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The Effect of Allowance Allocations on Cap-and-Trade System Performance

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Summary

We examine an implication of the "Coase Theorem" which has had an important impact both on environmental economics and on public policy in the environmental domain. Under certain conditions, the market equilibrium in a cap-and-trade system will be cost-effective and independent of the initial allocation of tradable rights. That is, the overall cost of achieving a given aggregate emission reduction will be minimized, and the final allocation of permits will be independent of the initial allocation. We call this the *independence property*. This property is very important because it allows equity and efficiency concerns to be separated in a relatively straightforward manner. In particular, the property means that the government can establish the overall pollution-reduction goal for a cap-and-trade system by setting the cap, and leave it up to the legislature – such as the U.S. Congress – to construct a constituency in support of the program by allocating the allowances to various interests without affecting either the environmental performance of the system or its aggregate social costs. Our primary objective in this paper is to examine the conditions under which the independence property is likely to hold – both in theory and in practice. A number of factors can call the independence property into question theoretically, including market power, transaction costs, non-cost-minimizing behavior, and conditional allowance allocations. We find that, in practice, there is support for the independence property in some, but not all cap-and-trade applications.

Keywords: Cap-and-Trade System, Tradable Permits, Coase Theorem, Allowance Allocation

JEL Classification: Q580, H110, L510

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THREE KEY ELEMENTS OF POST-2012 INTERNATIONAL CLIMATE POLICY ARCHITECTURE

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ABSTRACT

We describe three essential elements of an effective post-2012 international global climate policy architecture: a means to ensure that key industrialized and developing nations are involved in differentiated but meaningful ways; an emphasis on an extended time path of targets; and inclusion of flexible market-based policy instruments to keep costs down and facilitate international equity. This architecture is consistent with fundamental aspects of the science, economics, and politics of global climate change; addresses specific shortcomings of the Kyoto Protocol; and builds upon the foundation of the United Nations Framework Convention on Climate Change.

Key Words: global climate change, global warming, policy architecture, Kyoto Protocol

JEL Classification: Q54, Q58, Q48, Q39

THREE KEY ELEMENTS OF POST-2012 INTERNATIONAL CLIMATE POLICY ARCHITECTURE

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1. INTRODUCTION

The nations of the world continue to strive to negotiate what may become the post-2012 (or post-Kyoto) climate regime. This has happened primarily through the United Nations Framework Convention on Climate Change (UNFCCC), but in addition, the key emitting countries of the world have held a series of meetings under the auspices of the Major Economies Forum for Energy and Climate and the G20, and a number of nations have met in various bilateral venues. In each of these processes, the goal has been to foster international cooperation to address climate change when the first commitment period of the Kyoto Protocol expires at the end of 2012.

The Kyoto Protocol (United Nations 1997), which came into force in February 2005 and began to bind for ratified countries in 2008, represents the first significant multinational attempt to curb the greenhouse gas (GHG) emissions that are changing the global climate. The Protocol has both strengths and weaknesses that can provide lessons for the design of future international climate policy architecture. The design of such future international policy architecture is the focus of this symposium of four articles.

In this first article, we describe a promising post-2012 international global climate policy architecture with three essential elements: a means to ensure that key industrialized and developing nations are involved in differentiated but meaningful ways; an emphasis on an extended time path of targets; and inclusion of flexible market-based policy instruments to keep costs down and address concerns about international equity.

In the second article, Valentina Bosetti and Jeffrey Frankel (2010) provide an empirical examination of a related architecture which employs negotiated formulas to generate emissions targets for all countries through the end of the 21st century. Their approach — which builds upon political realities and constraints — is designed to limit global carbon dioxide (CO_2) concentrations to 460 parts per million (ppm).

Next, Gilbert Metcalf and David Weisbach (2010) recognize that the *defacto* post-2012 international climate policy architecture may quite possibly rely upon the bottom-up linkage of a diverse set of domestic climate policies. These authors analyze the promise, the mechanics, and the

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challenges of linking such heterogeneous policies, which might include national or regional cap–and-trade systems, carbon taxes, and some types of regulatory mechanisms.

Finally, Jing Cao (2010) presents the perspective of China, the most important of the emerging economies, by examining an approach which seeks to reconcile fairness, economic development imperatives, and sensible climate policy actions. She takes as her starting point the Copenhagen Accord, the major substantive outcome of the Fifteenth Conference of the Parties (COP-15) of the UNFCCC, in Copenhagen, in December 2009. Cao seeks to identify an international climate policy architecture which has at its heart a burden-sharing rule that countries might consider fair, a flexible structure for countries to choose their own domestic policy approaches, and an overall approach that is politically realistic.

1.1 Looking Back: The Kyoto Protocol's Strengths and Weaknesses

Among the Kyoto Protocol's strengths is its inclusion of provisions for market-based approaches intended to lower the cost of the global climate regime: emissions trading among Annex I countries that take on targets under the Protocol; "joint implementation" which allows for project-level trades among the Annex I countries; and the Clean Development Mechanism (CDM), which provides for the use of project-level emission offsets created in non-Annex I (developing) countries to help meet the compliance obligations of firms in Annex I countries. (Annex I of the UNFCCC and Annex B of the Kyoto Protocol are often used interchangeably to represent the industrialized countries that have national emissions targets under the Kyoto Protocol.)

Also, the Kyoto Protocol provides flexibility for nations to meet their national emissions targets — their commitments — in any way they want. By recognizing domestic sovereignty, it provides flexibility at the national level. Further, the Protocol has at least the appearance of fairness in that it focuses on the wealthiest countries and those responsible for the majority of the current stock of anthropogenic GHGs in the atmosphere. This is consistent with the principle enunciated in the UNFCCC of "common but differentiated responsibilities and respective capabilities." Finally, the fact that the Kyoto Protocol was signed by more than 180 countries and subsequently ratified by a sufficient number of Annex I countries for it to come into force speaks to the political viability of the agreement in terms of participation, if not compliance.

The Kyoto Protocol also has some weaknesses. First, some of the world's leading emitters are not constrained. The United States — until recently the country with the largest share of global emissions, about 19 percent (Gregg *et al.* 2008) — has not ratified and is unlikely to ratify the agreement. Also, some of the largest, most rapidly growing economies in the world do not take on targets, including China, India, Brazil, South Africa, Indonesia, South Korea, and Mexico. The developing world will soon overtake the industrialized world in total emissions. Indeed, China's CO_2 emissions have surpassed those of the United States (Gregg *et al*. 2008); and China's emissions are expected to continue to grow much faster than U.S. emissions (Blanford, *et al.* 2008).

Even if all of the Annex I countries, including the United States, were to reduce their CO_2 emissions to zero by 2030, it would be physically impossible for the world to achieve the frequently discussed climate target of stabilizing atmospheric CO_2 concentrations at or below 450 parts per million (ppm) without significant reductions by China and India. The Kyoto Protocol may not be as fair as originally intended, given how dramatically the world has changed since the UNFCCC divided countries into two categories in 1992. Approximately fifty non-Annex I countries now have higher per capita income than the poorest of the Annex I countries.

A second weakness of the Protocol is the relatively small number of countries which have agreed to take action. This "narrow but deep" approach will drive up the costs of producing carbon-intensive goods and services within the coalition of countries taking action. Through the forces of international trade, this approach leads to greater comparative advantage in the production of carbon-intensive goods and services for countries that do not have binding emissions targets, thereby shifting production and emissions from participating nations to non-participating nations — a phenomenon known as "emissions leakage." Leakage will reduce the cost-effectiveness and environmental performance of the agreement, and worse yet, push developing countries onto more carbon-intensive growth paths than they would otherwise have taken, rendering it more difficult for these countries to join the coalition of action later.

A third concern centers on the nature of the Kyoto Protocol's emissions trading elements. The provision in Article 17 for international emissions trading is unlikely to be effective, because the trading would need to be among national governments, not private-sector firms. The cost-effectiveness of cap-and-trade systems depends upon the participants being cost-minimizing entities. This is a reasonable assumption for private firms, because if such firms do not seek to minimize their costs, and indeed succeed in minimizing their costs, they will tend to disappear, given the competitive forces of the market. But nation-states are not simple cost-minimizers — many other objectives affect their decision-making. Furthermore, even if nation-states sought to minimize costs, they do not have sufficient information about marginal abatement costs of the multitude of sources within their borders to carry out cost-effective trades with other countries (Hahn and Stavins 1999).

Also, there is great concern regarding the CDM, an emissions-reduction-credit system. When an individual project results in emissions below what they would have been in the absence of the project, a credit — which may be sold to a source within a cap-and-trade system — is generated. This approach creates a challenge: comparing actual emissions with what they would have been otherwise. The baseline — what would have happened had the project not been implemented — is fundamentally unobservable. In fact, there is a natural tendency, because of economic incentives, to claim credits precisely for those projects that are most profitable, and hence would have been most likely to have been executed without selling credits. This is the "additionality" problem.

Fourth, the Kyoto Protocol, with its five-year time horizon (2008 to 2012), represents a relatively short-term approach for what is fundamentally a long-term problem. GHGs reside in the atmosphere for decades to centuries. And to encourage the magnitude of technological change that will be required to meaningfully address the threat of climate change, it will be necessary to send long-term price signals to the private market to stimulate sustained investment and technological innovation (Newell 2008).

Finally, the Kyoto Protocol provides insufficient incentives for compliance (Barrett 2008). The Protocol's enforcement mechanism — a requirement that countries make up any deficit in subsequent compliance periods — is unlikely to induce policy responses consistent with targets.

1.2 Looking Forward

Since the time the Kyoto Protocol was negotiated, scientific consensus regarding the likelihood of future climate change due to anthropogenic emissions of GHGs has grown (Watson 2001, Pachauri 2008), and economic analysis increasingly points to the wisdom of policy action (Shogren and Toman 2000; Kolstad and Toman 2001; Nordhaus 2008a, 2008b). However, the Kyoto Protocol's ambitious targets apply only to the short term and only to some industrialized nations. As a result, the agreement imposes relatively high costs and generates minor short-term benefits, while failing to provide a real solution. Some analysts therefore see the agreement as "deeply flawed" (Victor 2001; Cooper 2001; McKibbin and Wilcoxen 2002, 2004), but others see it as an acceptable or good first step (Grubb 2003; Michaelowa 2003). Virtually everyone agrees, however, that the current framework is not sufficient to the overall challenge and that further steps will be required.[1]

The negotiation of a post-2012 global climate policy architecture provides an opportunity to consider a significant dilemma. The Kyoto Protocol came into force without U.S. participation or meaningful participation by developing countries; its effects on climate change will be trivial; but the economic and scientific consensus points to the need for a credible international approach. Given the global commons nature of the climate problem, a multinational—if not fully global—approach is required. As long as global marginal benefits exceed every nation's own marginal benefits, countries will either want to avoid participating or avoid complying fully if they do participate. Successful international cooperation must change these incentives (Barrett and Stavins 2003).

2. THREE KEY ELEMENTS OF INTERNATIONAL CLIMATE POLICY ARCHITECTURE

A post-2012 international global climate policy architecture will need to contain three key elements: a means to ensure that the most important industrialized and developing nations are involved in meaningful ways; an emphasis on an extended time path of action; and inclusion of the flexibility offered by market-based policy instruments.

[1]For a summary of critiques of the Kyoto Protocol and some alternatives, see Aldy, Barrett and Stavins (2003). A survey of proposals is provided by Bodansky (2004); and a recent analysis of alternatives is found in Aldy and Stavins 2010.

2.1 Expanding Participation

The vast majority of the accumulated stock of anthropogenic CO_2 in the Earth's atmosphere was emitted by sources in industrialized countries.[2] Therefore, equity concerns may suggest that industrialized countries should take serious actions to reduce their emissions *before* developing countries are asked to make their own contributions to such efforts. It has therefore been argued that distributional equity favors a narrow coalition of action, like that embodied in Annex I. Efficiency, or more accurately, cost-effectiveness, favors a broader coalition of action, because these criteria focus on the margin, that is, are forward-looking. Indeed, we argue that broad participation — by major industrialized nations and key developing countries — is essential to address this global commons problem effectively.

2.1.1 Four Reasons for Employing a Broad Set of Participants

The share of global emissions attributable to developing countries is growing rapidly. China surpassed the United States as the world's largest emitter of CO_2 in 2006. The rate of growth in China's emissions is even more important: China emitted 8 percent of global anthropogenic CO_2 in 1981, and about 21 percent by 2008 (Gregg *et al*. 2008; Guan *et al*. 2009). More broadly, developing countries are likely to account for more than half of global emissions by the year 2020, if not before (Nakicenovic and Swart 2000; Pies and Schröder 2002; U.S. Energy Information Administration 2009).

In addition to being an important and growing source of emissions, developing countries provide the greatest opportunities for low-cost emissions reductions (Watson 2001). Therefore, inclusion of key developing countries in a climate regime can reduce overall costs dramatically. According to one estimate, if the major developing countries were to participate in achieving the Kyoto Protocol's emissions targets, total costs could be cut by 50 percent (Edmonds *et al*. 1997).

Another reason to include key developing countries in any post-2012 international climate policy architecture is that the United States has signaled its unwillingness otherwise to commit to significant emissions cuts. In the months leading up to Kyoto, the U.S. Senate voted 95-0 in support of the Byrd-Hagel resolution, which stated that the United States Senate would not approve any agreement that did not include major developing countries under binding targets. Other industrialized countries may be willing to agree to more stringent cuts if the United States, China, and other parties are part of the post-2012 architecture. The EU indicated in the run-up to COP-15 in Copenhagen, in December, 2009, that it would increase the stringency of its reduction target from 20 percent to 30 percent below 1990 levels by 2020 if other countries would make commitments to large reductions.

A final reason to include developing countries in a post-2012 global climate policy architecture is to ensure the environmental effectiveness of emissions reductions by participating

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[2]Taking into account land-use change (particularly deforestation), the responsibility for the atmospheric stock of anthropogenic carbon dioxide is more evenly distributed among developed and developing countries (Weisbach 2010).

countries. If developing countries are not included in an agreement, comparative advantage in the production of carbon-intensive goods and services may shift outside the coalition of participating countries, making developing countries' economies more carbon intensive than they otherwise would be, through emissions leakage. Estimates from computable general equilibrium models of potential carbon leakage rates under a global climate regime range from 5 percent to 34 percent (Paltsev 2001).

2.1.2 Cost-Effectiveness and Distributional Equity

If a post-2012 international climate policy architecture is to be meaningful, the large and rapidly-growing developing countries must be involved, due to the magnitude of their current emissions, their expected rates of growth in emissions, their lower costs of emissions reductions, the increased likelihood of U.S. participation and willingness by other industrialized countries to engage in deeper emissions reductions, and the possibility of carbon leakage. However, it is probably unreasonable to expect developing nations to incur significant emissions-reduction *costs* in the short term, because of consequences for their economic development. Furthermore, it can be argued on an ethical basis that industrialized countries should take the first emission-reduction steps on their own, since they are responsible for the bulk of anthropogenic-based concentrations of GHGs in the atmosphere.

This poses a policy conundrum. On the one hand, for purposes of environmental performance and cost effectiveness, key developing countries must participate in an international effort to reduce GHG emissions, but on the other hand, for purposes of distributional equity and international political pragmatism, they cannot be expected to incur the brunt of the consequent costs. These countries must get on the "global climate policy train" without necessarily paying full fare. How can this be accomplished?

Achieving developing country participation may require a trigger mechanism, imposing binding commitments only when per capita income, emissions per capita, or some other measure of development has reached a predetermined level. But there is no reason to limit action to such a simple, dichotomous instrument. A preferable approach would be continuous "growth targets" that become more stringent for individual counties as they become more wealthy (Lutter 2000). A growth target is not a number, but essentially an equation or set of equations that relate targeted emissions to per-capita income and other variables. Two necessary characteristics of a growth target formulation are that it not create perverse incentives that would encourage nations to increase their emissions and that it should be relatively simple, so as not to create impediments to negotiation (Aldy, Baron, and Tubiana 2003).

This is a natural extension of the progressive target allocation present in the Kyoto Protocol from the industrialized world to the developing world and from the cross-sectional dimension to the temporal dimension. The Kyoto Protocol's targets exhibit positive correlation between gross domestic product per capita and the degree of targeted emissions reduction below business-as-ususal (BAU) levels. In fact, according to Frankel (1999, 2005), the Kyoto targets exhibit an "income elasticity of reductions" of about 0.14, that is, for a 10 percent increase in per-capita GDP, a country's emissions reduction targets — on average — are about 1.4 percent more stringent.

2.1.3 A Formulaic Approach to Allocating Responsibility

In this symposium, Bosetti and Frankel (2010) propose a formulaic approach to generating emissions targets for all key countries for each five-year period remaining in this century. Their formula contains three elements: progressivity, latecomer catch-up, and gradual movement toward equal per capita emissions, while constraining targets so as not to impose costs over the century exceeding an average of 1 percent of GDP per year, or 5 percent of GDP for any country in any period (Frankel 2008; Bosetti and Frankel 2010). Game-theoretic analyses suggest that the use of such formulas can render negotiations more likely to succeed (Harstad 2008).

Their progressivity factor would adjust emissions targets based upon per capita income (applying the income elasticity of reductions implied by the Kyoto targets). "Latecomer catch-up" avoids rewarding countries that failed to curb their emissions after 1990, the Kyoto baseline year. This would include countries such as Canada, which ratified the Protocol but are unlikely to comply; countries such as the United States, which did not ratify the agreement; and countries such as China, which did not take on targets at Kyoto. This would help close the gap between 1990 emissions and the starting points of latecomers to the process. Finally, the "equalization factor" would move all countries in the direction of global average per capita emissions in the second half of the century, asking rich countries to make up, somewhat, for the fact that they previously enjoyed the benefits of unfettered CO_2 emissions, creating an environmental problem for which poor countries bear disproportionate impacts (Frankel 2008).

In the short term, such indexed targets for major developing countries could be set at BAU emissions levels, but they would become more stringent over time as the countries became wealthier. Whereas the emissions targets of China and the other major emerging economies in the Bosetti and Frankel proposal would be equivalent to BAU emissions from 2010 until 2025, then dropping below BAU, the poorest countries would have targets equal to BAU for the remainder of the century. Keeping even poor countries at or near BAU emissions is an important goal, since it prevents the possibility of significant carbon leakage.

If provision is not made for such a mechanism that includes developing countries at low or no cost to them, then the inevitable result will be a trade-off between cost-effectiveness (or efficiency) and distributional equity (Sugiyama and Deshun 2004). However, if emissions targets at BAU for the short- to medium-run (or even the long run for some regions) were combined with an appropriate international trading program (discussed below), this could — in principle — provide a direct economic incentive (subsidy) for developing-country participation. Developing countries could fully participate without incurring prohibitive costs (or even any costs in the short term). That is, cost-effectiveness and distributional equity could both be addressed.

2.2 An Extended Time Path of Targets

Global climate change is a long-term problem, due to the fact that the relevant GHGs remain in the atmosphere for decades to centuries, combined with the reality that significant technological change will be required to bring down costs to levels where greater actions can be taken. The Kyoto Protocol fails to reflect these fundamentally important realities with its short-term targets, an average 5 percent reduction from 1990 levels by the 2008–2012 "first commitment period." However, this apparently modest reduction translates into a severe 25–30 percent cut for the United States from what was its BAU emissions path. The reason for this is that the United States economy grew at an exceptionally rapid rate during the 1990s, exhibiting a remarkable 37 percent increase in real GDP from 1990 to 2000.

This contrasts dramatically with the situation in Europe and elsewhere, where economies grew more slowly or were even stagnant. Furthermore, emissions of CO_2 from the United Kingdom, Germany, and Russia fell significantly subsequent to 1990 (the Kyoto Protocol's baseline year) for reasons having nothing to do with climate policy. Emissions fell in the United Kingdom because of structural changes in the domestic coal industry initiated by Prime Minister Margaret Thatcher's government (1979–1990); emissions fell in Germany because reunification led to the closure of energy-inefficient plants in the former East Germany; and emissions fell in Russia because of its economic collapse in the 1990s (McKibbin and Wilcoxen 2002). It has been estimated that up to 80 percent of the European Union's CO_2 reductions under the Kyoto Protocol would be achieved by two countries — Germany and the United Kingdom, facilitated via the EU bubble that is part of the Protocol (Andersen 2002).

More broadly, the Kyoto Protocol's targets can be characterized as seeking to achieve "too little, too fast." They do little about the problem, but are unreasonable for countries that enjoyed significant economic growth after 1990. Two elements can ameliorate this problem: firm but moderate targets in the short term to avoid rendering large parts of the capital stock prematurely obsolete, and flexible but considerably more stringent targets for the long term to motivate (now and in the future) technological change, which in turn is needed to bring costs down over time (Goulder and Schneider 1999; Jaffe, Newell, and Stavins 1999; Pershing and Tudela 2003; Newell 2008). Emissions targets ought to start out at BAU levels, and gradually depart from BAU levels, becoming more stringent over time. Globally, the aggregate emissions target should not be monotonically increasing, but should reach a maximum level and then begin to decrease — eventually becoming substantially more severe than the constraints implied by the Kyoto Protocol's short-term targets.

Precise, numerical emissions targets for long time horizons, if they are inflexible, are impractical due to uncertainty over future growth, technological change, and the science of climate change and its effects. Some of the considerable uncertainty throughout the policy-economics-biophysical system will be resolved over time (Richels, Manne, and Wigley 2004, Mendelsohn 2008). Thus, long-term targets must retain some flexibility.

In addition, since long-run emissions targets would require that current political leaders (especially elected officials) bind future political leaders to costly commitments, many have pointed out that long-term targets are dynamically inconsistent and must incorporate constraints representing the economic reality that no country is likely to abide by an unenforceable international agreement that causes great economic disruption in any particular year or set of years (Frankel 2008).

The pattern we suggest is consistent with estimates of the least-cost time path of emissions for achieving long-term greenhouse-gas concentration targets: short-term increases in emissions — just slightly below the BAU path — and subsequent emission reductions (Wigley, Richels, and Edmonds 1996; Manne and Richels 1997).

Such a time path of long-term targets, put in place now, would be consistent with what is often denigrated as "politics as usual." That is, politicians are frequently condemned for the fact that in representative democracies there are strong incentives to place costs on future, not current, voters and, if possible, future generations. It is typically the politically pragmatic strategy. In the case of global climate policy, it can also be the scientifically correct and economically sensible approach.

2.3 Market-Based Policy Instruments

The third essential component of post-Kyoto international policy architecture will be necessary to achieve global cost-effectiveness and thereby to render the overall architecture politically achievable: working through the market rather than against it. There is widespread agreement that conventional regulatory approaches cannot do the job, certainly not at acceptable costs. To keep costs down in the short term and bring them down even lower in the long term through technological change, it is essential to embrace market-based instruments (that is, carbon pricing) as the chief means of reducing GHG emissions (Stavins 1997; Lackner 2005; Metcalf 2009).

On a domestic level in some countries, systems of tradable permits — now known as "cap-and-trade" — might be used to achieve national targets. In a cap-and-trade system, sources that have low costs of control have an incentive to take on added reductions, so that they can sell their excess permits to sources that face relatively high control costs and would hence wish to reduce their control efforts (Hockenstein, Stavins, and Whitehead 1997). This is the same mechanism that was used in the United States to eliminate leaded gasoline from the market in the 1980s at a savings of more than $250 million per year (Stavins 2003), and the same mechanism being used to cut sulfur dioxide (SO_2) emissions from power plants in the United States by 50 percent, at a savings estimated to be $1 billion per year (Schmalensee, *et al.* 1998; Stavins 1998; Ellerman, *et al.* 2000). The better model for climate change policy is the upstream lead-rights system (analogous to trading based on the carbon content of fossil fuels), rather than the downstream SO_2 emissions-trading system.

For some countries, systems of domestic carbon taxes may be more attractive than cap-and-trade approaches. Rather than imposing a cap on the quantity of pollution, and allowing regulated firms to trade allowances to establish a market price for pollution, a tax imposes a specific price on pollution and allows firms to decide how much to emit in response. A tax has an effect on firms' decisions that is essentially identical to the effect of the permit price created by a cap-and-trade policy; polluters decide, for each ton of emissions, whether to abate that ton (incurring the resulting abatement costs) or pay the tax and continue to emit that ton. Domestic carbon taxes — typically in the form of upstream taxes on the carbon content of fossil fuels — have frequently been recommended by academic economists (Metcalf 2007; Metcalf and Weisbach 2009),[3] but have received considerably less support in the policy community.

Another promising market-based approach is a hybrid of tax and tradable-permit systems — that is, an ordinary cap-and-trade system, plus a government promise to sell additional permits at a stated price (Roberts and Spence 1976; Kopp, *et al.* 2000; Pizer 2002; McKibbin and Wilcoxen 2002). This creates a price (and thereby cost) ceiling, and has hence been labeled a safety-valve system. Likewise, a price floor can be created by a government promise to purchase allowances from the market at a given price. The combination of the two approaches — known as a "price collar" — can have particular attraction (Murray, Newell, and Pizer 2009).

Among these alternative market-based policy instruments, the one which seems to be emerging as the preferred approach among industrialized countries is cap-and-trade (Jaffe and Stavins 2010). At the same time, the emission-reduction credit system created under the Kyoto Protocol — the Clean Development Mechanism — enjoys a solid constituency of support in the developing world (Somanathan 2008).

2.3.1 The Promise and Problems of International Emissions Trading

The Kyoto Protocol includes in Article 17 a system whereby the parties to the agreement can engage in trading their "assigned amounts," that is, their reduction targets, translated into quantitative terms of emissions (United Nations 1997). In theory, such a system of international tradable permits — if implemented only for the industrialized countries (as under the Kyoto Protocol) — could reduce costs by 50 percent. If such a system also included major developing countries, costs could be lowered to 25 percent of what they otherwise would be (Edmonds *et al.* 1997).

An undisputed attraction — in theory — of an international trading approach is that the equilibrium allocation of permits, the market-determined permit price, and the aggregate costs of abatement are independent of the initial allocation of permits among countries. Emerging empirical evidence supports this hypothesis for some domestic trading systems (Fowlie and Perloff 2008). However, permit allocations and aggregate abatement costs will only be independent as long as particularly perverse types of transaction costs are not prevalent (Stavins 1995), individual parties—be they nations or firms—do not have market power (Hahn 1984), and other conditions hold (Hahn and Stavins 2010). The market-power concern is a real one in the climate change context. In any event, the initial allocation can be highly significant in distributional terms, implying possibly massive international wealth transfers. Some analysts have highlighted this as a major objection to an international carbon trading regime (Cooper 1998, 2008), but it is essentially because

[3]Others have argued in favor of an international tax regime. See, for example: Cooper (1998, 2008); McKibbin and Wilcoxen (2002); Pizer (2002); Newell and Pizer (2003); and Nordhaus (2008a).

of this feature that a permit system can be used to address cost-effectiveness *and* distributional equity.

If an international trading system were used, it must be designed to facilitate integration with domestic policies that nations use to achieve their respective domestic targets. In the extreme, if all countries were to use domestic cap-and-trade systems to meet their national targets (that is, allocate shares from an international permit system to private domestic parties), then an international system can — in theory — be cost-effective, because a nation-nation trading system then evolves essentially into an international firm-firm trading system. On the other hand, if some countries were to use non-trading approaches, such as GHG taxes or various kinds of regulatory standards — which seems likely — cost minimization is less ensured (Hahn and Stavins 1999; Metcalf and Weisbach 2010).

Thus, individual nations' choices of domestic policy instruments to meet their targets can substantially limit the cost-saving potential of an international trading program. A trade-off exists between degree of domestic sovereignty and degree of cost-effectiveness. A possible answer, which we discuss below, is the linkage of independent domestic and regional cap-and-trade systems, and for that matter, domestic carbon taxes and some types of national regulatory systems, thereby facilitating some degree of cost-effective trades among individual sources (firms), both domestically and internationally.

2.3.2 Is the European Union Emissions Trading Scheme a Useful Model?

When the Kyoto Protocol was signed in 1997, few would have predicted that European countries would employ cap-and-trade systems, given the European Union's strenuous opposition to such approaches. But after some initial flirtations with carbon tax considerations, the EU launched a continent-wide trading system for CO_2 to meet its emissions reduction targets under the Protocol (Kruger and Pizer 2004).

The Kyoto Protocol establishes a bubble for the European Union, that is, it sets a cap on CO_2 emissions for the EU as a whole, allocated by the EU to its member states. Under this cap, the European Union Emission Trading Scheme (EU ETS) was established in 2005, and after a pilot phase, entered its more meaningful Kyoto phase in January 2008.

The EU ETS is the world's largest emissions trading system, covering some 12,000 facilities in 27 countries as of 2008, and accounting for nearly one-half of EU CO_2 emissions (Ellerman and Buchner 2007, Ellerman and Joskow 2008, Ellerman 2008, Convery and Redmond 2007). The pilot phase of the EU ETS (2005-2007) was designed to set up the institutional and operating structures necessary for trading. The cap in the EU system in this pilot phase was a very small reduction below expected emissions in the absence of the policy. Given that the system was designed not to begin to bind in meaningful ways until 2008, which turned out to be a time of global recession (and hence falling CO_2 emissions), it is much too soon to determine the impact of this new carbon market on emissions, or the cost savings from the EU ETS over more prescriptive approaches.

The EU ETS could conceivably serve as a prototype for a post-2012 international global climate regime, since the 30 states involved constitute an increasingly diverse set of sovereign countries. Many of the problems encountered and addressed by the EU ETS may be similar to those a fully international architecture would encounter. Indeed, the EU ETS has not been without its conflicts. Nine of the ten East European countries have sued the European Commission over their allotted emissions caps for 2008-2012. But the"club benefits" of continued membership in the European Union, including free labor and capital flows and access to broader markets, have apparently outweighed the costs of the EU ETS for these poorer nations, as they have chosen to remain within the system, rather than dropping out (Ellerman 2008).

2.3.3 The Status of Climate Cap-and-Trade in the United States

Although the U.S. government (Senate) did not ratify the Kyoto Protocol, some states have enacted policies to reduce their GHG emissions. The largest U.S. market-based initiative is the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade system among 10 northeastern states, initiated in 2003. The trading program, which began in earnest in 2009, covers electricity generators within the region. Allowances under RGGI are auctioned, and firms trade allowances and various financial derivatives (including futures and options contracts) in a secondary market. The RGGI CO_2 emissions cap for 2009-2014 roughly equals the sum of recent emissions among covered generators, then declines by 2.5 percent per year from 2015 through 2018.

California continues to take serious steps toward establishing its own cap-and-trade system for CO_2 emissions to meet the requirements of its Global Warming Solutions Act 2006 (otherwise known as Assembly Bill 32, or AB 32), namely achieving emissions in 2020 equal to those of 1990 (Jaffe and Stavins 2010).

In June 2009, the Federal government in the United States began to take its most significant steps toward putting in place a national cap-and-trade policy to reduce CO_2 emissions, with the passage in the House of Representatives of the American Clean Energy and Security Act, also known as the Waxman-Markey bill, named for the two Members of Congress who developed the legislation. The legislation would cap national GHG emissions by nearly all significant sources, including coal-fired power plants, factories, natural gas suppliers, and fuels, setting up an economy-wide cap-and-trade system to achieve emissions reductions. The target reductions for covered sources in the bill amount to cuts of 17 percent below 2005 levels by 2020, and progressively steeper cuts as time goes on (42 percent by 2030, and 83 percent by 2050).

In May 2010, companion legislation was introduced in the U.S. Senate by Senators John Kerry and Joseph Lieberman — the American Power Act. Like the House legislation, this proposal features a cap-and-trade system.

2.3.4 Linking National and Regional Cap-and-Trade Systems

In addition to the nations of the European Union and the United States, a number of other major countries in the industrialized world are currently considering the adoption of national cap-and-trade systems to reduce their CO_2 emissions, including Australia, Canada, Japan, and New Zealand (Jaffe and Stavins 2010). The increasing number of existing, planned, and proposed regional, national, and sub-national cap-and-trade policies for CO_2 emissions reduction raises the possibility that the linkage of these systems will be a significant element of future international climate policy architecture. In this context, linkage refers to the recognition of the allowances (permits) from one system for use in meeting compliance requirements of another. The potential benefits of such linkage include cost savings from increasing the scope of the market, greater market liquidity, reduced price volatility, lessened market power, and reduced carbon leakage (Jaffe and Stavins 2010).

Such linkage of domestic cap-and-trade systems can be initiated by bilateral or multilateral agreements among respective governments, but it leads to trading not among governments, but among firms within the respective countries. This circumvents the problems, mentioned earlier, which are inherent in international emissions trading under Article 17 of the Kyoto Protocol (Hahn and Stavins 1999).

Domestic cap-and-trade programs could be linked directly, either unilaterally or bilaterally. With a direct bilateral linkage, a pair of domestic cap-and-trade policies would recognize allowances from the other system. Under unilateral linkage, one system recognizes allowances from the other, but the recognition is not mutual. Allowance prices would converge with direct bilateral linkage, so long as there were no constraints on inter-system trades, and with unilateral linkage as long as the buying system's price was higher than the selling system's price – no trading would take place if the opposite were true (Jaffe and Stavins 2010).

A potential problem is that direct linkage of cap-and-trade systems will lead to the automatic transmission of cost-containment elements — banking, borrowing, safety valves, and price collars — from one system to the other. This raises concerns for some countries, because of the possible loss of control of their domestic systems, and raises the possibility that systems would need to be harmonized in advance of linkage.

This necessity for prior harmonization can be avoided through the substitution of indirect links for direct ones. If each cap-and-trade system links with a common emission-reduction credit system, then all of the cap-and-trade systems will be linked (indirectly), achieving the benefits of cost reduction, greater market liquidity, reduced price volatility, lessened market power, and reduced carbon leakage, but with greatly reduced transmission of cost-containment mechanisms from one system to another, thereby reducing, if not eliminating the need for prior harmonization. With a sufficient supply of credits, prices in all systems will converge, though this may not occur if binding constraints are imposed on the use of credits and allowances from other systems.

This is a rather good description of what appears to be evolving, that is, the emergence of regional and national cap-and-trade systems in the industrialized world, each of which allows offsets to some degree from the Clean Development Mechanism (CDM), the emission-reduction credit system in developing countries that was established under the Kyoto Protocol. Under the CDM, certified emissions reductions (CERs) are awarded for voluntary emission reduction projects in developing countries that ratified the Kyoto Protocol, but are not among the countries subject to emissions limitations. The industrialized countries that did take on emissions targets under the Protocol can use CERs to meet their commitments. The CDM will have generated more than 2.7 billion (tons of) CERs by the end of 2012, the vast majority of them for projects in China, India, and Brazil (Jaffe and Stavins 2010). The process of indirect linkage has begun, since CERs can be used to meet emissions commitments within the EU ETS and RGGI (under certain circumstances).

A potential concern associated with linking cap-and-trade systems through a common emission-reduction credit systems is "additionality" – credit systems, including the CDM, have been plagued by questions about the actual emissions reductions represented by credits, because of the difficulty of establishing a baseline against which reductions can be measured. Linking credit systems with cap-and-trade system passes this worry along to the latter system, in which it would otherwise not be a significant concern. Thus, there is a trade-off between the potential economic and environmental gains of such a bottom-up system of global indirect linkage, and the potential economic and environmental losses that linkage can bring about if additionality problems are severe.

2.3.5 The Role of Emissions Trading in a Future International Climate Policy Architecture

One of the key objections to the efficacy of a post-2012 international climate policy architecture with international emissions trading as a core element is that industrialized countries will not support such a policy, once the cross-border financial flows implied by trading allocations that favor developing countries (in order to prompt their accession to the agreement) become apparent (Victor 2007, Cooper 1998). However, despite the significant variation in per capita income across EU ETS member states, this has not turned out to be a point of controversy (Ellerman 2008). This may be due to the fact that, while trading is active, financial flows from emissions trading represent a very small portion of total imports and exports. For example, the United Kingdom is the largest emissions allowance importer in the ETS, importing 14 percent of its verified emissions, worth about £350 million. But this still represents a very small portion – less than one-tenth of one percent – of its total imports of goods and services, about £415 billion (Ellerman 2008). Furthermore, it is useful to keep in mind that any viable alternative that engages the major developing countries in an international climate policy architecture will likely involve some form of financial transfers from industrialized to developing countries.

The experience of the EU ETS, the U.S. preference for trading, and support voiced by other countries represent important political arguments for this element of a future international climate policy architecture. International permit trading — not among countries, *per se*, but among firms within and across countries — thus remains a promising approach to achieving global greenhouse targets, despite the challenges that exist. It is probably fair to state that the more one studies international tradable permit systems to address global climate change, the more one comes to believe that this is the worst possible approach — except, of course, for all the others.

2.3.6 Incorporating Linkage Among a More Heterogeneous Set of National Policies

Although cap-and-trade systems appear as of now to be the preferred approach in most parts of the industrialized world for meaningful GHG emission reductions, it also appears likely that some — perhaps a sizable share of — countries will use other approaches, ranging from other market-based instruments, in particular, carbon taxes, to more conventional types of regulatory instruments, such as performance standards and technology standards. This raises questions about whether bottom-up linkage among a heterogeneous set of national policies is feasible and at what cost.

The short answer is that although bilateral allowance recognition between cap-and-trade systems is the simplest and easiest form of linkage, it is also possible to link carbon tax systems with cap-and-trade systems. For that matter, some types of regulatory standards can also be linked (Hahn and Stavins 1999; Metcalf and Weisbach 2010). Direct linkages — and, more likely, indirect linkages through a common emission-reduction-credit system — are possible among a fairly broad, but not unlimited set of national policy instruments. Problems arise with some types of linkages, but some of these can be addressed through *ex ante* harmonization. Rather than saying more here, we direct the reader's attention to the companion paper in this symposium by Metcalf and Weisbach (2010), which focuses on these very questions.

3. CONCLUSION

The three elements we have identified are likely to be essential aspects of a future global climate change policy architecture that is meaningful and feasible, and can serve as a successor to the Kyoto Protocol. Key nations have to be involved, including major emerging economies through the use of economic trigger mechanisms such as growth targets. In addition, cost-effective time paths of targets are required: firm, but moderate in the short term, and in the long term, much more stringent and flexible. Finally, to keep costs down, market-based policy instruments need to be part of the package, whether emissions trading, carbon taxes, or hybrids of the two. Most likely, international linkage of regional, national, and even sub-national market-based instruments will be the means through which this third element is implemented.

This overall approach can be made to be scientifically sound, economically rational, and perhaps politically pragmatic. There is no denying that the challenges facing adoption and successful implementation of this climate policy architecture are significant, but they need not be insurmountable, and they are no greater than the challenges facing other approaches to the threat of global climate change.

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