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Linking Policies When Tastes Differ: Global Climate Policy in a Heterogeneous World

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Introduction

Global climate policy must address the tension that exists between the efficiency benefits of a uniform global policy and the variation in national and regional tastes for different policies. Although a coordinated global policy has been the goal of climate negotiations, going back to the 1992 United Nations Framework Convention on Climate Change (UNFCCC), it has become increasingly clear that we are heading toward a more decentralized system of local, national, or regional policies. Different countries will undertake different policies, ranging from market-based systems (such as greenhouse gas [GHG] charges or cap-and-trade systems) to quasi market-based systems (such as renewable portfolio standards) to command and control regulations (such as technology mandates).

Variations in policies, although catering to local tastes and preferences, can lead to substantial inefficiencies. If the shadow price of carbon is different in different parts of the world, high-cost mitigation strategies may be used where the shadow price is high, notwithstanding lower cost opportunities elsewhere. Moreover, carbon-intensive industry may move to locations with low shadow prices for carbon, a phenomenon known as carbon leakage. Thus a central question in a world of regional policies is how best to coordinate or link different types of systems to minimize these inefficiencies.

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In this article, which is part of a symposium entitled "Post-Kyoto International Climate Policy Architecture,"[1] we discuss the mechanics of linking different types of climate change policies and identify areas where linkage will be difficult. We do not suggest an optimal degree of policy homogenization. Rather our goal is to identify both opportunities for constructive linkage and policy choices that may limit the potential for, and attractiveness of, such linkage. We argue that the basic approach underlying emission reduction credit systems like the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation can be extended to create linkage opportunities in diverse emission control systems in ways that do not necessarily suffer from the shortfalls of the current CDM. Moreover, although emission reduction credit systems are designed to work with market-based systems like cap and trade, we describe ways in which they can also interact with tax systems and certain regulatory systems.

There is a large literature on linking carbon policies. Most of this literature focuses on linking cap-and-trade systems, either directly or indirectly, through a credit system. Contributions in this area include Ellis and Tirpak (2006), Jaffe and Stavins (2008), Jaffe, Ranson, and Stavins (2009), Flachsland et al. (2008), Flachsland, Marschinski, and Edenhofer (2009), Helm (2003), Carbone, Helm, and Rutherford (2009), and Anger (2008). We summarize and add to this literature, but we also focus on linking disparate systems, such as linking cap and trade to tax systems or linking market-based systems to command and control regulations.

The remainder of the article is organized as follows. We first discuss how and why the likely course of climate policies has moved toward local and regional systems. We then review the basic theory of linking and the methods of controlling carbon emissions. With this background, we next consider the various options for linking these systems and the problems that might arise in doing so. We conclude with a discussion of policy implications.

The Evolution of Thinking on Global Climate Architecture since Kyoto

The vision of a climate regime developed in the Framework Convention was of a global top-down architecture in which nations, starting with the developed world but then moving to the developing world, would agree to emissions reductions commitments. Although neither the Framework Convention nor its major achievement, the Kyoto Protocol, specified a single global system, such as a global tax or a global cap-and-trade regime, the idea was that basic obligations would be imposed on nations through an international agreement that would allow coordination, verification, and planning.

It appears increasingly likely, however, that the global architecture for climate change will percolate up from national and regional decisions to reduce GHG emissions rather than filter down from a global agreement. This is illustrated by the outcome of the negotiations at the United Nations climate change conference in Copenhagen in December 2009, where delegates from 193 nations met with the hope of extending the Kyoto Protocol and achieving a global agreement on emissions cuts. The conference was acrimonious and disorganized. At the last minute, a small group of nations produced the Copenhagen Accord, which is

[1]The other articles in the symposium are Bosetti and Frankel (2011) and Olmstead and Stavins (2011).

a nonbinding statement of principles. Other conference participants refused to sign the accord and instead "took note" of it.

Measured against the goal of achieving a global climate agreement, the Copenhagen conference was a failure. No treaty emerged. No binding commitments were made. Even soft targets were rejected, as was any monitoring of emissions by such major emitters as China. The European countries, which have taken the lead in reducing emissions and advocating for a global climate agreement, were entirely sidelined during the final negotiations. Demands by low-lying nations—those with the most to lose from climate change—were largely ignored.

However, if we measure the results of the Copenhagen conference not against the goal of a uniform worldwide policy but rather against the goal of moving toward a system of regional commitments, the outcome looks more positive. A group of major emitting countries that includes major developing countries (China and India) agreed to undertake emissions reductions of some form. Although not a large step forward, this commitment potentially establishes a precedent for more global participation in GHG emissions reductions. In fact, many of the commitments made in Copenhagen were formally agreed to in Cancun a year later.

It is clear that the form of the controls undertaken may differ significantly from country to country. Although the Framework Convention process will continue, after Copenhagen it seems increasingly unlikely that it will produce the type of agreement envisioned at its founding. This result, perhaps, should not be surprising. Analysts studying international agreements essentially predicted it.[2]

The failure to adopt a global top-down architecture does not necessarily stand in the way of a decentralized and heterogeneous system that is effective in reducing global emissions. It should, however, shift the focus away from the goal of a global agreement to the goal of price harmonization among major emitting nations. We believe this is a more appropriate focus.

The Basic Theory of Linking

In terms of efficiency, it does not matter whether there are regional carbon regimes rather than a unified global carbon regime if the price of carbon is the same across regions. For example, even if one region has a tax while another has a cap-and-trade system, as long as the permit price is roughly in parity with the tax rate, the results will be similar to a global regime in that only the most efficient mitigation options will be pursued. The same holds even if one nation or region uses command and control regulation and others use market-based mechanisms so long as the shadow price of the regulations is close to the price of carbon elsewhere.

[2]For example, Carraro (2007) distills the large game-theoretic literature on the design of global environmental agreements into three points. First, a global agreement that all countries ratify is unlikely to be an equilibrium. Second, global self-enforcing agreements are unlikely to emerge as an equilibrium. Third, a global equilibrium coalition structure is likely to emerge with multiple coalitions of different sizes. An implication of these observations is that any global agreement may simply ratify a de facto architecture established by smaller clusters of countries. Victor (2007) provides similar analysis of the political economy of global treaties.

Sources and Impacts of Inefficiencies in Regional Carbon Regimes

It is unlikely that the condition just described (i.e., homogeneous carbon prices) will be met if nations pursue uncoordinated and heterogeneous goals. If the shadow price of carbon varies across regions, there will be efficiency losses and possibly distributional effects. Efficiency losses arise because polluters in regions with a high carbon price will pursue abatement opportunities that cost more than opportunities available in those regions with a lower price. These efficiency losses can be large if there are significant differences in the marginal abatement cost of emissions reductions in different regions.

These differences in marginal abatement costs may manifest themselves in the form of carbon leakage, which arises when emissions in low-price or nonregulating regions go up because of higher carbon prices elsewhere. For example, if one region has a carbon price and the rest of the world does not, industries might relocate to the nonpricing areas. Similarly, if regions with stringent carbon pricing use less fossil fuel, the lower demand for fossil fuel may cause the equilibrium price of fossil fuel to decline, leading to increased demand elsewhere.[3] Carbon leakage may also result in distributional effects if low-price or nonpricing regions attract industry.

The economic importance of leakage continues to be debated (see, e.g., Babiker 2005; Bruvoll and Foehn 2006; Di Maria and van der Weft 2008; Felder and Rutherford 1993; Kuik and Gerlagh 2003; Paltsev 2001). Its political importance, however, cannot be overstated. For example, the Byrd-Hagel Resolution (S. Res. 98) stated that the United States should not be a signatory to the Kyoto Protocol in the absence of any legally binding commitment to emissions reductions by developing countries. This resolution, which passed the Senate in July 1997 by a vote of 95–0, stated that "the disparity of treatment between Annex I Parties and Developing Countries and the level of required emission reductions, could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof[.]"

An additional inefficiency that can arise with regional systems is that carbon markets, to the extent that they are used, will be thinner than if they were global, possibly increasing trading costs and reducing price discovery. Smaller and thinner markets also raise the risk that certain participants may be able to exercise market power.

Reducing Inefficiencies through Linkage

Linkage of systems can reduce these inefficiencies. By linkage, we mean policies that allow regional or national carbon regimes to interact in such a way as to narrow or eliminate differences in the marginal cost of abatement between different regions or countries. Although the simplest form of linkage is where two countries with cap-and-trade regimes agree to accept permits from the other country, there are other forms as well, which we discuss later. We do not consider mere policy coordination (i.e., trying to keep shadow prices roughly similar) to

[3]Whether such demand reductions lower the price of oil depends in large part on how oil-producing countries adjust production. Efforts by major oil-producing nations to maintain high oil prices help to mitigate the leakage problem. See Sinn (2008) for a discussion of oil-producing countries and their response to demand reducing policies.

be linkage unless it also includes a mechanism to link prices across regimes in a way that we will make more explicit later. Linkage raises a number of issues that deserve mention.

Magnitude of Payments

First, the magnitude of payments made by one country to another in a linked system depends critically on each country's emissions reductions targets. Consider two countries, A and B, which are considering linking their emissions reduction systems and have agreed to some aggregate reduction. The larger the share of the reduction for which country A is responsible, the greater the payments that will flow from country A to country B in a linked system (or the smaller the payments flowing from country B to country A).[4] This means that linkage may create game-theoretic concerns because the possibility of linkage may affect how countries set up their systems in the first place (Helm 2003): the possibility of linkage may give a country an incentive to set a low reduction target in the hopes of selling permits to other countries.

Winners and Losers

Second, there will likely be winners and losers within each country. To illustrate, assume the marginal cost of abatement prior to linkage is higher in country A than in country B. Full linkage lowers the marginal price of abatement in country A and raises the marginal price in country B. If the holders of permits in country A are not the same as the eventual users of the permits, then the holders will suffer a windfall loss while the permit users will face lower costs of emissions. Similarly, holders of permits in country B will enjoy a windfall benefit, but the users of the permits will be required to pay a higher price. Uncertainty about future linkages also creates price risk for permit holders, who might gain or lose depending on whether linkage is with a country that has higher or lower marginal abatement costs.

National Autonomy

Finally, linkage can be a challenge to national autonomy because cost shocks to a single country in a fully linked system are transmitted throughout the entire system. This could occur, for example, if an accident at a domestic nuclear power plant led to a decline in political support for nuclear power and a shutdown of this non-GHG-emitting source of electricity. The cost of abating emissions in the country suffering the shock rises, leading to a greater desire for emission-reducing activities in countries linked with this country. With a fully linked system, marginal abatement costs would rise in all countries by an equal amount. Of course, the larger the linked system, the smaller the cost increase because the shock is dissipated across a larger amount of emissions.

This last point is particularly relevant if a reduction in marginal abatement costs occurs because one country has weak monitoring and verification procedures that cause reported abatement activity to fall short of actual abatement. This transmits lower prices through a fully linked system and weakens overall abatement activities, a point discussed in some detail by Nordhaus (2007). For example, suppose that country A desires a given level of abatement and

[4]See Metcalf and Weisbach (2010) for graphical depictions of this issue as well as the next two issues.

enforces a cap-and-trade regime consistent with that desire, but that country B does not care as much about abatement and hence does not enforce its cap-and-trade regime. If country A were to link with country B, firms in country A could avoid the necessary emissions reductions by buying the (fraudulent) permits issued by country B. It would be as if country B simply issued more permits to firms in country A and pocketed the proceeds.

Systems for Controlling Emissions

Before considering approaches to linking emission reduction systems, it is helpful to briefly describe the major alternatives for controlling emissions as well as existing linkage systems. The four broad classes of systems for reducing emissions are cap and trade, taxes, subsidies, and command and control regulations, each with many variations.

Cap and Trade

In a cap-and-trade system, a nation or region sets an overall target for emissions, typically on an annual basis or for some other relatively short period.[5] Then, either through an auction, free allocation, or some combination, the nation issues a number of permits equal to the target. Permits trade freely in the market at a market determined price. To emit a ton of carbon dioxide (CO_2)—or other GHG in appropriate units, if covered under the system—covered polluters must own and surrender a permit to the government. This results in an equilibrium price such that each polluter's marginal abatement cost equals the price of the permits, and therefore marginal abatement costs are equalized across all covered entities.

A nation must choose from among a large number of parameters when designing a cap-and-trade system. It must decide which types of emissions are covered and where in the production chain permits will be required. It must decide whether it will try to limit price changes by imposing a price floor and/or a price ceiling on permits. It must decide on a monitoring and audit system as well as penalties for noncompliance. Finally, a nation may allow offsets, in which a covered entity can obtain additional permits by reducing emissions outside of the permit base. Because of the large number of design choices, a nation that chooses a cap-and-trade regime is unlikely to have a system that operates in exactly the same way as the cap-and-trade regimes of other countries.

Taxes

In a tax system, a nation sets a price for emitting a ton of CO_2. Covered emitters will reduce emissions until the marginal abatement cost is equal to the tax. Thus, just as with a cap-and-trade regime, a tax equalizes marginal abatement costs across all covered entities. The design issues that arise in a tax system are similar to those that arise in a cap-and-trade regime, including which entities to cover, where in the production process to impose the tax, and which monitoring and enforcement mechanisms to use.

[5]A longer term target may be set that is to be met by shorter term objectives. Moreover, through banking and borrowing provisions, the shorter term objectives may be tied together.

Subsidies

A nation or region can set the marginal benefit of abatement at a desired level by offering a subsidy for abatement. If a polluter decides to pollute rather than abate, the polluter loses the subsidy, thereby creating a marginal price for pollution that is equal to the subsidy rate. In a sense, a subsidy works just like a tax except that instead of paying a tax on emissions, a polluter loses a potential subsidy when it emits.

Subsidies are significantly harder to administer than taxes or cap-and-trade systems. To provide a subsidy for abating emissions, we have to know that the emissions would have otherwise occurred. That is, we have to determine behavior in the alternative (i.e., counterfactual) world that does not have a subsidy, and we can only guess at this. This problem is known as additionality, and it is a significant problem for any subsidy system.

Another form of subsidy is a subsidy for carbon-free investments such as production tax credits for wind generation or investment tax credits for solar projects. As noted by Metcalf (2009b), among others, these sorts of subsidies can lower the consumer price of electricity and so undermine the incentive for emissions reductions by increasing demand for electricity at the now lower price. Abatement subsidies, in contrast, do not lead to lower consumer energy prices. As discussed by Fullerton (2001), abatement subsidies from a baseline level of emissions serve as an entry barrier that raises the output price. New firms do not receive the subsidy because they have no baseline level of emissions, and thus suffer a cost disadvantage relative to incumbent firms.

Subsidies are often in the form of emission reduction credit (ERC) systems. ERC systems provide credits to firms in uncovered sectors that can be sold to firms in covered sectors who can use them in lieu of allowances to meet their obligations under a cap-and-trade system. The Kyoto Protocol's CDM is the most important emission reduction credit system in place today. The CDM works by paying developing countries to reduce emissions when they otherwise would not. The developing country firm receives a Certified Emissions Reduction (CER) equal to its reduction in emissions, and then it sells the CER to a Kyoto Annex B firm to use to meet its emission reduction obligations under the protocol.

As Wara (2007) notes, additionality has been a serious problem with the CDM, particularly for non-CO_2 GHGs, such as hydrofluorocarbon (HFC)-23. Moreover, the CDM mechanism illustrates a problem that is common to all subsidy systems: to be successful as a significant source of credible and real emission reductions, it must be able to scale up and approve, monitor, and verify many projects. But the very pressure to generate large reductions will make it difficult to ensure that those reductions are real.

Command and Control Regulations

A variety of command and control approaches are available to reduce GHG emissions. Regulatory approaches run the gamut from technology-based mandates to quasi market-based approaches. An example of the former would be the mandate that all new coal-fired power plants include technology for carbon capture and sequestration. Other examples would be the prohibition of any new coal-fired power plants and corporate average fuel economy (CAFE) standards. An example of a quasi market-based approach is a renewable portfolio standard system, which generally requires electric utilities to submit renewable electricity credits equal to a percentage of their electricity sales over some designated time period. Utilities purchase these credits from producers of qualified renewable electricity who are provided credits for each unit of renewable electricity production.

Existing Links

Linkages across existing emissions control systems are currently quite limited, in large part because only a few such systems are in place. The European Union Emissions Trading System (EU ETS) can be viewed as a linked system because there is no systemwide cap. Instead, individual member states have caps, and the systems are harmonized through a central authority. In addition, through its Linking Directive, the EU ETS links to developing countries through the CDM mechanism (Council Directive 2004/101/EC, art. 5, 2004 O.J. [L 338] 18).

The Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade regime among ten northeastern states in the United States, has several linking mechanisms. Offsets elsewhere in the United States are allowed, subject to some limits. In addition, once the allowance price meets specified thresholds, regulated entities can use emissions credits from other cap-and-trade regimes, including the EU ETS and ERCs issued under the UNFCCC. In the language we will be using in the following sections, this mechanism provides a one-way direct link (RGGI accepting EU ETS permits but not vice versa) as well as an indirect link (both RGGI and the EU ETS accepting emission reduction credits).

We turn next to the options for linking emission reduction systems. As noted in the introduction, there is a considerable literature on the issues involved in linking cap-and-trade systems. However, much less has been written on opportunities and issues concerning the linking of cap and trade and other policy approaches. The one exception is Hahn and Stavins (1999). In the next five sections, we build on and update their analysis to consider the options and challenges for linkages in a post-Kyoto world.

Linking Cap-and-Trade Systems

In this section, we summarize the current state of thinking on the issue of linking cap-and-trade systems, using the taxonomy and analysis of Jaffe, Ranson, and Stavins (2009). As they noted, linkages can be direct or indirect. Two countries can directly link their cap-and-trade systems by allowing permits issued by one system to be used to satisfy permit surrender requirements in the other system. Directly linked systems can be one way or two way. Under a one-way linked system, only one of the countries recognizes the other country's permits, whereas under a two-way system, both countries recognize each others' permits. An indirect linkage involves two countries linking through a third. We do not address indirect linkage separately in the discussion that follows because all the issues we discuss concerning directly linked systems apply equally to indirectly linked systems.

Two-Way Directly Linked Systems

A two-way directly linked cap-and-trade system between two (or more) countries is perhaps the easiest system to understand. Permits will flow from the low-price system to the high-price system until prices between the two countries are equalized (or harmonized). Limits on permit flows could lead to incomplete harmonization of prices. Similarly, the system's rules may allow the use of permits from a foreign system, but at a less than one-for-one rate. In this case, the permit prices would harmonize up to the exchange rate between the two countries.

Countries can also be linked through a chain of bilateral linkages. For example, if country A is linked directly with country B, and country B (but not country A) is linked directly with country C, countries A and C are in effect linked. A common permit price will tend to emerge across the three countries.

A number of important issues can arise when directly linking cap-and-trade systems. We review the most salient here. The key issue is the extent to which decisions in one country propagate to the other country in ways that might be contrary to local preferences or decisions. Although we will discuss these issues in the context of linking cap-and-trade systems, most of them will also arise in the other linkage configurations described here.

Permit Base

It is unlikely that two independently designed systems will cover the same sectors and GHGs. For example, country A may include the transportation sector in the group of covered sectors, whereas country B does not. Similarly, country A may include a number of GHGs, whereas country B limits its system to CO_2.

If permit bases vary, countries can still link their systems. However, the country with the narrower base has to accept permits from the other country's broader base. For example, if country A's permit base is industry and transport, whereas country B's base is only industry, the linked system's base would be industry in both countries and transport in country A. Country B could not link to country A and exclude A's transport sector because all of country A's permits trade in a common pool at a single price, so linking to any portion of that pool automatically ends up linking (indirectly) to the entire pool of permits.

If country B's reasons for excluding its domestic transport sector apply to country A's transport sector as well, then country B may not want to link systems at all. It is not clear, however, the extent to which this situation would occur. A sector may be excluded from a cap-and-trade regime for any number of reasons, of which some may and some may not extend to the same sector in a foreign country. For example, if a sector is excluded domestically because the costs of compliance are excessive, inclusion of that sector by another country would not likely be a barrier to linkage. However, if a sector is excluded because of problems with monitoring and ensuring compliance, linking to a country that includes that sector may be problematic.

It is also possible that a country with a broad base may not be willing to link to a country with a narrow base because of distributional considerations. Countries with narrow bases will, all else held equal, tend to have a higher marginal abatement cost. As noted earlier, when linking systems, the country with the higher marginal abatement costs tends to gain more than the other country. Although both countries gain, the relative size of the gains may make negotiations difficult, particularly when the relative size has been determined by a policy decision to have a narrow base.

Similar considerations apply for permits issued for gases covered by country A but not covered by country B. If country A's allowance system uses a single type of allowance denominated in units of CO_2 and publishes exchange rates for covered GHGs, then it would not be possible for country B to refuse permits sold by country A firms to country B firms for gases not covered by country B. If, however, country A issues separate permits for different gases—as was proposed, for example in the American Clean Energy and Security Act (H.R. 2454) with its creation of a separate permit market for HFCs—then country B might choose not to accept permits for gases covered in country A but not country B.

Offsets

A similar issue arises with noncovered gases in both countries when these gases are allowed as offsets in one country but not the other. Methane emissions in the agricultural sector are an example of a gas that is commonly not covered by cap-and-trade systems but may be allowed in an offset program by some countries. If country A allows agricultural methane offset projects, whereas country B does not, country B will have to decide whether offsets can be applied to count against emissions in country B. For all practical purposes, country B will not be able to prevent the use of such offsets because if country B declares that offsets may not be applied against country B emissions, firm B1 in country B can purchase permits from firm A1 in country A, which in turn can replace its permits with offsets purchased from firm A2.

Upstream Versus Downstream Coverage

Nations implementing a cap-and-trade system have to determine whether to impose it upstream (on the production of fossil fuels), midstream (on industrial users), or downstream (on consumers). In general, the further upstream the system is imposed, the simpler the system and the broader the likely coverage. In any case, a nation can make a number of choices. For example, transportation can be included in a system either upstream, on the production of motor fuel, or midstream, on wholesalers or retailers.

Linking systems that are imposed at different stages in the production of emissions should not be a problem. For example, suppose that country A imposes its system upstream while country B imposes its system midstream. Midstream businesses in country B could purchase permits from upstream businesses in country A and vice versa.[6]

Auctioned Versus Freely Allocated Permits

Regions implementing a cap-and-trade regime have to choose whether to auction all or a portion of the permits or to allocate them freely. It is likely that nations or regions will make different choices and may change their choices over time. However, these choices should not

[6]Note that there is a serious problem with countries imposing a cap-and-trade system or tax in different places in the production cycle because traded products can be double taxed or not taxed at all. For example, if country A imposes a tax upstream and country B imposes a tax midstream, a product partially produced in country A and country B might face taxes in both or neither. This coordination problem, however, is not related to linking; it exists for both linked and nonlinked systems.

pose a barrier to linking systems because whether firms purchased permits or received them for free has no bearing on their market price or opportunity cost of use.[7]

Cost Containment Measures

Nations may take a number of measures designed to avoid unexpectedly sharp increases (and possibly decreases) in permit prices. Cost containment mechanisms include safety valves, price collars, borrowing and banking, and managed reserve systems.[8] If country A's cap-and-trade system has some form of cost containment, whereas country B's system does not, the cost containment may be transmitted through both systems. To illustrate, assume country A has a cap-and-trade system with a price collar limiting the price to range between L_A (floor) and H_A (ceiling). In the absence of any limits on trading, permit prices in country B will also range between L_A and H_A. Assume a very stringent system in country B that leads to high permit prices in the absence of linkage. If the systems are linked, then firms in country B will choose to cover their emissions by purchasing permits from firms in country A.

This situation can also lead to cross-country transfers. If country A sets a ceiling on its permit price and country B does not, when the ceiling is hit, covered emitters in B will effectively be able to purchase permits from the government of country A to avoid further emissions reductions. If country A's collar is equally spread around the expected permit price, this may not be a problem, at least *ex ante,* but if the ceiling is expected to be hit, such a price ceiling may reduce the incentive for country B to link with country A because of the expected transfers.

One mechanism that can limit this problem is to adjust the exchange rate for new permits issued pursuant to a ceiling or permits purchased pursuant to a floor. For example, if both countries have an equal number of permits that are exchanged on a one-to-one basis, but country A issues 20% more of its permits under its price ceiling, the exchange ratio can be adjusted to 1.2:1.

Countries would also have to decide how to handle borrowed permits in a banking and borrowing system or a managed reserve system (as described, for example in Murray, Newell, and Pizer 2009). Assume country A has a managed reserve system in which firms wish to borrow permits to reduce the current permit price. Country B does not have any mechanism in place to allow permit borrowing. Firms in country A would only wish to borrow permits from their managed reserve if country B's permit price in the absence of linking is higher than country A's price in the absence of borrowing. If this were not the case, then it would be

[7]This is true to a first-order approximation. Permits can be allocated in ways that distort markets. The American Clean Energy and Security Act (Waxman-Markey) as well as the American Power Act of 2010 (Kerry-Lieberman) allowed for output-based permit allocations in trade-affected industries. This amounts to a production subsidy and so reduces the opportunity cost of using permits.

[8]A safety valve prevents permit prices from exceeding a prespecified price by allowing the government to sell additional permits at that price. A price collar works similarly except that it imposes both a price limit and a price floor. Managed reserve systems try to achieve a similar goal of price stability through a flexible mechanism that allows the government to adjust the number of permits. Banking and borrowing allow permits issued for one period to be used in a different period. They reduce price fluctuations because if the current price is high, permits can be borrowed from the future and used now, and if the price is low, they can be banked. Newell, Pizer, and Zhang (2005) provide an analysis of many of these mechanisms .

cheaper for firms in country A to purchase permits from country B than to borrow against future allocations (which in most programs would have to be repaid with interest). Assume that is the case. In the absence of any limits on permit transfers between the two countries, country A's managed reserve becomes available to country B, leading to complete price harmonization across the two countries. As with a safety valve system, harmonization would be incomplete if limits were placed on the number of country A permits that could be used in country B.

Enforcement Mechanisms

Regions implementing cap-and-trade regimes will likely have different enforcement mechanisms, including monitoring, reporting, and verification systems as well as penalty systems. If a country has a weak enforcement system, this can affect the price of permits in a linked system and thus be a potentially serious barrier to linking.

To illustrate, suppose that country A has a weaker enforcement system than country B, and the two countries decide to link. The weak enforcement system in country A results in a lower permit price in that country, and when the two systems link, this lower permit price is transmitted to country B. If, in the extreme, country A has a very lax enforcement system so that emissions sources in country A can cheat at will, country A would in effect simply sell permits to firms in country B with no offsetting emission reductions in country A. If country A has a fixed number of permits, this simply adds those permits to the pool of permits for sources in country B. Thus enforcement is likely to be a central concern in linking systems, and for linkage to be attractive, countries will have to be convinced that potential linkage partners have comparable enforcement regimes.

Compliance Periods

Emissions control programs may differ in terms of compliance periods. Country A, for example, may issue permits that must be used within a three-year window, whereas country B may issue permits that must be used within a ten-year window. Given the stock nature of the pollutant, differences in compliance periods will have no impact on damages from emissions, and fully linked systems with different compliance periods would effectively lead to a uniform compliance period based on the longer of the two. If firms in country A wished to bank permits more than three years out, they could sell their own country permits to firms in country B and purchase country B permits, which have a longer compliance period. When the firm in country A wished to use the permits, it could exchange them with a firm in country B for permits that were released within the three-year window recognized by country A.[9]

It is not clear why countries would wish to set short compliance periods such that this became an issue. To the extent there is variation in compliance periods, linkage would effectively lead to harmonization of compliance periods tilted toward the longer period. This facilitates firms' planning and would likely contribute to the smooth operation of carbon markets.

[9]This assumes that country A would not accept permits from other systems that were released outside the compliance period.

One-Way Directly Linked Systems

The preceding discussion assumes two-way linkage. If only one of the two countries allows the use of permits from the other country's system, then we have a one-way linked system. Assume country A allows the use of permits from country B, but country B does not reciprocate. Linkage only leads to harmonization if country A has a more stringent cap than country B (in the sense that permit prices are higher in country A in the absence of linking). In this situation, a safety valve or some other cost containment feature in country A's cap-and-trade system has no impact on permit prices in country B. All of the issues that have been described concerning two-way linked systems also pertain here for the country that allows linking.

Linking Cap-and-Trade and Tax Systems

Although cap-and-trade systems have been favored in Europe and the United States, some countries or regions may prefer to implement carbon taxes. Scholars who have argued in favor of carbon taxes include Cooper (2006), Nordhaus (2007, 2008), Metcalf (2007, 2009a), and Metcalf and Weisbach (2009), among others.

To illustrate the linking of cap-and-trade and tax systems, assume country A has a cap-and-trade system and country B has a carbon tax. The two systems can be linked by allowing cap-and-trade permits to be remitted as payment for the tax and by allowing payment of taxes in excess of the tax otherwise due on emissions in country B to satisfy the requirement to own a permit. Specifically, a firm in country B could purchase country A permits and remit them in lieu of tax payments at the country B tax rate. Conversely, a firm in country B could remit carbon tax payments to its government in excess of its emissions and receive emission tax payment credits (ETPCs) for the tax payment in excess of emissions that could be sold to firms in country A, which could then use the ETPCs in place of permits for covered emissions.

In essence, we can think of a carbon tax as simply a permit system with a fixed price or a very narrow collar on its price. Linkage of a tax and a cap-and-trade system is then the same as linking a cap-and-trade system with another cap-and-trade system that has a price ceiling and floor. Firms could purchase country A permits for use in country B's tax/permit system and, conversely, firms could purchase permits from the government of country B (at the tax rate) and use those permits to satisfy their country A obligations. Credits in excess of carbon tax liability could be made refundable but more likely would be carried forward or backward as is the common practice in most countries.

However, it is hard to imagine that an unrestricted linking of these two types of systems would be politically acceptable because, in effect, unrestricted linking turns a cap-and-trade system into a tax. If permit prices in country A deviated from the tax rate in country B, there would be an incentive to buy or sell permits to push them back into parity. Consider the case where permit prices in country A are higher than the tax rate in country B. Demand for ETPCs in country B that are to be used to satisfy emissions in country A would be high and would drive permit prices down to the tax rate. Tax revenue, however, would flow to country B. If instead, permit prices in country A are lower than the tax rate in country B, firms in country A would have incentives to undertake additional abatement activities to free up permits to sell to firms in country B. This would drive up permit prices to the tax rate and in effect create a floor in country A's cap-and-trade system. It would also reduce revenue in the taxing country, a factor that limits the attractiveness of linking for country B.

The upshot is that if country A has chosen a cap-and-trade regime over a tax, linking to a country with a tax system would negate that choice. For example, if country A's goal was to have an absolute limit on emissions, that goal would be defeated by linking to a tax system because domestic industry could always increase its emissions by buying permits from country B. Similarly, a country with a tax may not be willing to accept an unlimited number of permits as payment of the tax (because doing so reduces tax revenues).

One way to mitigate this problem would be to restrict linkage to a set number of permits in a given period. For example, firms might be allowed to satisfy only a fixed percentage of their cap-and-trade obligations with ETPCs purchased from the other country.[10]

Finally, it is important to note that all of the issues discussed here concerning linking cap-and-trade systems, such as the permit base and enforcement rules, also apply to linking a tax and a cap-and-trade system.

Linking Through ERC Systems

ERC systems create a method of linking a country with a carbon price to a country without a price. For example, as noted earlier, the CDM mechanism links developing countries to a cap-and-trade system, the EU ETS. It is also possible to use an ERC system with tax systems. Firms in countries with carbon tax systems could submit ERCs as credit against their carbon tax liability, with the value of the credit equal to the tax rate times the number of tons of emission reductions represented by the credits.

All of the concerns we have discussed about CDMs (e.g., additionality) apply whether the credit system is linked with a cap-and-trade or a tax-based system. An additional concern is that ERCs used to reduce carbon tax payments have a direct impact on a country's fiscal budget, whereas the fiscal impact is less direct in a cap-and-trade system (and may in fact be immaterial if permits are freely allocated rather than auctioned). Thus ERCs can create opportunities and possibly problems for linking by two countries that both have a carbon price.

ERCs can be used to link countries' emission reduction systems directly or indirectly.

Direct Linkage

Countries without ERC systems can directly link to countries with ERC systems. This effectively incorporates the ERC system of one country with the cap-and-trade system of the other. For example, suppose countries A and B each have a cap-and-trade system, but A also has an ERC system with a third country. If countries A and B link, country A's ERC system becomes incorporated into country B's system. Concerns about the effectiveness of the ERCs might limit the attractiveness of linking to a country with an ERC system. That is, a country that chooses not to have an ERC system, say, because of concerns about additionality, might be equally unwilling to link to a country that has an ERC system.

[10]More generally, country A could have a sliding scale whereby their permit liability could be satisfied with a certain percentage of ETPCs at par, an incremental percentage at a given discount, and higher increments at higher discounts up to some limit.

Indirect Linkage

Countries may choose not to link their tax or cap-and-trade systems directly but could instead link them indirectly through engagement with countries with ERC systems. Consider two countries with cap-and-trade systems that are not linked but that have an ERC system with the same third country. ERCs would presumably flow to the country with the higher permit price, and, over time, permit prices would equilibrate unless there were limitations on the amount of credit offsets allowed by the higher priced country.

Indirect linkage may, but need not, lead to price harmonization in two indirectly linked countries, one of which uses a cap-and-trade system (country A) and the other a tax (country B). If the permit price in country A exceeds the tax rate in country B, emission reduction credits would flow to country A and put downward pressure on permit prices in that country. Assuming no limit on the use of emission reduction credits, permit prices would fall to the level of the tax rate in country B. At that point, firms in the third country, which has an ERC system, would be indifferent between selling emission reduction credits to firms in country A or country B.

A similar story holds if the tax rate in country B exceeds the price of permits in country A. In this case, ERCs would flow to country B but would have no effect on the tax rate. The diversion of permits from country A (in the form of ERCs) to country B would put upward pressure on permit prices in country A.

Linking Market-Based Systems with Regulatory Regimes

Linking market-based systems with regulatory-based systems may be possible depending on the form of regulation under consideration. Hahn and Stavins (1999) consider linkage between cap-and-trade systems and a fixed quantity standard. We consider three possible regulatory approaches: quantity standards, intensity standards, and technology mandates.

Quantity Standards

Quantity standards may take the form of firm-specific caps on emissions with no provision for trading among covered firms. In this case, caps might be a "bubble," building on the use of such bubbles by the U.S. Environmental Protection Agency for air quality management in the late 1970s, where a manufacturer with multiple plants might be required to cut overall emissions by a given amount but have the freedom to choose where to make the cuts. Alternatively, the standard might take the form of a requirement of a uniform percentage reduction in emissions across all firms (or plants). Either way, the marginal cost of abatement is unlikely to be equalized across emitters.

Quantity standards can be linked to either a cap-and-trade or tax system. Assume country A imposes a quantity standard in the form of a fixed emissions cap at the firm level, whereas country B relies on a cap-and-trade system or tax. Furthermore, let the tax rate or permit price equal p in country B. Firms subject to the quantity restriction in country A that have marginal abatement cost greater than p would prefer to undertake emission reduction activities in country B if those activities could count toward their quantity cap. To further illustrate this point, imagine that a firm with historic emissions of 100 tons of CO_2 per year now faces a firm-specific annual cap of 60 tons. A linked system would allow the firm to continue to release 100 tons of CO_2 if it submitted permits (or ERCs) purchased from a firm in country B, which is subject to a cap-and-trade system (or ETPCs from a country with a carbon tax), representing 40 tons of emission reductions in country B.[11] A similar scheme could be undertaken to link country A's quantity standard with a country that has an ERC system. Linking quantity standards to a cap-and-trade, tax, or ERC system will tend to equalize the shadow price of emissions reductions in country A and increase the efficiency of its regulatory system.

Two-way linkage is possible if those firms in country A that are subject to a quantity restriction can receive ERCs for emission reductions in excess of their required reduction. Similar to ETPCs in a carbon tax system, firms would receive ERCs for the difference between their allowed and actual emissions. Those credits could then be sold to firms in country B that are subject to a cap-and-trade system or carbon tax. Trade in this direction would be desirable if the marginal cost of emissions reductions for the firm in country A is below the permit price (or tax rate) in country B.

Even though it is inefficient, countries may choose to create a regulatory approach that caps emissions but does not allow within-country trading to equalize the marginal costs of abatement, because institutions to support emissions trading may not be sufficiently robust to allow competitive trading. Political opposition to trading may also preclude this efficiency-enhancing policy option.

One benefit of allowing two-way linking with trading systems in another country (or countries) is that the trading will serve to reduce the dispersion in marginal abatement costs among firms in country A. However, this also entails the cost of monitoring and verifying emissions reductions in a foreign country, where the country with a quantity standard relies on monitoring and enforcement in the linked country that has a carbon price.

Conversely, a country with a carbon price that links to a country with a quantity standard would have to ensure that the emissions reductions claimed by low marginal abatement cost firms would not have happened anyway. This raises the possibility of gaming, which may make two-way linking with a country that has quantity caps problematic. Imagine that country A sets firm-specific quantity caps that are a reduction from a baseline that assumes future economic growth. The caps might allow emissions in excess of current emissions. In this case, the country has an incentive to set the cap as high as possible, knowing that emissions reductions in excess of those mandated by the cap can be sold in carbon markets in those countries with which country A is linked. This issue is eliminated with one-way linking, in which permits may only be used to help reach quantity targets.

Intensity Standards

Intensity standards are targets specified as emissions per dollar of gross domestic product (GDP) (or some other measure of economic activity).[12] One attraction of an intensity target is that it sets restrictions on emissions while allowing countries to experience economic

[11]This system can easily be extended to a country applying a percentage reduction regulation.

[12]Intensity targets have been studied by Ellerman and Wing (2003), Pizer (2005), Jotzo and Pezzy (2007), and Newell and Pizer (2008), among others.

growth. Thus intensity targets may be an attractive option for developing countries, which are likely to place a higher priority on growth than emissions reductions.

Like uniform percentage reduction regulations, intensity standards can be translated into specific caps on emissions (given GDP). For example, if a country sets an intensity standard at the national level, it will have to establish quantity standards or some other form of regulation to ensure that national emissions relative to GDP do not exceed the target. Alternatively, a country may set an intensity target in terms of emissions per unit of output or dollar of sales for individual firms. Either way, the firm-specific standard can be translated into a quantity regulation, and the mechanisms that have been described here concerning quantity standards can then be applied to link to other countries' trading or tax systems.

Technology Mandates

Some countries may mandate specific technologies to reduce GHGs. A country might, for example, choose to prohibit the siting of new coal-fired electric generating plants in the absence of carbon capture and sequestration. Or it may mandate that power in a particular region be produced by a specified portfolio of sources. Or it may require trucks and automobiles to have a specified efficiency. This type of regulatory policy is more difficult to link to GHG programs in other countries because of the problem of additionality (i.e., identifying the counterfactual). For example, consider a firm that builds a natural gas power plant in a country with such a technology mandate. In the absence of the technology mandate, would the firm have built the natural gas power plant or a coal-fired power plant?

Let us assume for the moment that we can solve the additionality problem (a nontrivial assumption) and the firm can reasonably argue that it would have built a coal plant in the absence of this technology mandate. To determine if linkage would be attractive, we have to estimate the amount of CO_2 that has been saved by the substitution of the gas-fired for the coal-fired power plant. This can be done either on a plant-by-plant basis or at the national (or international) level in terms of the emissions savings from this mandate per megawatt of capacity. Once the emission differential between coal and gas has been determined, then one-way linkage is feasible. A country with a technology mandate that disallows coal construction might allow the construction of a coal-fired power plant if the builder were to submit sufficient allowances (or ERCs) from another country to cover the additional emissions that would result from the construction of the coal-fired facility.

However, one-way linkage of this form seems unrealistic for a number of reasons. First, we might expect regulatory approaches in the form of technology mandates to be more prevalent in developing countries where markets are insufficiently developed for the country to rely on a market-based approach. But the linkage that has been described here is a reverse-CDM project that leads to money flowing *out* of the developing country. Second, countries implementing technology mandates may impose the mandates for multiple reasons. A decision by China, for example, to ban coal-fired power plants might arise more from a concern about local air quality than from climate change considerations.

Linkage in the other direction is also possible for some technology mandates. Consider a CAFE type mandate on motor vehicle fleet efficiency. Assume, for example, that the Shanghai Automotive Industry Corporation (SAIC), China's largest auto manufacturer, achieves a fleet efficiency that exceeds the mandated efficiency by 2 miles per gallon.[13] Based on agreed-upon assumptions about vehicle miles traveled over the life of the car, the higher fuel efficiency could generate ERCs for SAIC that it could sell to firms in other countries.[14] Similarly, manufacturing decisions to produce appliances that exceed mandated appliance standards might generate marketable ERCs. The gaming issue that arises here with lax mandates is similar to the one described earlier concerning quantity standards.

Full harmonization in linked programs occurs when the marginal cost of abatement for GHGs is equalized across countries. Although it is unlikely that full harmonization would occur when countries relying on regulation to reduce GHGs link to countries relying on market-based approaches, the difference in marginal abatement costs will likely be narrow.

Linkage of regulatory systems raises many of the additionality and measurement difficulties of the current CDM structure. Focusing on opportunities such as the SAIC example is in the spirit of a recommendation made by Victor (2007) to focus on bilateral agreements on emissions reductions at a sectoral level, which have more bang for the administrative buck than the current CDM approach.

Linking with Countries That Take No Action

The only linkage opportunity available for countries that implement no measures to reduce GHG emissions is through an ERC system like the Kyoto Protocol's CDM mechanism. However, as time progresses, we expect that few major emitting countries will fall into this category. Major emitting countries in the developing world either have implemented or are likely to implement some form of regulation. Although the regulations may be aimed at other goals (e.g., reducing local pollution or gasoline consumption), they will have an ancillary benefit of reducing GHG emissions. Whether the measures taken will be sufficiently stringent to effect a substantial reduction in emissions is unclear. But these measures certainly form the basis for linkage to occur.

Conclusions

If the post-Kyoto climate policy architecture that emerges includes multiple approaches to controlling GHG emissions, linking can play an important role in lowering the overall costs of emissions reductions, reducing price volatility in cap-and-trade systems, increasing market liquidity, and reducing the potential for market power. Linking heterogeneous systems, however, will be difficult because policy choices in one system may affect the other linked system. Moreover, poorly designed linkage schemes could strain international agreements if the shadow price of emissions varies widely across countries.

[13]According to Bradsher (2009), Chinese experts estimate that new cars in China get nearly 36 mpg and that new regulations will increase fuel efficiency to over 42 mpg by 2015.
[14]This essentially describes how higher fuel efficiency might be the basis for a CDM project under the Kyoto Protocol.

Linkage problems can be reduced to the extent that different control systems harmonize *ex ante* on a desired price for GHG emissions. One option would be for countries to agree to a price band on emissions. For market-based systems, this would mean setting tax rates within a band (that would grow over time at some agreed-upon rate or schedule) or creating allowance allocations that lead to allowance prices trading within the specified band. For countries taking a nonmarket-oriented regulatory approach, there is no observable price, but a shadow price of the regulations would be the appropriate analogue.

If countries do not agree at some broad level on an appropriate price path (or band) for emissions, then linkage would bring about partial or full convergence of prices. However, it would do so at increasing political cost because financial transfers across borders would strain the international emissions control architecture.

In the absence of formal linkage systems, trade flows and movements in carbon-intensive activities from high- to low-price countries (i.e., leakage) will create a de facto linkage system. That is, to some extent, prices will converge toward the lowest price among significant carbon-emitting countries, and that price is unlikely to be zero. Enough co-benefits, in the form of reduced air and water pollution, arise with reductions in GHGs to ensure that the shadow price on emissions will be positive. Unfortunately, this price is unlikely to be high enough to bring about a sufficient reduction in emissions to ensure that we avoid unacceptable buildups in atmospheric GHG concentrations by the end of this century.

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