and demonstration, and energy efficiency programs—has linked these programs to carbon market design. It is not clear there is any efficiency advantage to this linkage, but from a practical point of view the use of carbon market revenue to support other GHG mitigation programs has had appeal to policymakers and has shown up as a prominent feature of both proposed and implemented carbon market design.

3. Program Overview and Key Design Choices

GHG emissions trading programs have been established at the international, regional, national, and sub-national levels, as highlighted in Figure 1**.** Though the normative theory discussed above focuses on cost-effectiveness, regulators developing each program have had to grapple with significant stakeholder interest in many design choices. The most contentious issues have revolved around: which sectors to include; how to minimize competitive losses to firms; how to limit consumer price increases; whether and how to employ emissions offsets; and the extent and manner of allowance trading by firms.

This section explores those key questions, summarizing the initial design choices in a variety of emissions trading programs and highlighting notable design elements. Table 1 gives a broad overview of central design elements in a variety of past, present, and (for the United States) proposed carbon trading systems.

Additionally, this section touches on the institutional and political histories of major programs. Although we cannot do full justice to the broad array of political and economic choices leading to each decision, we note some key factors that affected initial design choices. While all carbon trading programs are relatively young, some have changed substantially since launching. We describe those major changes, and the market experiences that prompted them, in section four as we discuss market experience more generally.

3.1 Program Overview

3.1.1 *Kyoto Protocol*

The Kyoto Protocol, adopted in 1997, established the first "non-voluntary" carbon market, committing certain nations to meet GHG emissions reduction targets and establishing a framework for allowance trading across international borders. The Protocol entered into force in February 2005, ninety days after the threshold of fifty-five nations had ratified (or otherwise approved) the document. Thirty-seven industrialized signatories, known as Annex-I nations, are responsible for reducing emissions by specified targets (United Nations Framework Convention on Climate Change 2012b). If a nation cannot meet its target, it may either purchase allowances (called Assigned Amount Units, or AAUs) from a fellow Annex-I nation, or purchase emissions offsets from projects that decrease emissions in other parts of the world.

The Kyoto Protocol established two major mechanisms to offset emissions: the Clean Development Mechanism (CDM) and Joint Implementation (JI). CDM projects, which reduce emissions in developing nations, earn one Certified Emissions Reduction credit (CER) per metric ton of GHG emissions reduction, which may be purchased by nations to meet their obligations under the Protocol. JI projects also earn one credit per metric ton of emissions reduction (called Earned Reduction Units, or ERUs) and come primarily from projects in the former Soviet Union. Both project types seek to encourage clean energy investment and learning while allowing Annex-I nations flexibility in meeting their emissions targets (United Nations Framework Convention on Climate Change 2006).

With its next phase scheduled to begin on January 1, 2013, the future of the Kyoto Protocol as a framework for reducing emissions is uncertain. Negotiations in Durban, South Africa in late 2011 ended with nations "agreeing to agree" by 2015 on a comprehensive plan to reduce emissions that would take effect by 2020 under the broader UNFCCC. However, no broad-reaching extension of the Kyoto Protocol was reached. At the Durban conference, European Union nations recommitted to their targets, and several former Soviet states pledged to reduce their GHG emissions in the next phase of the Kyoto Protocol. However, the United States never ratified the Protocol; China (the world's largest emitter) is not required to reduce emissions under it; and Canada, Japan, and Russia have not agreed to take on additional commitments under Kyoto after 2012 (United Nations Framework Convention on Climate Change 2012b).

In the context of the UNFCCC, where nations continue to negotiate GHG reduction targets with or without the Kyoto Protocol, Australia has committed to modest emissions reductions by 2020, promising to enact deeper cuts if the world's other major emitters commit to an "ambitious global deal" (United Nations Framework Convention on Climate Change 2011). Similarly, New Zealand will only agree to ambitious targets if there is a "comprehensive global agreement" on GHG emissions reductions (United Nations Framework Convention on Climate Change 2011).

These varying commitments paint an uncertain picture moving forward. Nonetheless, a variety of governments have developed market-based programs to reduce their GHG emissions within or outside of the Kyoto framework. The following section provides a review of major programs.[7]

3.1.2 *EU Emissions Trading System*

Although most European nations favored a carbon tax going into the Kyoto negotiations, the European Union has created by far the world's largest market-based system to reduce GHG emissions: the EU Emissions Trading System (EU ETS). In fact, the EU ETS began operating in 2005, three years before Kyoto's first commitment period began. The program has operated in phases, with a pilot phase from 2005-2007 covering the power sector and certain heavy industry, a second phase from 2008-2012 expanding coverage slightly, and a third phase set for 2013-2020 that will add a significant range of industrial activity (Ellerman *et al.* 2010; European Commission 2012a).

Under the first two phases, each of 27 EU nations (later expanded to 30) submitted National Allocation Plans (NAPs) to the European Commission.[8] Each NAP set an emissions target for covered sectors, and was reviewed by the Commission, which had the power to adjust the number of allowances allocated to each EU member. The program's initial design was highly decentralized, and once the NAPs were finalized, nations had significant discretion on how to distribute emissions credits to different sectors of their economies (Ellerman *et al.* 2010).

The pilot phase was something of a test, where governments and the private sector could develop a better understanding of how the trading program would function as the cap tightened in future phases. NAPs were developed under tight deadlines, and the Commission's adjustments to each national proposal were hampered by shortages of time and data. Despite the difficulty of calculating business-as-usual (BAU) projections with incomplete data, the Commission developed targets based on a modest emissions reduction goal (Ellerman *et al.* 2010).

[7] For more details on other proposed and existing programs, see Hood, Christina (2010).

[8] Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. The program later added Iceland, Liechtenstein, and Norway.

Even with modest reduction targets, member nations worried that pricing carbon could harm industrial sectors subject to international competition and raise consumer costs for domestic electricity. As a result, the vast majority of European Union Allowances (EUAs) were allocated free of charge in the pilot and the second phases. Each nation, through its NAP, determined the level and distribution of free allocation to different sectors through 2012 (Ellerman *et al.* 2010; European Commission 2012a). NAPs also specified the number of offset credits emitters in each nation could purchase from CDM or JI projects, with limits ranging from 0-20 percent (European Commission 2009).

Market experience, research and analysis in the EU ETS have led to significant changes as the program enters its third phase in 2013. We discuss that experience and changes in allowance allocation, offset rules, the ability to bank credits, and more in section four.

3.1.3 *United States*

The United States, which signed but never ratified the Kyoto Protocol, has seen dozens of legislative efforts to address GHG emissions. Although the effectiveness of an emissions trading approach was first demonstrated on a large scale by the United States' sulfur dioxide and nitrous oxide programs under the 1990 Clean Air Act Amendments, the U.S. Congress has not passed a GHG trading program (Burtraw *et al.* 1998; Meckling 2011).

Building on a variety of past efforts beginning as early as 2003's Climate Stewardship Act (cosponsored by Senators Joseph Lieberman and John McCain), the U.S. House of Representatives narrowly passed the American Clean Energy and Security Act in 2009 (better known as the Waxman-Markey bill, after the bill's cosponsors).[9] The Waxman-Markey bill would have established an economy-wide emissions trading program, focusing initially on the power and industrial sectors, and allowing emitters to offset up to 30 percent of their emissions from either U.S.-based or CDM offset projects (Larsen *et al.* 2009). However, political opposition doomed the legislation in the Senate, where it was never taken up (Meckling 2011; GovTrack 2012). Despite the absence of a nationwide system, several regions had already developed plans to implement their own GHG trading programs.

In 2005, nine Northeastern states became the first collection of jurisdictions in the United States to agree to an emissions trading program, with one additional state joining in 2006, and one state (New Jersey) withdrawing in 2011 (Christie 2011).[10] Known as the Regional Greenhouse Gas Initiative (RGGI), this program only covers large electricity generators. Revenues from auctioning of allowances go to state governments, which are required to invest at least 25 percent of those funds towards energy efficiency or renewable energy programs. Offsets for emitters are limited to just 3.3 percent, and come from projects mostly within RGGI states (Regional Greenhouse Gas Initiative Inc. 2012).

[9] For details on a variety of U.S. emissions trading proposals, see Aldy and Pizer (2008). For details on the 2003 McCain-Lieberman Act, see Pizer and Kopp (2003).

[10] The original nine were Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Maryland joined in 2006.

A second U.S.-based emissions trading system will begin in California in 2013. Arizona, California, New Mexico, Oregon, and Washington initiated the Western Climate Initiative (WCI) in 2007, later adding Utah and Montana, as well as British Columbia, Ontario, Manitoba, and Quebec (we discuss these Canadian provinces below). However, all U.S states other than California have declined to participate in the WCI emissions trading program set to begin in 2013 (Craig 2011). The WCI has developed detailed policy proposals to coordinate future programs implemented by its members, with an eye toward linking state programs under one umbrella.[11] California's emissions trading program, mandated by legislation, uses provisions developed by the state's Air Resources Board in consultation with the WCI, and will auction roughly 2/3 of its allowances in 2013 (California Code of Regulations 2011). Although the California program has yet to take effect at the time of this writing, participants have already begun trading futures contracts for emission allowances (Point Carbon 2012a). California's program will initially cover the power sector and large industrial sources, accounting for roughly 37 percent of the state's GHG emissions, and expand to cover 85 percent by 2015 (California Code of Regulations 2011).

A final regional agreement, the Midwestern Greenhouse Gas Reduction Accord (MGGRA), was signed in 2007 by one Republican and five Democratic governors. The accord, which included Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba along with several observer states, was to function like the WCI, helping its members establish programs by 2012. In 2010, MGGRA released a detailed model rule for member states to adapt and use. The proposal covered the power sector, major industrial emitters, and transportation fuel distributors, with most allowances being allocated free of charge at the discretion of member states (Midwest Greenhouse Gas Reduction Accord 2010). Despite the MGGRA's progress, new political leadership and shifting economic priorities ended the effort in early 2011 (Volvovici 2011).

3.1.4 *Canada*

Canada ratified the Kyoto Protocol in 2002, but never passed comprehensive legislation to regulate emissions. Driven by strong economic growth and a booming energy sector, CO2 emissions exceeded their targets and Canada withdrew from the Kyoto Protocol in 2011 (Canadian Government 2011b). Many Canadian policymakers are reluctant to act on climate change without the United States taking comparable action. Nonetheless, several provinces have made independent efforts to reduce GHG emissions (Canadian Government 2011a; De Souza 2011).

Quebec is currently on track to implement a GHG emissions trading program starting in 2013 (Quebec Government 2012a). Since nearly all of its electricity comes from non-carbon emitting hydropower, the program will not impact most electricity generators, but will apply to industrial sources (Centre for Energy 2012). Quebec developed the system using provisions developed under the WCI, allowing it to link with California as soon as 2013 (for a more detailed discussion on linking, see section 5.1). British Columbia, Manitoba and Ontario, also WCI

[11] For details, see www.westernclimateinitiative.org and www.wci-inc.org

members, plan to adopt trading programs in the future, but have not specified dates (Western Climate Initiative 2012). Manitoba was also a member of the now-defunct MGGRA.

The resource-rich province of Alberta, which produces over 40 percent of Canada's GHG emissions, has adopted an approach based on reducing emissions intensity. Large emitters, including oil producers, must reduce their emissions per unit of output by 12 percent against a varying baseline measurement between 2007 and 2010. If they cannot meet these targets, emitters can comply by one of three mechanisms: purchase excess credits from another emitter, purchase Alberta-based offsets, or pay CN$15 per metric ton towards an energy/climate technology fund (Alberta Government 2011a). Most allowances are allocated freely to emitters, and as of 2010, the program covered 97 facilities which accounted for roughly 50 percent of Alberta's GHG emissions (Alberta Government 2011a, b, 2012). The program's modest intensity reduction targets means that even if emitters meet their targets, overall GHG emissions may well increase (for a critical discussion of this issue, see Doluweera et al(2011)).

3.1.5 *New Zealand and Australia*

New Zealand launched a unique emissions trading program in 2008 with an approach focused on forestry. After seeing extensive deforestation in 2006 and 2007, the New Zealand government gave the forestry sector an incentive to replant and conserve while capping large emitters. Under the New Zealand Emissions Trading Scheme (NZ ETS), the government assigns offset credits to domestic projects that conserve or replant forests. Large emitters in all sectors of the economy must meet specified GHG reduction targets by reducing emissions, purchasing offsets, or paying NZ$25 per metric ton of emissions. Notably, the program includes pre-1990 forestry, meaning that permanent deforestation of more than 2 hectares of trees planted before 1990 requires the surrender of allowances (New Zealand Ministry for the Environment 2011). The NZ ETS is one of the few programs that currently includes transportation fuels, and this sector, along with the power sector and forestry, receives no free allocations of allowances. Industries facing international competition, horticulture, and fishing have received some free allocation (New Zealand Government 2012).

In Australia, after a long and contentious political process in which the prime minister reversed her position, a series of bills became law in 2011 that will begin an emissions trading program in 2015. In the meantime, major carbon emitters will pay a steadily increasing carbon tax set by the legislation. Government revenues from this tax and auctions beginning in 2015 will go to new spending on efficiency, renewables, and technology, with at least 50 percent of revenues going to increased pension payments, increased tax credits, and decreased income taxes for households (Australian Government 2012b). In August, 2012, Australia announced that its program will link with the EU ETS, allowing emitters to surrender EUAs to comply with up to 50 percent of their requirements (Australian Government 2012a; Reklev 2012a). Additionally, European emitters may use Australian allowances for compliance as early as 2018. However, Australia's current opposition party has made repealing the carbon price "the top priority" on its agenda, calling into question the policy's viability moving forward (Australia Liberal Party 2012).

3.1.6 *South Korea, Mexico, and Voluntary Markets*

Recent legislation passed in South Korea and Mexico has laid the groundwork for new national-level programs beginning in 2015. Much about these programs remains to be decided, but one interesting feature of Korea's program is that it will not allow international offsets for compliance until at least 2020 (Reklev 2012b). Additionally, some have speculated that Mexico's new president, Enrique Pena Nieto, is unlikely to implement much of the recently-passed climate legislation (Teixeira 2012). Other emissions trading proposals are currently under discussion or development in a wide variety of nations, including Brazil, Chile, China, India, and others (Hood 2010).

Finally, voluntary carbon markets refer to a variety of organizations that allow individuals or businesses to purchase offsets from emissions reduction projects. Since 2002, voluntary markets have grown from $43M in revenues to a peak of $705M in 2008, and stood at $572M as of 2011 (Ecosystem Marketplace and Bloomberg New Energy Finance 2008-2012). Dozens of organizations offer voluntary carbon offsets, and their standards for evaluating and monitoring GHG reduction projects are typically less stringent than those used for the CDM or JI. One benefit of less stringent standards is reduced bureaucracy and the potential for lower project costs; however, weaker standards could also lead to certification of projects that do not provide their stated benefits (Benessaiah 2012).

3.2 Key Design Choices

3.2.1 Setting the Cap and Comparability Issues

A fundamental question for any cap-and-trade program is the level of the cap. Jurisdictions have taken a variety of approaches to setting reduction targets and measuring progress. As noted in Table 1, some programs explicitly base cap levels on the Kyoto Protocol targets and 1990 baseyear, but many have developed alternative targets and baseyears. Absent a common approach to setting targets, to sharing responsibility for emission reductions across jurisdictions, or to measuring progress, it is difficult to compare the goals of one program to the next without controversy.

Adding to the comparability challenge is the fact that most programs do not cover all economic activity. For example, a 21 percent reduction in the cap specified by the EU ETS does not represent a 21 percent GHG emission reduction across the entire economy. Instead, the ETS is one of several tools implemented by the EU to reach its Kyoto Protocol targets. Australia and New Zealand, on the other hand, cover all or almost all economic activity with their trading systems, and will attempt to reach their pledges under the 2011 Copenhagen Accord almost entirely through emissions trading. Sub-national programs in the United States and Canada neither cover the entire economy nor explicitly link their reduction goals to any international agreement.

Clearly, researchers face a variety of challenges in comparing regional, national, and sub-national programs, especially when those programs are designed to address a global problem. We explore this issue further in section 5.3.

3.2.2 Regulated Sectors and Allocation

Since greenhouse gas emissions occur as a by-product of virtually every form of economic activity, governments face the crucial questions of which sectors to regulate and whether to auction allowances or allocate them free of charge. After an early tendency to provide free allocations, new programs and the revised EU ETS have moved toward auctioning allowances (we discuss some reasons for this in section 4.4).

The EU ETS, RGGI, and other programs have focused on covering large point sources such as power plants and factories. Such sources have relatively low monitoring costs and—from a political perspective—are often easier to target for regulation than sources such as transportation. Additionally, most electric power markets do not face substantial competition from foreign firms, meaning that many power producers can pass along costs to consumers. As a consequence, electricity generators receive fewer free allowances in most programs than other types of emitters. RGGI and the NZ ETS, for example, give no free allowances to the power sector.

Heavy industrial processes (e.g., cement, aluminum, lime, fuel refiners) are covered by every system other than RGGI, but fearing economic dislocation, governments have given substantial free allocations to these firms. In every trading program that includes them, these typically trade-sensitive industrial sectors receive up to 95 percent free allocation. Regulators generally calculate a sector or firm's level of free allocation based on formulas including exposure to foreign competition and each sector's ability to reduce their emissions intensity.

3.2.3 *Cost and Volatility Containment*

We begin the discussion of costs by noting that market-based emissions reduction programs typically offer substantial savings over traditional standards-based regulation (Stavins 1998; Carlson *et al.* 2000). Among market-based programs, normative theory emphasizes the value of either fixing or constraining prices, as noted in section 2.2. Yet, the political debate and press coverage has put more focus on avoiding *high* prices. This may be unsurprising, given that a market-based program inevitably broadcasts prices much more transparently than standards-based regulation. Regardless of the motivation, significant uncertainty over abatement costs has led program designers to include mechanisms to prevent allowance prices from exceeding economically and politically tolerable levels.

The emissions trading programs discussed above have typically turned to one or more of the following three types of cost containment. First, regulators can impose a price ceiling, allowing emitters to purchase allowances directly from the government at the ceiling price. For example, participants in California or Quebec's program will be able to purchase credits from the government for $40-$50/metric ton, essentially capping trading prices (Western Climate Initiative 2012).

Second, emitters may be allowed to bank or borrow allowances from past or future compliance periods. This option allows emitters greater flexibility in meeting emissions reduction targets over time without forcing them to precisely achieve each interim target (as noted in section 2.1, this type of flexibility is justified on cost-effectiveness grounds alone). The EU ETS, which began with no banking or borrowing between phases, now allows unlimited banking of credits (Ellerman *et al.* 2010). Although it would also reduce compliance costs, borrowing provisions have been less widely adopted (Fell & Morgenstern 2009).

Third, high market prices can trigger provisions that relax the constraints of the program.[12] In RGGI, for example, if carbon prices reach $7/metric ton, emitters are allowed to purchase more carbon offsets to meet their compliance needs. If prices reach $10/metric ton, emitters may purchase still more offsets to reach their targets (Regional Greenhouse Gas Initiative Inc. 2012).

Some programs also employ price floors to prevent market prices from falling below a certain level. Auction price floors are used in RGGI, along with anticipated programs in Australia, California, and Quebec. These floors may seek to accomplish two goals: maintaining prices at a level where firms have an incentive to invest in emissions-reduction technology; or providing a steady source of revenue for governments.

3.2.4 *Offsets*

International emissions offsets offer a very large potential pool of mitigation opportunities, providing industrialized nations a lower-cost option for GHG reductions relative to reducing emissions within their own borders (Weyant & Hill 1999). Domestic or local offsets can also offer cost savings relative to opportunities within a given cap-and-trade program, but represent a smaller universe of activities compared to international offsets. Although specific provisions and restrictions vary, all programs to date employ offsets in some capacity.

Offsets from the CDM and JI play a major role in the EU ETS, with NAPs in some nations allowing up to 20 percent of emissions reductions to be met with offsets. (Ellerman *et al.* 2010). Participants in the EU ETS may not purchase CDM or JI offsets from forestry or land-use change projects, due largely to questions over the permanence of carbon sequestration in forestry projects (Kim *et al.* 2008). Additionally, some have raised concern over potential harm to indigenous peoples due to forestry projects (Stickler *et al.* 2009).

While international offsets have played by far the largest role to date, regional or local offset programs to reduce emissions exist in several established and emerging trading programs. The notion that offsets should take place within a program's borders, instead of from international CDM or JI projects, has taken hold in some cases. Offset projects based within a program's borders ensures that the associated investment stays close to home, to the benefit of local economies. On the other hand, local offset projects may cost more than offsets provided abroad, implying higher costs for locally regulated industries.

In New Zealand's program, where no auctions are held, emitters comply with any unmet reduction goals by purchasing offsets, either from New Zealand-based forestry offsets or from CDM or JI projects (New Zealand Government 2012; Point Carbon 2012c). Regional programs in North America such as RGGI, California, and Quebec have generally avoided the CDM, instead giving preference to offsets from regional or domestic emissions reduction projects. These North American programs allow offsets to make up just a small share of compliance, so firms do not need to draw on the millions of tons of offsets available from the CDM or JI.

---

[12] Exactly how these latter mechanisms might affect behavior is sometimes unclear, particularly when speicific actions trigger a significant and well-understood price decline. With banking, such an expected decline is at odds with a typical no-arbitrage condition.

3.2.5 *Market Monitoring and Oversight*

After the 2008 financial crisis, virtually all financial markets came under new scrutiny. Carbon markets were no exception, and new proposals for trading programs in the United States came with calls for strong oversight. In fact, the 2010 Dodd-Frank financial reform and consumer protection bill created an interagency working group to conduct a study on maintaining and increasing transparency for carbon markets (Interagency Working Group for the Study on Oversight of Carbon Markets 2011). Similarly, an EU directive adopted in 2011 (the Markets in Financial Instruments Directive, or MiFID) will significantly expand oversight of carbon markets (European Commission 2012b). Primary goals for market oversight include facilitating price discovery, ensuring transparency and access to information, and preventing manipulation or abuse in the marketplace.

Monitoring and oversight occurs in the primary (first purchase or issuance), secondary, and derivatives markets. In primary markets, regulators typically seek to track initial ownership of allowances, how allowance auctions are conducted, and the creation/verification of offset credits. As an example, RGGI tracks allowance ownership through its CO2 allowance tracking system (COATS), employs an independent monitor to review auctions, and requires member states to verify emissions offset programs (Regional Greenhouse Gas Initiative 2010).

Oversight of secondary markets, where spot transactions occur and futures contracts are created, presents a different set of challenges. Equal access to information is vital to ensure an unbiased marketplace, and programs seek to ensure this by announcing new market data at pre-determined intervals. Additionally, regulators may seek to limit market power of any single entity by limiting positions, as seen in California and Quebec’s forthcoming programs (California Code of Regulations 2011; Quebec Government 2012b).

Derivatives based on emissions allowances are typically subject to the same market oversight as other derivatives instruments. In the United States, oversight of these instruments and exchanges falls under the purview of the Commodity Futures Trading Commission (Interagency Working Group for the Study on Oversight of Carbon Markets 2011).

4. Market Experience and Lessons

Having explored the initial design features associated with different carbon markets, we now turn to market experience and evolution. We focus on the EU ETS, CDM, and RGGI, where there are at least several years of data (see Figure 1), but also include recent information on futures contracts in New Zealand and California that began trading in 2011. We draw a number of lessons based on the experience to date, highlighting price levels, market operation, banking, allocation and revenues, leakage, and offsets.

We do not focus directly on the Kyoto Protocol, as its primary compliance instrument, called Assigned Amount Units (AAUs), are typically traded in “one-off” transactions, negotiated and sold directly from one Annex-I nation to another (Aldrich & Koerner 2012). Although nations have traded millions of AAUs in these transactions, standardized exchanges have not emerged. Instead, the Kyoto Protocol's primary contribution to emissions trading markets has been the development of the EU ETS and the CDM, which we do explore below.[13]

Figures 2 and 3 provide basic information on carbon prices and volumes. Carbon prices in all markets have been falling since 2008 in response to the current economic recession. Nonetheless, volumes have been increasing, both in terms of activity within markets as well as the creation of new markets. The EU ETS has dominated the marketplace, with far greater volumes, liquidity, and price volatility than any other market. The EU ETS is also the largest outlet for CDM/JI credits. Additionally, the EU system is the only one where a significant secondary market has developed, with market participants buying and selling standardized contracts up to five years in advance on a variety of exchanges. While trading in the EU ETS began mostly with non-standardized OTC transactions, exchange-based trading likely surpassed OTC volumes sometime in 2008, indicating increased levels of standardization and liquidity (Ellerman *et al.* 2010).

4.1 Lesson: Positive Prices Imply Emissions Abatement, But How Much Is Unclear

The mere presence of a consistently positive price on carbon suggests that these trading programs are having at least some impact on behavior with regard to emissions levels. Program design, underlying fuel prices, and larger economic forces all impact behavior of market participants, but due primarily to the youth of the EU ETS and other programs, research on the extent of each of these impacts relative to the carbon price remains limited.

One way to approach the abatement question is to estimate emissions reductions based on elasticities derived from related analyses. A rough analysis of projections from the proposed U.S. Waxman-Markey legislation suggests emission semi-elasticities of 0.0015-0.0061 in the year 2015.[14] That is, for each \$10/metric ton increase in the price of U.S. CO2 allowances, emissions from 2012-2015 would fall between 1.5 to 6 percent compared with a scenario with no price on CO2 emissions. If similar economic dynamics are at play in the EU ETS, an allowance price of \$16/metric ton (the Phase I average for the EU ETS) would suggest that the program resulted in reductions of 2-9 percent compared with BAU.

Existing research falls in line with this rough calculation. Empirical research on Phase I of the EU ETS suggests that during 2005-2007, emissions fell by 2-5 percent compared with BAU (Ellerman & Buchner 2006; Ellerman *et al.* 2010; Anderson & Di Maria 2011). If accurate, this level of abatement is consistent with the notion that Phase I of the EU ETS was less an ambitious carbon-reduction plan than an attempt to gain experience for future emissions reduction efforts. Since Phase II of the ETS has not yet concluded, we lack empirical research on abatement from 2008-2012. However, using the semi-elasticities noted above, the \$20/metric ton

---

[13] Note that the EU ETS provides for corresponding adjustments in AAUs as EU allowances are transferred among EU countries. See EU Directive 2003/87/EC.

[14] Author's analysis of data from Energy Information Administration, "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009."

average price of EUAs from 2008 through mid-year 2012 implies a reduction of 3-12 percent compared to BAU.

A key question—and sometime criticism—of current market-based policies is the degree to which they encourage long-term investment in new technologies rather than solely short-term fuel-switching and energy conservation. Much has been written about both the importance of this long-term investment to address climate change, and the potential effectiveness of market-based policies to drive it (Jaffe 2002; Newell 2010). However, markets for CO2 may be too new to fully inspire the long-term confidence to make those investments, and early research into the EU ETS suggests that such investments may be limited (Leiter *et al.* 2011).

4.2 Lesson: Despite Some Rough Patches, Markets Have Generally Matured And Operated Effectively

Given the youth of the carbon markets, some learning and evolution is to be expected. Despite the exceptions noted below, markets have generally functioned well, enabling price discovery, increasing market transparency, and reflecting larger economic trends. Although smaller markets like RGGI and New Zealand do not see high volumes of trading, market depth and liquidity in the EU ETS is extensive.

One challenge in the EU ETS has been the availability and quality of baseline emissions data. The EU ETS' pilot phase caps were constructed under time pressure and with a shortage of reliable data (Ellerman *et al.* 2010). When the first tranche of actual emissions data was released in 2006 by the EU Commission, market participants were surprised by the low emissions levels vis-à-vis allowance supply, which sparked a dramatic fall in prices. This issue was also related to the inability to bank credits, which we discuss below in section 4.3. Large price swings directly related to data problems appear to be mostly absent since 2006-2007. However, governments have come under criticism for not releasing timely and detailed data on individual allowance trades and holdings (de Perthius 2011).

A second issue impacting the EU ETS has been the types of offsets allowed under the UN-administered CDM. We discuss this issue in detail in section 4.6 below. Thirdly, the EU ETS has faced three high-profile cases of market manipulation, two of which were not specific to emissions trading markets. One of these two cases involved traders manipulating value-added tax (VAT) laws in different countries to defraud governments of over €1B from 2008-2009, while the second involved cyber-attacks which likely stole over €50M worth of allowances on spot exchanges in 2011 (de Perthius 2011; Frunza *et al.* 2011). The one major problem unique to emission markets occurred when CDM credits (CERs) previously collected by the Hungarian government for compliance re-entered the market. This type of emissions credit "recycling" negates the environmental value of a carbon reduction, and diminishes the integrity of the trading system (de Perthius 2011).

After each instance of market manipulation, the EU Commission revised its rules to address the specific problem. For the VAT fraud and CER recycling issues, the Commission has increasingly centralized oversight of the ETS, making it harder for individuals to take advantage of differences between national-level laws and regulations. The cyber-attacks, which forced a multi-day suspension of spot trading, prompted the Commission to re-examine the security measures put in place by the various exchanges that facilitate trading (European Commission 2010).

As for RGGI, the program's independent market monitor has found no major irregularities since trading began in 2008 (Potomac Economics 2009, 2010, 2011). Market and auction data is released by RGGI regularly, and allowance holdings are traceable online through the program's COATS System (COATS).[15]

A final issue for market behavior has been uncertainty stemming from the central role of policy. Since emissions markets (excluding voluntary markets) are created by governments, changes in policy have the potential to dramatically impact those markets. As the EU ETS enters its third phase, the EU Commission is reportedly considering a delay in auctioning millions of EUAs, which would likely drive up short term prices (Allan 2012; Szabo 2012b). However, unless those allowances are retired permanently, they eventually would come into the market, suppressing future prices. Additionally, program changes intended to reduce the supply of EUAs may decrease the level of certainty market participants can expect from the EU Commission, potentially deterring investors from participating in the futures market or from banking allowances.

Carbon markets in the United States and Australia also face major uncertainty over policy. RGGI saw a major decrease in the size of its market when New Jersey withdrew from the program in 2011(Christie 2011). As mentioned earlier, Australia's opposition Liberal Party has vowed to eliminate that county's proposed emissions trading program if it gains control of the government in 2013 (Australia Liberal Party 2012). In New Zealand, rules were revised to allow one allowance to be surrendered for two metric tons of emissions during a transition phase (Fallow 2009). We return to this issue in section 5.2.

4.3 Lesson: Banking Matters

As noted above, the first release of actual EU ETS emissions data in 2006 showed emissions levels charting a course well below their Phase I cap. Because EUAs in Phase I could not be banked and could only be used between 2005 and 2007, an oversupply of permits meant that prices were likely to drop—and drop they did.[16] In the first quarter of 2006, spot EUAs traded at €25/metric ton. By the final quarter of 2007, spot prices were essentially zero, at €0.06/metric ton (see Figure 2; Point Carbon 2012b).

This precipitous drop did not represent the underlying price of carbon, nor was it solely a problem of limited data; rather, it reflected the inability of market participants to bank allowances for use in future phases. Had emitters been able to use their remaining Phase I credits in Phase II of the EU ETS, prices would still have dropped in response to news of a current-period oversupply, but certainly would not have approached the near-zero levels seen in late 2007. The rationale for not allowing banking was the desire to separate Phase II, which coincided with the first Kyoto compliance period, from the EU ETS' Phase I trial period—but the consequences of this decision were clear. Spot prices for Phase I allowances approached zero, even while contract futures prices for Phase II EUAs hovered above €20/metric ton (Point

---

[15] See www.rggi-coats.org for details.

[16] While 2005-2007 EUAs could not be banked, CDM credits could be moved forward. However, the oversupply was more than CDM movements could accommodate.

Carbon 2012b). The EU Commission, as well as designers of future programs, took careful note. In current and future phases of the EU ETS, as well as all other major emissions trading programs, unlimited banking of permits between phases is permitted.

An emerging question is exactly how much banking an emissions trading system can (and should) support. Analyses of the failed Waxman-Markey bill suggested that by 2022 (10 years after trading's hypothetical start date), firms would have accumulated banked credits of 7-12 billion metric tons of allowances, 140 to 240 percent of the program's 2022 cap of roughly 5 billion metric tons (Energy Information Administration 2009). Recent EU ETS estimates suggest compliance entities, banks, and other market participants are banking nearly 2.5B allowances, roughly 119 percent of Phase II's annual cap for carryover into Phase III (Neuhoff *et al.* 2012).

From a normative perspective, we would want market participants to be as well-informed as possible about the direction of future policy and to bank accordingly. However, if policymakers behave in the unexpected ways noted at the end of section of 4.2, this may have consequences. For example, New Zealand's late decision to allow one allowance to count for two metric tons of emissions increases supply and lowers prices. The reverse is true of the EU's decision to hold back auctioned allowances. Even if temporary, these experiences (of having the government step into the market) will influence the way market participants view the rigidity of the emissions cap and consequent allowance prices. An important unanswered question is the degree to which governments ought to be disciplined or flexible in the face of various events.

4.4 Lesson: Allowance Allocation Can Involve Large Revenues And Distributional Impacts

Every major emissions trading program (with the exception of RGGI) allocates at least some free allowances to heavy industry and, in some cases, power generators. In Phase I of the EU ETS, most NAPs compelled power generators to reduce their emissions more than other sectors (Ellerman *et al.* 2010). Concerned about a consequent rise in consumer electricity prices and encouraged by industry, regulators and elected officials allocated the power sector a large share of allowances at no charge (Markussen & Svendsen 2005). In competitive markets such as Germany, power generators passed along the opportunity costs of these free allowances to their customers, allowing generators to extract rents roughly comparable to their proportion of freely allocated allowances (Ellerman & Joskow 2008; Sijm *et al.* 2008; Ellerman *et al.* 2010). Put simply, power companies effectively charged customers for permits they received for free.

This predictable market outcome demonstrated that free allocation did not necessarily protect consumers, but did have distributional consequences. Some commentators have expressed indignation that large emitters profited while passing on new costs to consumers (Gow 2006; Harrison 2009). The European Commission has responded by revising the program's guidelines, limiting free allocations and increasing the proportion of allowances sold at auction. Heavy industry facing significant international competition, which tends to prevent firms from passing on allowance or abatement costs, will continue to receive substantial free allocations. In contrast, power generators will receive limited free allowances, and only in specified nations (European Commission 2012a).

Despite well-known public finance arguments against earmarking, governments may also seek to put rents extracted from emissions trading programs to particular purposes. In many programs (such as Alberta, Australia, California, and RGGI), governments must put a share of revenues raised from auctioning emissions toward low-carbon energy projects. These investments include renewable energy projects, carbon capture and storage technology, efficiency programs, and more. RGGI states, for example, invested over 60 percent of their auction revenues (roughly $480M) towards energy efficiency and renewable energy programs between 2008 and 2010. Other revenues from RGGI went towards direct energy assistance to households, and a small share went to non-related government projects (Regional Greenhouse Gas Initiative Inc. 2011).

4.5 Lesson: Significant Competitiveness Impacts and Emissions Leakage Are Not Inevitable

In the absence of a global regime, reduced economic competitiveness of covered sectors is often mentioned as a key concern with carbon taxes or emissions trading programs. Two distinct issues arise in this context. First, an emissions trading program entails economic costs and can redistribute economic activity – both jobs and capital – away from regulated sectors, particularly emission-intensive manufacturing. These costs and redistribution are economic issues. In addition, some of this manufacturing activity may shift to unregulated jurisdictions, with domestic emission reductions re-appearing elsewhere in the world. In addition to amplifying the economic issues, this emissions "leakage" is an environmental issue. If significant, leakage draws into question the underlying environmental rationale for emission trading programs. However, a review of the (limited) empirical literature indicates that, at least for the early phases of the EU ETS and RGGI, competitive losses and leakage appear to have been small in the few sectors where it has occurred.

Ellerman et al (2010) found "no observed impact" on competitiveness in the oil refining, cement, aluminum, or steel sectors during Phase I of the EU ETS. Demailly and Quirion (2008) found that Phase I of the EU ETS created only a small loss of competitiveness in the iron and steel sectors. Lacombe (2008) found a similar limited impact on the EU refining sector during Phase I. An analysis of the EU aluminum sector by Reinaud (2008) found no statistical evidence of negative competitiveness impacts from the program, but notes that information gaps remain.

However, one survey of firm managers suggests larger competitive impacts and associated leakage in certain sectors. For example, 55 percent of survey respondents in metals manufacturers and 44 percent of pulp/paper and cement/lime/glass manufacturers stated they have either moved or are considering moving out of the EU ETS compliance zone, while only 14 percent of other firms stated they have moved or are considering such a move (Point Carbon 2011). There are reasons to regard such survey results with caution. First, the survey consists of a fairly small sample size (n=215 for the entire EU economy). Second, survey respondents may not disaggregate the cost of CO2 from the overall cost of electricity, potentially leading to an overemphasis on the weight of carbon prices.

If the lower estimates from the EU are accurate, these minimal competitiveness impacts and leakage rates may reflect the modest GHG reduction targets implemented in the first phase of the EU ETS. Additionally, uncertainty over emissions reduction policies around the world may delay firms from making decisions on moving to jurisdictions where GHG policies could enter into effect after the firms' relocation.

These observed competitiveness impacts and leakage generally fall below the levels predicted by some analyses of emissions pricing in the United States. Aldy and Pizer (2008) estimated that a \$15/metric ton carbon price in 2012 would result in decreased heavy industrial production by 1.6-3.4 percent. Ho, Morgenstern, and Shi (2008) estimated that a \$10/metric ton price would decrease production of most trade-exposed heavy industry by between one and three percent, though some industries would see decreases up to 7.7 percent. A U.S. interagency analysis of the proposed Waxman-Markey bill (Interagency Competitiveness Analysis Team 2009) estimated that the legislation would result in an increase in marginal production costs of between zero and four percent. Finally, Fischer and Fox (2009) estimated that a high (\$50/ton) carbon price could result in leakage rates of up to 27 percent for some energy-intensive sectors.

Leakage and competitiveness issues in RGGI has also been a concern, given that the program may result in a loss of \$1.5B for the power sector through 2021 (Hibbard *et al.* 2011). Since RGGI states operate in an electricity market integrated with non-RGGI states, the potential for leakage in the power sector clearly exists. Some research has suggested leakage rates ranging from 28 percent with \$3/metric ton prices to 90 percent with \$7/metric ton prices (Chen 2009; Wing & Kolodziej 2009; Kindle *et al.* 2011).

However, low carbon prices resulting from a weak economy and historically low natural gas prices may have prevented extensive leakage in RGGI. One empirical study in New York State from 2008-2010 suggests that allowance prices were too low to cause leakage (Kindle *et al.* 2011).

4.6 Lesson: Offsets Can Work, But They Are Complex

The Kyoto-established CDM and JI mechanisms have generated tens of thousands of emissions reduction projects worldwide, allowing the EU ETS and other trading programs to reduce costs while speeding technological transfer to developing countries. We will focus here on the CDM, as CDM projects have outnumbered JI projects by over 12:1 from 2007-2011 (Fenhann 2012). Exactly which types of projects should receive offset credits has received the most attention. For offsets to truly reduce emissions, credits can only be given to projects that would not have occurred without the offset credit program. That is, projects must provide "additional" emissions reductions compared with a world where the CDM did not exist.

Although much research indicates that the CDM has resulted in real emission reductions, a variety of researchers have described cases where non-additional projects received credits under the program (Wara 2008; Elsworth & Worthington 2010; Lambert 2011; Zhang & Wang 2011). The most problematic project type in the past has been HFC-23, a refrigerant used in industrial processes that has roughly 10,000 times the global warming potential (GWP) of carbon dioxide (United Nations Framework Convention on Climate Change 2012a). Because of its high GWP, projects that reduce HFC-23 receive large amounts of credits.

Figure 4 shows how, despite a very small proportion of projects, HFC-23 reduction projects received a large share of reduction credits from 2005-2006. Lambert (2011) finds that inadequate baseline measurements helped create a perverse incentive, encouraging HFC-23 emitters to temporarily *increase* their emissions, allowing them to later reduce HFC-23 output and claim thousands of valuable credits. In the wake of such research, the European Commission voted in 2011 to disallow credits from projects reducing HFC-23 (European Commission 2011).

Additionally, the CDM Executive Board revised its guidelines regarding HFC-23 and other similar gases, leading to an increased number of rejected project proposals.[17] Figure 4 shows the result, as HFC-23 projects have received far fewer offset credits since 2006.

The number of proposed and implemented CDM projects has grown substantially, led by renewable energy such as wind, solar, or biomass. Still, overall issuance of CDM credits has decreased steadily since 2007. This trend likely reflects stricter rules established by the CDM Executive Board, as well as the fact that many planned renewable projects have not yet begun receiving offset credits.

In Phase II of the EU ETS, the usage of offsets varied considerably among EU nations, ranging from a low of zero in Malta and Liechtenstein to 13 and 18 percent in Spain and Lithuania, respectively. Overall, the use of CERs for compliance across all EU nations from 2008 through mid-2012 was roughly six percent, totaling 456 million CERs. When ERUs, earned from JI projects are included, the figures reach over 7%, or roughly 555 million international offsets.[18] However, phase II NAPs allowed EU nations to use offsets for an average of 11 percent of their emissions reductions, meaning that emitters have chosen not to use their maximum number of offsets. Germany and the United Kingdom, the region's two largest GHG emitters, have used fewer than half of their allowed offsets for compliance through phase II.[19]

This limited use of offsets in Phase II is likely related to the ability of firms to bank their ability to use offsets into Phase III of the EU ETS. If firms expect allowance prices to rise (or credit prices to fall), they may refrain from using offsets in the current period.

The CDM has also presented a variety of distributional questions due to the associated transfer of resources from Annex-I nations to developing nations. Through 2011, by far the largest share of projects and credits were going to China and India. In fact, between 2006 and 2011, over half of each year's CDM credits went to projects in China (topping out at 75 percent in 2007) (Fenhann 2012). Since China is the world's largest carbon emitter, it is not surprising that a large share of GHG reduction projects would flow there. However, nations or political stakeholders that believe China should commit to a more stringent emissions reduction plan, or see China as a competitor, may object to the transfers enable by the CDM (International Energy Agency 2012).

Most researchers agree that the CDM has successfully produced real emissions reductions, but whether the projects are meeting broader development objectives, such as economic growth or technology transfer, remains uncertain (Lecocq & Ambrosi 2007; Olsen 2007; Sutter & Parreno 2007; Dechezlepretre *et al.* 2008; Schroeder 2009; Popp 2011).

In light of the concerns described above, and coupled with rapidly falling prices (see figure 2), rules for CDM projects continue to evolve. Currently, a variety of CDM project types face review from the CDM Executive Board and the EU ETS, where over 7,900 CDM or JI

---

[17] Author's analysis of CDM data from Fenhann, 2012. "CDM projects," accessed via www.cdmpipeline.org

[18] Author's analysis of data from European Environment Agency, http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer.

[19] Percentage of offsets allowed through NAPs from Ellerman et al (2010).

projects have been approved, and nearly 3 billion offset credits have been allocated (CDM & JI Monitor 2012; Fenhann 2012). Meanwhile, members of the European parliament have called for restrictions on CDM credits for certain types of power generation, and methane capture from landfills (McGarrity 2012). More ominously, a recent market report projects low long-term CER prices, which would limit incentives for technological innovation (Szabo 2012a).

5. The Future of Carbon Markets: New Issues

We are now at a very different place than we were fifteen years ago. In the late 1990s, intellectual and stakeholder debate focused on a single global trading program being designed as "the" vehicle to address global climate change. The key issues were the design of that program. Today, that form of top-down global program seems far away, if not impossible. Instead, we see a multiplicity of national and even sub-national trading programs emerging. Moreover, we now have real experience with these carbon markets. At the same time, the future of national climate change policy in the United States—the largest developed country emitter and original protagonist of emission trading—is uncertain. If a comprehensive U.S. policy does emerge, it is not clear whether that policy will be in the form of an emission trading program, an emission tax, a tradable performance standard, or traditional regulation. This raises a number of new issues that have received little attention in the previous literature and that in some cases were not fully anticipated or understood during the design stages of existing carbon market systems.

5.1 Linking Carbon Markets

Front and center in the new discussion of carbon markets is how, whether, and when different markets can be "linked" so that regulated entities in one jurisdiction can use allowances or credits from another jurisdiction for compliance, and possibly vice-versa (Jaffe *et al.* 2009). There are a variety of motivations for these kinds of linkages: achieving global cost savings and gains to trade, reducing domestic market volatility, lowering domestic compliance costs, creating momentum for global action, addressing potential concerns of major trading partners, and creating the framework to become a net exporter of emission credits, among others. At the same time, there are challenges to linking, most notably the risk to environmental integrity, the need to harmonize features (and corresponding loss of sovereignty over program design), and the distributional consequences of higher (or lower) prices.

Much of the linking work has focused on the mutual gains to trade. Indeed, the early analysis of the Kyoto Protocol focused on how much cheaper a global trading system would be compared to a variety of autarkic systems (Weyant & Hill 1999). As domestic emissions trading proposals began incorporating features like price caps, additional work began to show that certain features in one system could lead to increased emissions if two systems were linked. For example, Fischer (2003) shows that linking a system that is indexed to output with and ordinary capped system almost always increases emissions. As linking discussions have become more serious, people have begun to think about exactly which features have to be aligned to avoid such issues, and which do not (Mace *et al.* 2008).

In practice, linkages may be one-way or two-way (Mehling & Haites 2011). In a one-way linkage, credits in one system can be used for compliance in another, but not vice-versa. In a two-way linkage, both systems mutually allow the other's credits to be used for compliance.[20] It is useful to further distinguish within each direction of linkage between the buy- and sell-linkage decisions and how they relate to the aforementioned concerns (recognizing that any buy-linkage decision by one actor represents a sell-linkage decision, explicitly or implicitly, by the seller). A buy-linkage represents the decision by one trading system to accept for compliance allowances or credits created and offered for sale by another system. Sell linkages represent an implicit or explicit decision by one jurisdiction to allow or encourage other jurisdictions to use its allowances or credits for compliance.

Concerns about environmental integrity typically arise in the buying system (Mace *et al.* 2008). The buying system is the one deciding that the seller's credits or allowances are valid for compliance in the buying system (the selling system has already decided to use their own credits for compliance). Concerns about harmonizing features can arise in either system, depending on who has more power in the linking negotiation; this is frequently a function of the relative market size. Currently, for example, the EU set the terms for Norway, Iceland, and Lichtenstein to enter the EU ETS, as did California in the California-Quebec linkage. Meanwhile, the CDM as a seller of credits remains independent, although the EU has set certain conditions on the kinds of CDM credits it will accept.

Finally, distributional concerns tend to arise in the selling system. For the buying system, linking lowers prices with the same environmental outcome—something many programs desire. Lower prices generally mean less redistribution among various market agents. For the selling system, linking raises prices. There are still gains to trade for the selling system as a whole, but higher prices generally mean more redistribution among buyers and sellers within the selling system. For this reason, Australia has restricted international sales of its allowances, despite the net gains from trade (Jotzo & Betz 2011).

One of the more interesting (and unanswered) questions is how de-linking might work. Recent events in Europe, with Greece contemplating an exit from the Eurozone, should certainly make stakeholders think twice about what might happen down the road. So long as linked trading systems maintain distinct units of account, however, the better analogy is a pegged currency system rather than a currency union. In that case, it would appear to be not too problematic should delinking be necessary.

5.2 New Information and Revision

The discussion of linking and possibly delinking, as well as the carbon market experience discussed in the previous section, very clearly highlights that policies will be revised and even overhauled as time passes. The EU decision to hold back allowances in Phase III and the New Zealand decision to allow one allowance for every two tons of emissions during 2010-2012 are

[20] Linkages can also be indirect: If A links to B and B links to C, A will have an indirect linkage with C. For example, A's credits can be used for compliance in B, freeing up B's credits to move into C. The net result would be credits leaving A and entering C.

prime examples (New Zealand Government 2009). And unlike conventional regulation, where the financial consequences of policy revisions are limited to impacts on physical investment, allowance markets have the potential to create much larger financial gains and losses. When allowance banking is a major part of a trading program, these financial gains and losses can occur even when policy revisions are entirely speculative.[21]

Consider a numerical example: Suppose a cap-and-trade program with 100 metric tons in annual allowances leads to 10 metric tons of reduction at an average cost of $5/metric ton and a marginal cost of $10/metric ton. The total cost of the abatement would be $50 and the market value of the allowances under the cap would be 100 × $10 = $1,000 per year (highlighting the earlier point about the relative size of compliance costs compared to allowance value). Suppose the government contemplated lowering the cap to 90 metric tons next year, with an expected average cost of $10/metric ton and marginal cost of $20/metric ton. Abatement costs would potentially go from $50 to $200, but the market value for this year's allowances would go from $1,000 to $2,000 if they could be banked for use next year (setting aside discounting for simplicity). Moreover, suppose the market had previously over-complied and was holding another 100 metric tons worth of allowances for future use. The market value of allowances in circulation would go from $2000 to $4000. If future years' allowances are circulated in advance (as is done in many programs), then the market value impact multiplies again.

While desirable from a dynamic efficiency point of view, such changes in market value implies financial impacts and consequences regardless of whether the contemplated change happens. If the holders of the allowances tend to be exactly the same people who face compliance obligations, the net effect of changes in market value could be relatively small, as the market value of allowances will fluctuate along with the cost of their future compliance obligation. However, exactly how allowances are valued on balance sheets can create problems even for these businesses.[22] Of course, if individuals without obligations are holding allowances, the consequences could be quite dramatic. It is unclear whether such impacts on speculative holdings should be viewed as fair or unfair, but there are clear impacts.

What do these market impacts imply for the broader issue of policy revision? First, policy revision still must happen. One of the defining characteristics of climate change is uncertainty about impacts. Coupled with the interdependence of policies in different jurisdictions, revisions to carbon market policies are essential to long-term efficiency (Murray *et al.* 2009). While markets and affected stakeholders may crave certainty, governments cannot guarantee certainty where it does not fundamentally exist.

Second, governments should strive for transparent and orderly policy revisions. Many government agencies, from central banks, to regulators, to courts, make decisions on a regular

---

[21] This is a significant difference between pollution taxes and emission trading. The financial consequences of taxes only arise when the tax rate actually changes. However, speculation alone can create financial consequences under an emission trading program with banking.

[22] For example, under the Dodd-Frank Act, certain types of transactions have capital and margin requirements, though it is unclear whether these requirements would apply to a carbon market, were it to emege (Epifani *et al.* 2012).

basis that have significant market consequences. Regulatory agencies, courts, and legislatures all need to pursue market-sensitive decisions in a way that allows all market participants equal access to information as well as advance notice of the sequence and timing of the decision process. This is one area where the EU ETS has recently been criticized (Allan 2012; Szabo 2012b).

Finally, and most relevant to the topic of policy design, there may be ways that emission trading policies can be made more amenable to necessary revisions. For example, one legislative proposal in the U.S. would have implemented a very specific schedule for periodic 5-year reviews and revisions, with Presidential submission of recommendations shortly after the compliance year ends, and then expedited Congressional action within six months.[23]

Another option is to put these decisions into the hands of an oversight entity, similar to a central bank.[24] Such an entity would be responsible for periodic reviews and changes to the emission limit or other rules, and would have the flexibility to do so deliberatively and outside the explicitly political sphere of legislatures. Given experiences with central banks and monetary policy, this approach has some appeal. However, it would be more challenging to take this approach with climate change because of the continuing divergence of views about the appropriate level of response, even among experts.

5.3 Alternative Policies and Comparability

The checkered history on emissions trading in the United States highlights the fact that we are heading into a world, not only of decentralized, bottom-up creation of emission trading regimes with varying rules, but where some jurisdictions may set aside emissions trading altogether and pursue emission taxes or more traditional regulation. Recently, for example, there has been an unusual confluence of interest in carbon taxes to both address climate change and the burgeoning U.S. deficit (Chemnick 2012). South Africa has also shown interest in a carbon tax (RSA 2010). Meanwhile, policy-related emission reductions in the United States over the past few years (and likely in the near term) have arisen from tighter regulations on automobile fuel economy and tailpipe GHG emissions, renewable electricity capacity additions associated with federal and state subsidies and mandates, and new EPA power plant emission regulations.[25]

This diversity of policy approaches was not altogether unexpected. Under the Kyoto Protocol, there is no requirement to implement a domestic emissions trading program. The EU ETS, which sits at the apex of the carbon market discussion, only covers roughly half of European emissions, with traditional regulation used elsewhere (for example, with automobiles). And in the United States, where concerns about competitiveness dominated the emission trading debate, the Waxman-Markey bill did not seek to require trading partners to have an emission

---

[23] Low Carbon Economy Act of 2007, S. 1766, 110th Congress. See §102(b), §501(b), and §501(c).

[24] See discussion in Pizer and Tatsutani (2008) and Newell et al (2005).

[25] The economic downturn and low natural gas prices have had a further downward impact on emissions over the last few years.

trading program, only a "nationally enforceable and economy-wide greenhouse gas emissions reduction commitment for that country that is at least as stringent as that of the United States."[26]

What this immediately raises, however, is the need to measure the "comparability" of policies. Comparability is important for carbon markets because, among trading programs, comparability is necessary for jurisdictions to consider linking. In addition, among the broader suite of policies, comparability is necessary to avoid escalating concerns over competitiveness and emission leakage that could threaten the sustainability of emission trading. The Kyoto Protocol solved this issue by having countries negotiate agreed targets for one another based on a 1990 baseline. During the lead-up to the Copenhagen Accord, there was considerable debate over this with regard to various countries' pledges.[27] Most discussions look at emission reduction efforts in one of five ways: (1) emission reductions versus a historic baseline (percent reductions compared to 1990, 2005, etc.); (2) emission reductions versus a business as usual baseline (e.g., percent reductions compared to forecast levels in 2020); (3) reductions in emission intensity (percent reductions in emissions per unit of gross domestic product/energy use/power generation, against a historical baseline or future projection); (4) reductions in emissions per capita; or (5) the realized carbon price. However, there is no agreement on which metric is best, as many raise practical issues (e.g., conversion among currencies or calculation of business-as-usual forecasts), and different metrics yield dramatically different views.

This question of comparability is only compounded when evaluating actual implementation of policies and their outcomes, as opposed to economy-wide emission pledges. That conversation is only just beginning, as countries embark on negotiations over a new climate change agreement based on the 2011 Durban Platform for Enhanced Action, as well as grapple with their own domestic stakeholders who are frequently concerned about whether other major emitters, as well as economic competitors, are undertaking their fair share. Unlike the situation in Kyoto, where the dimension of comparability was a relatively narrow range of deviations from 1990 emission levels, future comparability discussions will undoubtedly be much more complex.[28]

5.4 International Negotiations

What does this imply for future international negotiations concerning carbon markets? Unlike earlier, Kyoto-style negotiations that focused on a sequence of top-down, larger-to-smaller emission trading issues—national emission caps, trading rules, and then further details, such as the CDM—the new, post-Durban negotiations will necessarily focus on the tools for a

---

[26] American Clean Energy and Security Act of 2009, H.R. 2454 as passed by the House of Representatives, §767(c)(1).

[27] See, for example, Levin and Bradley (2009); Pew (2011); and Jotzo (2010).

[28] Targets under the Kyoto Protocol ranged from 8 percent below 1990 emission levels for the European Union to 10 percent above 1990 emission levels for Iceland (http://unfccc.int/kyoto_protocol/items/3145.php). The targets were somewhat renegotiated in the Marrakech Accords, which established limitations on the use of forestry sinks for compliance with the original targets (http://unfccc.int/methods_and_science/lulucf/items/3063.php). This relatively narrow range of targets had dramatically different consequences for countries facing different growth rates or other structural changes after 1990.

bottom up approach. On the one hand, a new agreement will need to support concerns over comparability and transparency of effort. Those countries pursuing and already engaged in carbon markets will want assurances that other jurisdictions will do their fair share. This is important if support in those countries for carbon markets is to continue, and will guide future responses to competitiveness concerns.

On the other hand, a new agreement will need to focus on ways to provide institutional support for markets themselves. Aside from spurring the creation of the EU ETS and other trading programs, the CDM is arguably one of the most important contributions coming out of the Kyoto Protocol. Despite the various challenges it continues to face, it has an institutional structure that allows it to evolve and benefits significantly from the credibility afforded to it by its role in the agreed international architecture. The negotiations could look for ways that a wider variety of country contributions can be supported. For example, some developing countries may want something like “model rules” for establishing a domestic trading program that would presumptively link to developed country programs already utilizing the CDM.[29] While such programs can and may emerge organically without an anchor in international agreements, creating model rules could be valuable, particularly for the many countries that will be too small to pursue an entirely customized approach.

6. Summary

The overarching messages from this survey are that carbon markets are sizable, they have been expanding rather than contracting, market rules are evolving and not static, and that a new architecture based on a more organic, bottom-up international design raises a suite of new questions. A global emission trading has not emerged as “the” policy solution for climate change in the way it may have been envisioned in the mid- to late-1990s. Other policy tools—carbon taxes and traditional regulation—are being implemented or considered in a variety of sectors and jurisdictions. And comprehensive climate policy in some key jurisdictions, including the United States, is largely on hold.

The design elements of carbon markets are benefiting from experience. Experience with windfall profits from free allowance allocation has led to an increased use of auctions. Jurisdictions are learning to handle market-sensitive information in a more transparent and orderly manner, but there is still progress to be made. Efforts to moderate both high and low prices are providing lessons on what works and what does not, as well as making the simple point that prices matter. Perhaps most importantly, we are seeing that carbon allowance trading can support emission reductions and send market signals for future investment. However, the strength of those signals for future investment hinge on confidence in the emission market, the underlying regulatory framework and its stringency, and the broader investment climate.

The evolving nature of carbon markets and associated design changes imply that confidence in the market cannot be one hundred percent. Governments cannot provide certainty

---

[29] In the Clean Air Interstate Rule, the US EPA provided a model rule for states to adopt that would automatically comply with requirements under the Clean Air Act. Or, they could develop their own rules, subject to EPA approval.

where it does not fundamentally exist. Looking forward, however, authorities need to be clearer and more orderly about policy revisions, recognizing the consequent impacts on market price, market participants, and future market confidence.

Among the many issues facing markets in the future, the emergence of multiple emission trading programs has put front and center the question of how, whether, and when these programs will be linked together. While a variety of motivations drive interest in linking, and there are a variety of ways to create links, three key concerns have limited linking so far. Buyers tend to be concerned about environmental integrity, as the buying system is establishing that purchased allowances are valid for compliance in their system. The necessary harmonization of certain design features also means that one or the other system is giving up some sovereign control. Perhaps most importantly for sellers, selling systems will generally see increases in allowance prices, with potentially adverse distributional consequences (despite overall gains from trade). For this reason, linkages among trading systems have proceeded relatively slowly.

What is role of international negotiations regarding carbon markets in this emerging, bottom up world? One role is to address the issue of comparability among different trading systems as well as among emissions trading, taxes, and traditional regulation. Comparability among trading systems supports linking and comparability more generally can help avoid escalating competitiveness concerns. The latter concerns, related to both emission and economic leakage, represent one of the greatest challenges to the long-term sustainability of carbon markets. In addition to comparability, it will be useful to explore how international institutions can more directly support carbon markets in a more decentralized regime. The CDM is a significant contribution; perhaps there are others.

Fifteen years after the signing of the Kyoto Protocol and the creation of the first vehicle for carbon markets, the Kyoto model of a unified global carbon trading system is essentially over. Carbon markets are not, however, over. The challenge now is to figure out how they can work in a much more complex—but clearly more realistic—world.

Tables and Figures

Table 1: Selected Emissions Trading Program Provisions

	~Size (metric tons)	Basis for cap level	Covered Sectors	Allowance Allocation	Cost Containment	Offsets
Australia	0M	5 percent below 2000 levels by 2020. Based on Kyoto targets.	Power sector, most heavy industry, transport, waste. Agriculture and deforestation are exempt.	Auctions begin in 2015. A$23/ metric ton tax in 2012. In 2015, 66-95 percent free allocation to heavy industry.	No price floor. Ceiling set at A$20/metric ton above expected EUA price.	Up to 12.5 percent CDM/JI in 2015. Up to 100 domestic offsets after 2015, 50 percent may be CDM/JI. No offsets from 2012-2015.
California	160M in 2013 400M in 2015	15 percent below 2012 levels by 2020.	2013: Power sector, large industrial. 2015: Fuel distributors (transport, nat. gas).	~2/3 of permits auctioned in 2013. Some free allowances to electricity, industry, decreasing over time.	Auction floor of $10/metric ton. Effective ceiling of $40-50/ton in 2012.	Restricted use of CDM/JI. Four types of domestic offsets OK. Up to 8 percent offsets.
EU Phase I (2005-2007)	2.2B	National Allocation Plans.	Power sector, most heavy industry.	10 percent max auctioned. Up to 100 percent free allocation in power sector and industry.	No price ceiling/floor.	CDM/JI OK. 0-20 percent offsets allowed. No forestry or nuclear project credits.
EU design changes	2.1B	EU burden-sharing (II) and linear decline (III).	New industrial activity added in 2008, more added in 2013. Aviation added in 2012.	~50 percent auctioned in 2013. Free allocations mostly phased out by 2020.	No change.	Roughly 6-7 percent offsets OK through 2020.
New Zealand	8.2M	No explicit cap. Based on Kyoto targets.	All sectors of the economy phased in by 2015.	No auctions. 60-90 percent free allocation to industry based on energy intensity.	No price floor. Effective NZ$25/metric ton ceiling in 2012.	CDM/JI OK, but mostly domestic offsets to this point. All reduction goals met with offsets.
Quebec	5M	15 percent below 2005 levels by 2020.	2013: Power sector, large industrial. 2015: Fuel distributors (transport, nat. gas).	~10 percent auctioned in 2012, up to 50 percent by 2013. Some free allowances to electricity, industry decreasing over time.	Auction floor of $10/metric ton. Effective ceiling of $40-50/metric ton in 2012.	No CDM/JI in first phase, could be introduced later. Up to 8 percent of entity's allocation may be offset.
RGGI	150M	10 percent below 2009 levels by 2018.	Power sector only.	No free allocations.	Price floor at $1.93/metric ton in 2012. $7-10/metric ton price ceiling triggers additional offset allowances.	No CDM/JI. 3.3 percent maximum offsets in 2012. 5-10 percent maximum if price ceiling is reached.
Waxman-Markey (H.R. 2454)*	2.3B	17 percent below 2005 levels by 2020, 83 percent below 2005 by 2050.	Power sector, large fuel processors. Large industry by 2014.	~27% auctioned in first year. Free allocations to power sector, trade-exposed industry, and others based on energy intensity.	$10/metric ton floor. Effective $28/ton ceiling for first year, later increasing.	30 percent max offsets per entity. CDM/JI OK unless program administrator deems otherwise.

Note: *Waxman-Markey bill (H.R. 2454) as passed by the U.S. House of Representatives in 2009.

Figure 1. Timeline for Selected GHG Emissions Trading Programs

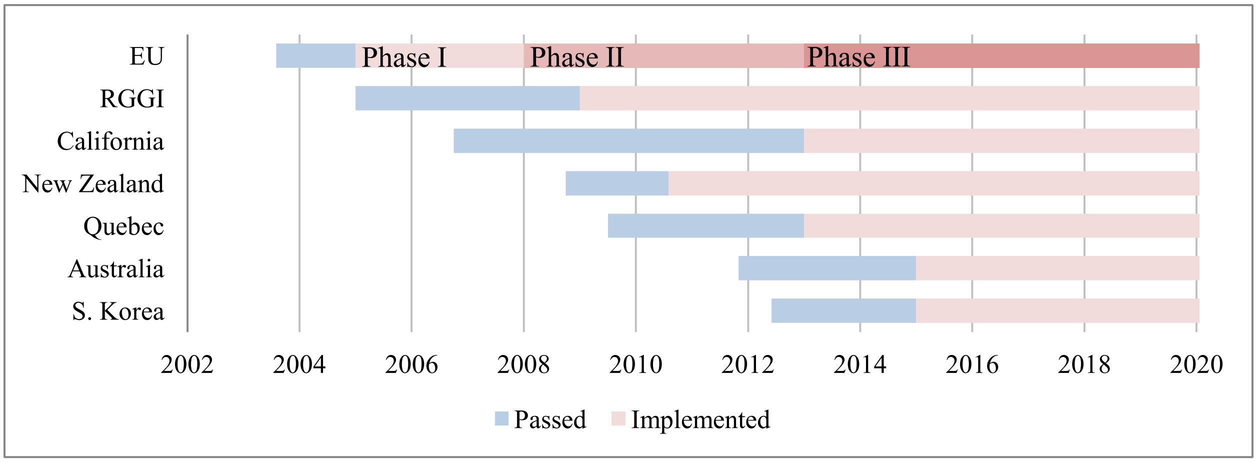
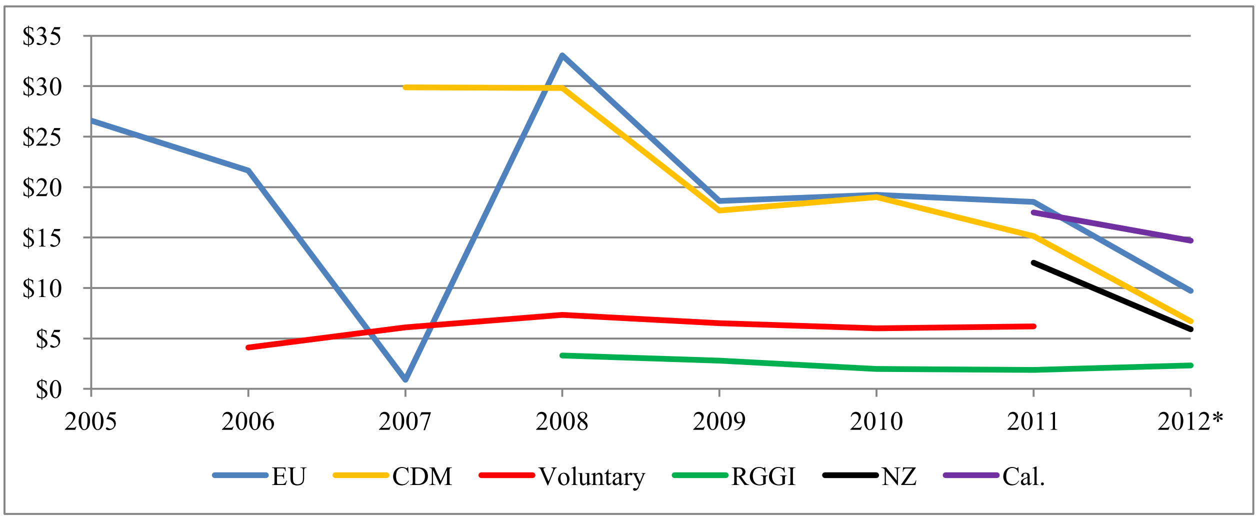
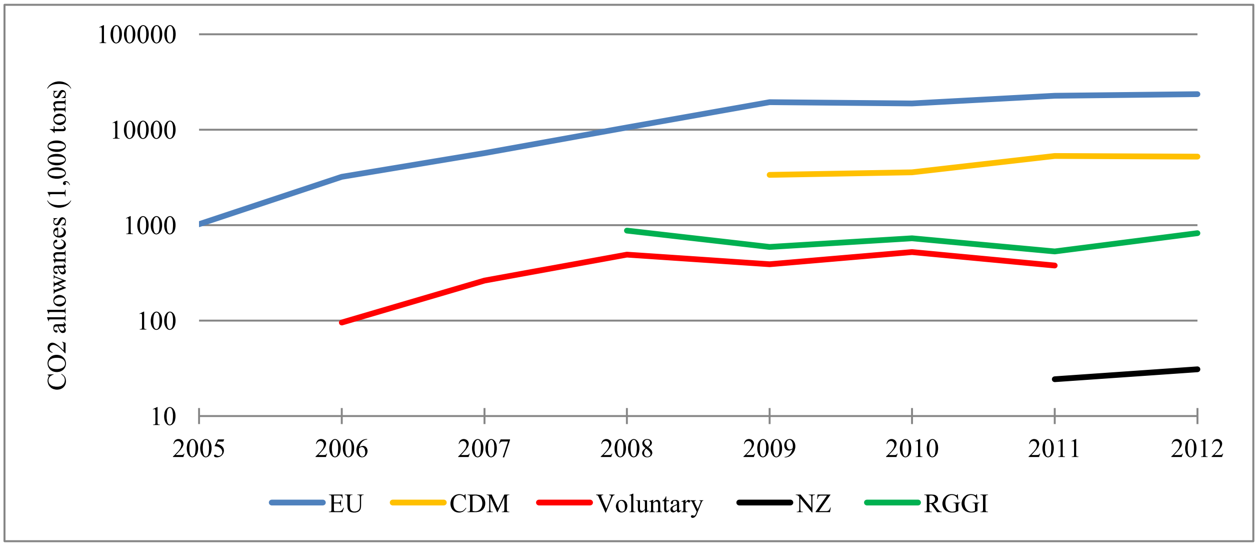


Figure 2. CO2 Prices (Annual Average Price Per Metric Ton CO2, Nominal US$)



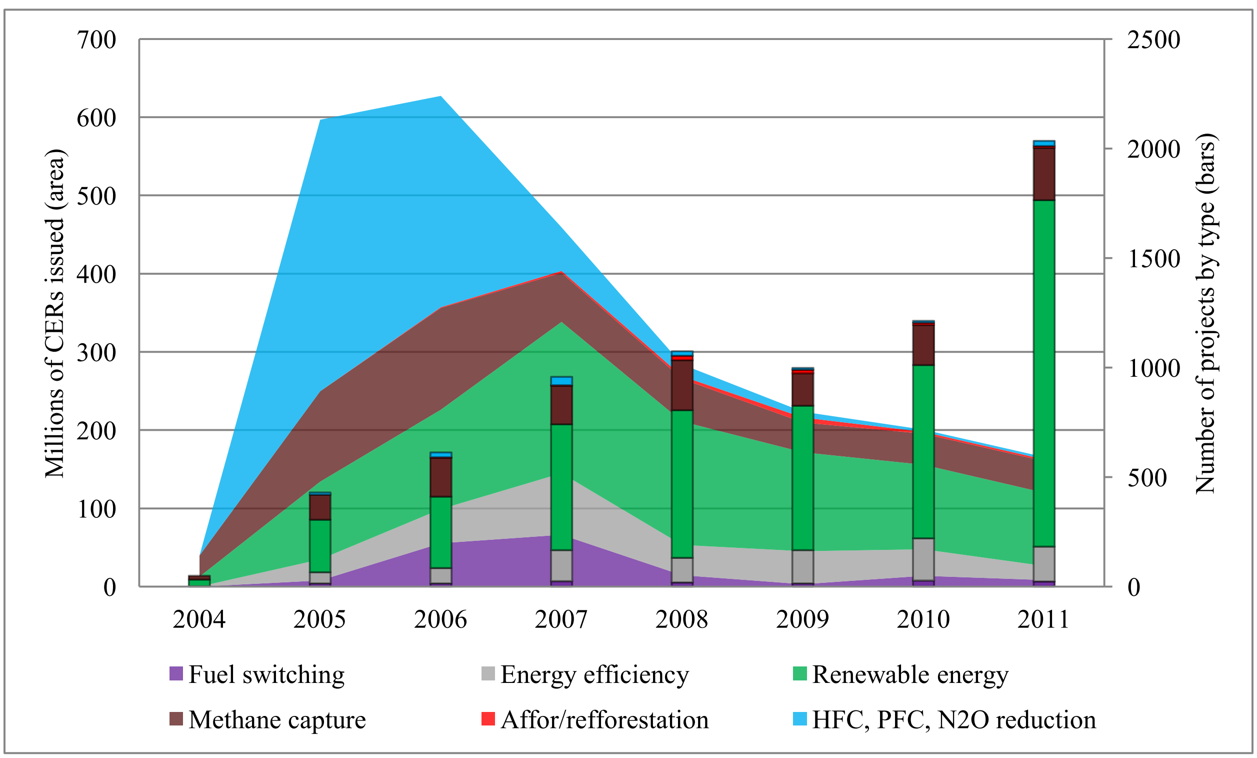
Note: Exchange-traded prices are through June 30, 2012 as reported by the following sources: Point Carbon, RGGI COATS, Ecosystem Marketplace/Bloomberg New Energy Finance.

Figure 3. Volume of CO2 Allowance Trades (Daily Average)



Note: Exchange-traded volumes are through June 30, 2012 as reported by the following sources: Point Carbon, RGGI COATS, Ecosystem Marketplace/Bloomberg New Energy Finance.

Figure 4. Number of CDM Projects (Bars) and Credits Issued (Area), by Project Type



Note: Data are from Fenhann (2012). Up to 3 percent of 2011 projects may be pending validation.

References

Alberta Government, 2011a. Alberta results demonstrate responsible, clean energy production. Environment A (Ed.), Ottowa

Alberta Government, 2011b. Climate Change Update. URL http://environment.gov.ab.ca/info/library/8416.pdf

Alberta Government, 2012. Alberta Environment and Sustainable Resource Development: Report on 2010 Greenhouse Gas Emissions. Secretariat CC (Ed.), Edmonton, Alberta

Aldrich, E.L., Koerner, C.L., 2012. Unveiling Assigned Amount Unit (AAU) Trades: Current Market Impacts and Prospects for the Future Atmosphere 3, 229-245

Aldy, J.E., Krupnick, A.J., Newell, R.G., Parry, I.W.H., Pizer, W.A., 2010. Designing Climate Mitigation Policy. Journal of Economic Literature 48, 903-934

Aldy, J.E., Pizer, W.A., 2008. Issues in Designing U.S. Climate Change Policy. Resources for the Future Discussion Paper 08-20

Allan, A., 2012. Market split on impact of EU price support plan. URL http://www.pointcarbon.com/news/1.1937474

Anderson, B., Di Maria, C., 2011. Abatement and Allocation in the Pilot Phase of the EU ETS. Environmental and Resource Economics 48, 83-103

Australia Liberal Party, 2012. Our Plan to Abolish the Carbon Tax. URL http://www.liberal.org.au/Pages/Our-Plan-to-Abolish-the-Carbon-Tax.aspx

Australian Government, 2012a. Australia and European Commission agree on pathway towards fully linking Emissions Trading Systems. URL http://www.climatechange.gov.au/media/whats-new/linking-ets.aspx

Australian Government, 2012b. Securing a clean energy future: The Australian Government's Climate Change Plan. Efficiency CCaE (Ed.), Canberra

Barrett, S., 1998. Political economy of the Kyoto Protocol. Oxford Review of Economic Policy 14, 20-40

Benessaiah, K., 2012. Carbon and Livelihoods in Post-Kyoto: Assessing voluntary carbon markets. Ecological Economics 77 (May), 1-6

Boden, T., Marland, G., Andres, B., 2011. Global CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2008. Center CDIA (Ed.), Oak Ridge National Laboratory

Bovenberg, A.L., Goulder, L.H., 2001. Neutralizing the Adverse Industry Impacts of CO2 Abatement Policies: What Does It Cost? In: Carraro C & Metcalf GE (eds.) Behavioral and Distributional Effects of Environmental Policy. University of Chicago Press, Chicago, pp. 45-85.

Burtraw, D., Evans, D.A., 2009. Tradable rights to emit air pollution. Australian Journal of Agriculture and Resource Economics 53, 59-84

Burtraw, D., Krupnick, A., Mansur, E., Austin, D., Farrell, D., 1998. Costs and Benefits of Reducing Air Pollutants Related to Acid Rain. Contemporary Economic Policy 16, 379-400

Burtraw, D., Palmer, K., 2008. Compensation rules for climate policy in the electricity sector. Journal of Policy Analysis and Management 27, 819-847

Burtraw, D., Walls, M., Blonz, J., 2010. Distributional Impacts of Carbon Pricing Policies in the Electricity Sector. In: Metcalf GE (ed.) U.S. Energy Tax Policy. Cambridge University Press.

California Code of Regulations, 2011. Subchapter 10 Climate Change. p. Sections 95800 to 96023. State of California

Canadian Government, 2011a. Parallel Paths: Canada-U.S. Climate Policy Choices. NRTEE (Ed.), Ottowa

Canadian Government, 2011b. Statement by Minister Kent. URL http://www.ec.gc.ca/default.asp?lang=En&n=FFE36B6D-1&news=6B04014B-54FC-4739-B22C-F9CD9A840800

Carlson, C., Burtraw, D., Cropper, M., Palmer, K.L., 2000. Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?" Journal of Political Economy 108, 1292-1326

CDM & JI Monitor, 2012. CDM Board Rejects coal projects, major EU ETS role unlikely. In: Point Carbon

Centre for Energy, 2012. Quebec. URL http://www.centreforenergy.com/factsstats/mapscanada/qc-energymap.asp

Chemnick, J., 2012. All sides agree a carbon tax could be included in expected tax code overhaul. In: Environment and Energy Daily, Washington

Chen, Y., 2009. Does a regional greenhouse gas policy make sense? A case study of carbon leakage and emissions spillover. Energy Economics 31, 667-675

Christie, C., 2011. Governor Christie: New Jersey's Future is Green. State of New Jersey, http://www.nj.gov/governor/news/news/552011/approved/20110526a.html

Craig, G., 2011. Six US states leave the Western Climate Initiative. URL http://www.platts.com/RSSFeedDetailedNews/RSSFeed/ElectricPower/6695863

de Perthius, C., 2011. Carbon markets regulation: The case for a CO2 Central Bank. Climate Economics Chair Information and Debates Series

De Souza, M., 2011. Canada won't jump into cap-and-trade carbon market on its own: Kent. In: Vancouver Sun, Vancouver

Dechezlepretre, A., Glachant, M., Meniere, Y., 2008. The Clean Development Mechanism and the international diffusion of technologies: An empirical study. Energy Policy 36, 1273-1283

Demially, D., Quirion, P., 2008. European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry. Energy Economics 30, 2009-2027

Dinan, T.M., Rogers, D.L., 2002. Distributional Effects of Carbon Allowance Trading: How Government Decisions Determine Winners and Losers. National Tax Journal 55, 199-222

Doluweera, G.H., Jordan, S.M., Moore, M.C., Keith, D.W., Bergerson, J.A., 2011. Evaluating the role of cogeneration for carbon management in Alberta. Energy Policy 39, 7963-7974

Ecosystem Marketplace and Bloomberg New Energy Finance, 2008-2012. State of the Voluntary Market Reports.

Ellerman, D., Buchner, B., 2006. Over-Allocation or Abatement? A Preliminary Analysis of the EU Emissions Trading Scheme Based on the 2006 Emissions Data. MIT Joint Program on the Science and Policy of Global Change

Ellerman, D., Joskow, P.L., 2008. The European Union's Emissions Trading System: In Perspective. Pew Center on Global Climate Change

Ellerman, D.A., Convery, F.J., Perthius, C.d., 2010. Pricing Carbon. Cambridge University Press, Cambridge, UK.

Elsworth, B., Worthington, B., 2010. International Offsets and the EU 2009: An update on the usage of compliance offsets in the EU ETS. Sandbag UK

Energy Information Administration, 2009. Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009. Washington

Epifani, L., Danish, K., McClellan, M., 2012. Joint CFTC and SEC Rule Adopts Final Definition for "Swap;" Delineates Exclusion for Certain Energy Transactions. URL http://www.vnf.com/news-alerts-741.html

European Commission, 2009. EU action against climate change: The EU Emissions Trading Scheme, 2009 edition. Brussels

European Commission, 2010. Communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank, the Economic and Social Committee and the Committee of the Regions: Reinforcing economy policy coordination. p. 11, Brussels

European Commission, 2011. Emissions trading: Commission welcomes vote to ban certain industrial gases. URL http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/56

European Commission, 2012a. Climate Action. URL http://ec.europa.eu/dgs/clima/mission/index_en.htm

European Commission, 2012b. Ensuring the integrity of the European carbon market. URL http://ec.europa.eu/clima/policies/ets/oversight/index_en.htm

Fallow, B., 2009. Business backs emission plan changes. In: New Zealand Herald, Aukland

Fell, H., MacKenzie, I., Pizer, W., 2012. Prices versus quantities versus bankable quantities. Resource and Energy Economics 34, 607-623

Fell, H., Morgenstern, R.D., 2009. Alternative Approaches to Cost Containment in a Cap-and-Trade System. 09-14, Resources for the Future Discussion Paper

Fenhann, J., Jacob Ipsen Hansen, Maija Bertule, 2012. CDM Projects. Program UNE (Ed.), Riso Centre

Fischer, C., 2003. Combining rate-based and cap-and-trade emission policies. Climate Policy 3S2, S89-S109

Fischer, C., Fox, A., 2009. Comparing policies to combat emissions leakage: Border tax adjustments versus rebates. Resources for the Future Discussion Paper 09-02

Fischer, C., Newell, R., 2008. Environmental and technology policies for climate mitigation. Journal of Environmental Economics and Management 55, 142-162

Frunza, M.-C., Guegan, D., Lassoudiere, A., 2011. Missing trader fraud on the emissions market. Journal of Financial Crime 18, 183-194

GovTrack, 2012. H.R. 2454 (111th) American Clean Energy and Security Act of 2009. URL http://www.govtrack.us/congress/bills/111/hr2454

Gow, D., 2006. Power Tool: European energy groups involved in carbon capture are manipulating the scheme for profit. In: The Gaurdian, UK

Harrison, P., 2009. Carbon windfall profits seen for EU industry. In: Reuters

Hassett, K.A., Mathur, A., Metcalf, G.E., 2009. The Incidence of a U.S. Carbon Tax: A Lifetime and Regional Analysis. Energy Journal 30, 155-177

Hibbard, P.J., Tierney, S.J., Okie, A.M., Darling, P.G., 2011. The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States. Analysis Group

Ho, M.S., Morgenstern, R., Shih, J.-S., 2008. Impact of Carbon Price Policies on U.S. Industry. Resources for the Future Discussion Paper DP-08-37

Hood, C., 2010. Reviewing Existing and Proposed Emissions Trading Systems. International Energy Agency, Vienna

Interagency Competitiveness Analysis Team, 2009. The effects of H.R. 2454 on international competitiveness and emission leakage in energy-intensive trade-exposed industries. URL http://www.epa.gov/climatechange/economics/pdfs/InteragencyReport_Competitiveness-EmissionLeakage.pdf

Interagency Working Group for the Study on Oversight of Carbon Markets, 2011. Report on the Oversight of Existing and Prospective Carbon Markets. Commission CFT (Ed.), Washington

Interagency Working Group on Social Cost of Carbon (Interagency), 2009. Social cost of carbon for regulatory impact analysis under Executive Order 12866. Department of Energy, Energy Efficiency and Renewable Energy, Washington

International Energy Agency, 2012. Global carbon-dioxide emissions increase by 1.0 Gt in 2011 to record high. URL http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html

Jaffe, A.B., Newell, R.G., Stavins, R.N., 2003. Technological Change and the Environment. In: Maler KG & Vincent JR (eds.) Handbook of Environmental Economics. Elsevier Science, Amsterdam, pp. 217-223.

Jaffe, A.B., Richard G. Newell, Robert N. Stavins, 2002. Environmental Policy and Technological Change. Environmental and Resource Economics 22, 41-69

Jaffe, J., Ranson, M., Stavins, R.N., 2009. Linking tradable permit systems: A key element of emerging international climate policy architecture. Ecological Law Quarterly 36, 789-808

Jotzo, F., 2010. Comparing the Copenhagen emission targets. In: Environmental Economics Research Hub, Canberra: ANU

Jotzo, F., Betz, R., 2011. Australia's emissions trading scheme: opportunities and obstacles for linking. Climate Policy 9, 402-414

Kim, M.-K., McCarl, B.A., Murray, B.C., 2008. Permanence discounting for land-based carbon sequestration`. Ecological Economics 64, 763-769

Kindle, A.G., Shawhan, D.L., Swider, M.J., 2011. An Empirical Test for Inter-State Carbon-Dioxide Emissions Leakage Resulting from the Regional Greenhouse Gas Initiative. New York Independent Systems Operator

Lacombe, R.H., 2008. Economic Impact of the European Union Emission Trading Scheme: Evidence from the Refining Sector. MIT.

Lambert, R.S., 2011. Perverse incentives under the CDM: an evaluation of HFC-23 destruction projects. Climate Policy 11, 851-864

Larsen, J., Kelly, A., Heilmayr, R., 2009. WRI Summary of H.R. 2454, the American Clean Energy and Security Act (Waxman-Markey). World Resources Institute

Lecocq, F., Ambrosi, P., 2007. The Clean Development Mechanism: History, Status, and Prospects. Review of Environmental Economics and Policy 1, 134-151

Leiby, P., Rubin, J., 2001. Intertemporal Permit Trading for the Control of Greenhouse Gas Emissions. Environmental and Resource Economics 19, 229-256

Leiter, A.M., Paolini, A., Winner, H., 2011. Environmental regulation and investment: Evidence from European industry data. Ecological Economics 70, 759-770

Levin, K., Bradley, R., 2009. Comparability of Annex I Emission Reduction Pledges. Washington: WRI

Mace, M.J., Millar, I., Schwarte, C., Anderson, J., Broekhoff, D., Bradley, R., Bowyer, C., Heilmayr, R., 2008. Analysis of the legal and organizational issues arising in linking the EU Emission Trading Scheme to other existing and emergin emission trading schemes. World Resources Institute, Washington

Markussen, P., Svendsen, G.T., 2005. Industry lobbying and the political economy of GHG trade in the European Union. Energy Policy 33, 245-255

McGarrity, J., 2012. EU lawmakers urge U.N. to ban landfill gas projects. URL http://www.pointcarbon.com/news/1.1939382

Meckling, J., 2011. Carbon Coalitions: Business, Climate Politics, and the Rise of Emissions Trading. MIT Press, Cambridge, MA.

Mehling, M., Haites, E., 2011. Mechanisms for linking emissions trading schemes. Climate Policy 9, 169-184

Midwest Greenhouse Gas Reduction Accord, 2010. Final Model Rule for the Midwestern Greenhouse Gas Reduction Accord.

Murray, B.C., Newell, R.G., Pizer, W.A., 2009. Balancing Cost and Emissions Certainty: An Allowance Reserve for Cap-and-Trade. Review of Environmental Economics and Policy 3, 84-103

National Research Council, 2010. Chapter Five. In: Climate Change in Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. The National Academies Press, Washington, DC.

Neuhoff, K., Schopp, A., Boyd, R., Stelmakh, K., Vasa, A., 2012. Banking of Surplus Emisssions Allowances: Does the Volume Matter? DIW Berlin, Berlin

New Zealand Government, 2009. Summary of the proposed changes to the NZ ETS. In: Emission trading bulletin. New Zealand Government, Aukland

New Zealand Government, 2012. NZ ETS 2011-Facts and Figures. Ministry for the Environment, Wellington

New Zealand Ministry for the Environment, 2011. Report on The New Zealand Emissions Trading Scheme.

Newell, R.G., 2010. The role of markets and policies in delivering innovation for climate change mitigation. Oxford Review of Economic Policy 26, 253-269

Newell, R.G., Pizer, W.A., 2003. Regulating Stock Externalities Under Uncertainty. Journal of Environmental Economics and Management 45, 416-432

Newell, R.G., Pizer, W.A., Zhang, J., 2005. Managing Permit Markets to Stabilize Prices. Environmentand and Resource Economics 31, 133-157

Olsen, K.H., 2007. The clean development mechanism's contribution to sustainable development: a review of the literature. Climactic Change 84, 59-73

Pew Center on Global Climate Change (Pew), 2011. Common Metrics: Comparing Countries' Climate Pledges. Washington: C2ES

Pizer, W.A., 2002. Combining price and quantity controls to mitigate global climate change. Journal of Public Economics 85, 409-434

Pizer, W.A., Kopp, R.J., 2003. Summary and Analysis of McCain-Lieberman "Climate Stewardship Act of 2003.". Resources for the Future

Pizer, W.A., Tatsutani, M., 2008. Managing Costs in a U.S. Greenhouse Gas Trading Program. Resources for the Future Discussion Paper 08-23

Point Carbon, 2011. Carbon 2011. Tvinnereim E, et al (Ed.)

Point Carbon, 2012a. Carbon Market North America. URL http://www.pointcarbon.com/polopoly_fs/1.1932730!CMNA20120629.pdf

Point Carbon, 2012b. EU ETS Market Data. URL http://www.pointcarbon.com/news/marketdata/euets/forward/eua/

Point Carbon, 2012c. New Zealand ETS Market Data. URL http://www.pointcarbon.com/news/marketdata/nzets/prices/

Popp, D., 2011. International Technology Transfer, Climate Change, and the Clean Development Mechanism. Review of Environmental Economics and Policy 5, 131-152

Potomac Economics, 2009, 2010, 2011. Annual Report on the Market for RGGI CO2 Allowances.

Quebec Government, 2012a. Quebec in Action: Greener by 2020. URL http://www.mddep.gouv.qc.ca/changements/plan_action/pacc2020-en.pdf

Quebec Government, 2012b. Regulation respecting a cap-and-trade system for greenhouse gas emission allowances. In: c. Q-2

Regional Greenhouse Gas Initiative, 2010. Fact Sheets. URL http://www.rggi.org/design/fact_sheets

Regional Greenhouse Gas Initiative Inc., 2011. Investment of Proceeds from RGGI CO2 Allowances.

Regional Greenhouse Gas Initiative Inc., 2012. Program Design. URL http://www.rggi.org/design

Reinaud, J., 2008. Climate Policy and Carbon Leakage: Impacts of the European Emissions Trading Scheme on Aluminum. International Energy Agency, Vienna

Reklev, S., 2012a. Australia to link with EU CO2 market, drops price floor. URL http://www.pointcarbon.com/news/1.1967394

Reklev, S., 2012b. Korea bans CERs in domestic CO2 market to 2020. URL http://www.pointcarbon.com/news/1.1941926

Republic of South Africa National Treasury, 2010. Reducing Greenhouse Gas Emissions: The Carbon Tax Option. In: Discussion Paper for Public Comment

Samuelsohn, D., 2008. Lieberman-Warner substitute represents 'consensus' among many senators--Boxer. URL http://www.eenews.net/EEDaily/2008/05/21/archive/2?terms=summary+of+funding+under+boxer+substitute+to+the+lieberman

Sandel, M., 1997. It's immoral to buy the right to pollute. In: New York Times

Schroeder, M., 2009. Utilizing the clean development mechanism for the deployment of renewable energies in China. Applied Energy 86, 75-90

Sijm, J., Hers, S., Lise, W., Wetzelaer, B., 2008. The impact of the EU ETS on electricity prices. European Commission, Brussels

Stavins, R.N., 1998. What Can We Learn from the Grand Policy Experiment? Lessons from SO2 Allowance Trading. Journal of Economic Perspectives 12, 69-88

Stickler, C.M., Nepstad, D.C., Coe, M.T., McGrath, D.G., Rodriguess, H.O., Walker, W.S., Soares-Filho, B.S., Davidson., E.A., 2009. The potential ecological costs and cobenefits of REDD: a critical review and case study from the Amazon region. Global Change Biology 15, 2803-2824

Sunstein, C., 2007. Of Montreal and Kyoto: A tale of two protocols. Harvard Environmental Law Review 31, 1-29

Sutter, C., Parreno, J.C., 2007. Does the Current Clean Development Mechanism deliver its sustainable development claim? An analysis of officially registered CDM projects. Climactic Change 84, 75-90

Szabo, M., 2012a. "Dead" CERs to trade below 3 euros indefinitely: Barclays. In: Point Carbon

Szabo, M., 2012b. EU CO2 permit auction delay illegal: German lawyer. URL http://www.pointcarbon.com/news/1.1929012

Teixeira, M., 2012. Mexico's climate law to face challenge under new president. URL http://www.pointcarbon.com/news/1.1941779

Tietenberg, T.H., 1985. Emissions Trading. Resources for the Future, Washington.

United Nations Framework Convention on Climate Change, 2006. Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005: Decisions adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol. URL http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf

United Nations Framework Convention on Climate Change, 2011. Compilation of economy-wide emission reduction targets to be implemented by Parties included in Annex I to the Convention. Bonn, Germany

United Nations Framework Convention on Climate Change, 2012a. Global Warming Potential. URL http://unfccc.int/ghg_data/items/3825.php

United Nations Framework Convention on Climate Change, 2012b. Kyoto Protocol. URL http://unfccc.int/kyoto_protocol/items/2830.php

Volvovici, V., 2011. Midwest US ditches carbon market, focuses on jobs. URL http://www.pointcarbon.com/pages/shop/1.1510367

Wara, M., 2008. Measuring the Clean Development Mechanism's Performance and Potential. UCLA Law Review 55, 1759-1803

Weitzman, M.L., 1974. Prices vs. Quantities. Review of Economic Studies 41, 477-491

Western Climate Initiative, 2012. History. URL http://www.westernclimateinitiative.org/history

Weyant, J.P., Hill, J., 1999. The Costs of the Kyoto Protocol: A Multi-Model Evaluation, Introduction and Overview. The Energy Journal Special Issue on the Costs of the Kyoto Protocol: a Multi-Model Evaluation, vii-xliv

Wiener, J., 2001. Something borrowed for something blue: Legal transplants and the evolution of global environmental law. Ecological Law Quarterly 27, 1295-1371

Wing, I.S., Kolodziej, M., 2009. The Regional Greenhouse Gas Initiative: Emission Leakage and the Effectiveness of Interstate Border Adjustments. Boston University Dept. of Geography and Environment Working Paper, Boston

Zhang, J., Wang, C., 2011. Co-benefits and additionality of the clean development mechanism: An empirical analysis. Journal of Environmental Economics and Management 62, 140-154