To link or not to link: benefits and disadvantages of linking cap-and-trade systems

CHRISTIAN FLACHSLAND*, ROBERT MARSCHINSKI, OTTMAR EDENHOFER

Potsdam Institute for Climate Impact Research, PO Box 601203, 14412 Potsdam, Germany
*Corresponding author. *Email*: Christian.Flachsland@pik-potsdam.de

ABSTRACT
A framework was devised for policy-makers to assess direct bilateral cap-and-trade linkages. A systematic analysis of the economic, political and regulatory implications indicates potential benefits along with a number of potentially negative side effects. Theoretically, economic benefits are expected from quasi-static short-term and dynamic efficiency gains. However, a careful review of these arguments indicates that, due to the presence of market distortions or terms-of-trade effects, international emissions trading may not be welfare-enhancing for all countries. Political benefits are derived from the reinforced commitment to international climate policy and the elimination of competitiveness concerns among linking partners, but this must be weighed against the possible incentive to adjust national caps in anticipation of linking. Regulatory disadvantages may arise from the linked system's inconsistency with original domestic policy objectives, and from the partial de facto cession of discretionary control over the domestic emissions trading system. Finally, as an illustration, a link between the EU ETS and a prospective US trading system is assessed, and the major trade-offs identified.

Keywords: carbon markets; climate policy; domestic emissions trading systems; emissions trading; EU ETS; linking; US ETS

1. Introduction

After the initiation of the EU Emission Trading Scheme (EU ETS) in 2005, several cap-and-trade systems are now emerging world-wide, e.g. in the USA, Australia, New Zealand, Canada, Japan and Switzerland.[1] Direct bilateral links between regional cap-and-trade systems have been proposed as one option to strengthen economic efficiency and politically reinforce the international emissions trading regime (e.g. Stern, 2007, 2008; Edenhofer et al., 2008; Garnaut, 2008).[2] Others, however, have emphasized the considerable political and regulatory challenges that this would entail (e.g. Egenhofer, 2007; Victor, 2007; McKibbin et al., 2008). The objective of this article is to develop a framework for comprehensively assessing - from a policy-maker's point of view - the expected benefits and drawbacks of a link between two cap-and-trade systems.

We find that the major expected benefits from linking are economic and political in nature. Static efficiency gains derive from enabling trade across systems with different pre-link allowance prices, from increased market liquidity, and the reduced volatility. Inasmuch as linking creates an institutional lock-in on a jointly agreed reduction schedule, it also enhances the dynamic efficiency of climate policy. In political terms, linking can serve as a signal of commitment to close international cooperation. Links across OECD cap-and-trade systems - e.g. a transatlantic EU-US link (EU Commission, 2009) - can become important test cases for further carbon-market-based cooperative climate policy between developed and developing countries.

On the other hand, linking also involves a number of potential economic, political and regulatory caveats. For some countries, negative distortionary or terms-of-trade effects may outweigh the efficiency gains from enabling international emissions trade. There are also some economic distributional questions about how efficiency gains are shared between linking partners, potential losses of cobenefits associated with emissions abatement, and whether linking could introduce a perverse incentive for allowance sellers to relax their cap. The greater openness of a linked trading system also implies a higher exposure to market shocks. From a political perspective, the important normative question arises of whether linking partners mutually accept their effort level, i.e. their reduction schedules. In terms of regulatory consequences, unfettered linking entails a 'mixing' of system designs, which can turn into a disadvantage if it leads to a 'washing out' of any of the two systems' original policy priorities. Finally, linking also limits the scope for regulatory interventions of the single systems.

In a policy application based on these arguments, we identify the major trade-offs that policymakers face when considering a specific link between the EU ETS and a US cap-and-trade system along the lines of the Waxman-Markey proposal (Waxman and Markey, 2009). In the face of limited knowledge about the prospective efficiency gains and negligible benefits from the increased market size, the political signal for international and domestic climate policy, and the effect as a commitment mechanism appear as the most tangible benefits of a transatlantic link. These benefits need to be weighed against the potential conflict over the relative priority of cost containment versus environmental effectiveness, and the loss of unilateral control over the domestic carbon market.

The following sections analyse the economic (Section 2), political (Section 3) and regulatory (Section 4) implications of linking. In Section 5 we apply these theoretical findings to the case of a link between the EU ETS and a US ETS along the lines of the Waxman-Markey proposal. Section 6 contains the conclusions.

2. Economic implications

Three types of economic implications are considered: (i) quasi-static, short-term efficiency gains, (ii) dynamic efficiency gains, and (iii) distributional effects. A series of counter-arguments against the conventional gains-from-trade rationale are discussed. In this context, the economic benefits of linking are not as clear-cut as they may seem.

2.1. Short-term efficiency gains

The basic rationale for linking cap-and-trade systems is that significant efficiency gains can be realized when permit prices (implicitly: marginal abatement costs) across schemes are equalized through trade (e.g. UNCTAD, 1992; Chichilnisky and Heal, 1995; Edenhofer et al., 2007), with a greater pre-link difference in the allowance price leading - ceteris paribus - to a greater benefit from linking. In standard partial equilibrium analysis (e.g. Anger, 2008), linking will always be a Pareto improvement, i.e. no system will be worse off after linking than it was before.

Quantitative estimates for the expected efficiency gains from international emissions trading were first created in the context of the Kyoto Protocol (e.g. Weyant and Hill, 1999). Typical results from these modelling studies suggest cost savings of about 50% for Annex-I only trade, and up to 75% for the case of global permit trade. However, few such computations have so far been carried out for post-Kyoto climate policy. As one exception, Russ et al. (2009) assume a policy scenario in line with current EU objectives,[3] and - after applying two different types of models - conclude that a global carbon market with trade across all countries and sectors would halve the abatement costs compared with the no-trade case.

While confirming the basic rationale for linking carbon markets, these analyses of large trading coalitions are not tailored to situations where policy-makers have to decide on a link between two given trading systems. As an exception, Carbone et al. (2009) choose a game-theoretic approach and systematically assess the bilateral linking option with a general equilibrium model calibrated on the base year 2015. They generally find large benefits only for linkages between asymmetric countries, with the highest global and EU welfare gains occurring for the case of an EU-China link. This would enable the EU to take advantage of China's low-cost abatement options, and would allow China to benefit from selling permits.

However, as a principal objection to the conventional gains-from-trade analyses, it should be questioned whether the latter's implicit assumption of a 'first-best' world, i.e. one without market imperfections such as distorting taxes or externalities, does not lead to an overly optimistic and misleadingly clear-cut view on linking. Generally speaking, the theory of the second-best (Lipsey and Lancaster, 1956) states that optimality conditions that hold in a first-best world may no longer be valid in a second-best world, i.e. one characterized by distortions. In the context of climate policy, pre-existing energy taxes and/ or fuel subsidies, as well as uncompetitive energy markets, suggest a second-best scenario.

Hence the standard prescription of an 'equalization of permit prices' may cease to be optimal in some cases or - worse - could even become harmful.

As a simple example, assume that - for instance, due to market power in the permit market - the one-to-one correspondence between marginal abatement costs and permit prices is lost. Evidently, emissions trading cannot yield an efficient outcome under such conditions. More formally, Babiker et al. (2004) and Paltsev et al. (2007) have shown that an increase in carbon prices due to emissions trading can reinforce pre-existing distortions associated with inefficiently high fuel taxes - up to the point where the corresponding welfare losses outweigh the primary gains from emissions trade. In a similar vein, McKibbin et al. (1999) demonstrate how a country may become subject to falling terms-of-trade after engaging in international emissions trading.

Another reason why partial equilibrium analysis may overestimate the efficiency gains from linking is its neglect of adjustments in relative prices via international trade in goods. In fact, as one of the pillars of trade economics, the factor price equalization theorem (Samuelson, 1949) states the conditions under which efficiency is guaranteed even if production factors (e.g. emissions allowances) are not internationally traded. The relevance of this insight for climate policy and the resulting redundancy of emissions trading has been emphasized by Copeland and Taylor (2005). Admittedly, for the theorem to hold strictly, a set of rather restrictive assumptions is required, but the underlying mechanism will also work - albeit in a weakened form - in a less idealized context. Obviously, there are several other non-traded inputs, such as labour and energy, which have different prices across regions, without a perceived urgent need to have 'one price' for these.

Finally, a side-benefit of linking consists of the creation of a larger carbon market, with more players and allowances and thus higher liquidity, which can particularly benefit smaller systems.[4] Moreover, price shocks within one system will be absorbed and cushioned within a larger overall market. However, from a single system's point of view this implies that, as a downside, volatility from other systems might be imported (McKibbin et al., 2008). As a consequence, the overall economic effect remains ambiguous: the benefits of spreading domestic price volatility over a larger market needs to be weighed against the costs of imported additional volatility.

2.2. Dynamic efficiency

Basic economic theory holds that the implementation of an ambitious climate policy creates a time-inconsistency problem for a government with limited commitment power (Kydland and Prescott, 1977). Intertemporal economic efficiency breaks down when firms suspect that the government will loosen climate policy once sufficient private investments into low-carbon technology have materialized. Hence, firms do not invest the optimal amount in the first place (Helm et al., 2005; Montgomery and Smith, 2007).

Drawing on Putnam (1988), we argue that internationally linked cap-and-trade systems are less prone to the lure of discretionary policy than systems in autarky, due to mutual pressure among linking partners not to relax emission caps, e.g. relative to some long-term schedule.[5] As a consequence, linked systems can establish a more credible price signal, and improve the dynamic efficiency of their climate policy. Admittedly, such pressure will also exist in the absence of linkages; however, only a linked carbon market provides some kind of sanctioning mechanism, such as trade restrictions (Rehdanz and Tol, 2005), or complete de-linking. When justifying national caps vis-à-vis domestic stakeholders, national policy-makers can point to this international pressure, claiming that it 'ties their hands' to some extent.

Evidence of this mechanism could be observed in negotiations over the Phase I National Allocation Plans (NAP) in the EU ETS: on the basis of a pre-announced formula, the EU Commission successfully rejected several national allocation plans in which countries had endowed themselves with generous allocations (Zapfel, 2007). As pointed out by Ellerman et al. (2007, p.350), the possibility of 'blaming' the EU Commission as an institution representing some greater good sometimes helped to justify the adoption of unpopular decisions vis-à-vis the domestic constituency. In this sense, the multilateral architecture of the EU ETS helped to uphold the environmental ambition of the system.

2.3. Distributional considerations

Three types of distributional questions arise in the context of linking. The first, and most obvious, concerns the distribution of the short-term efficiency gains expected from linking. As illustrated in Figure 1, in a partial equilibrium setting the region with the steeper marginal abatement cost (MAC, here assumed to be linear) curve will always obtain the largest share of the total benefits from trading. This is simply because the shift in abatement activity (depicted on the x-axis) is identical for both regions, leaving the relative size of the areas X and Y - which represent the gains from trade - to depend only on the steepness of the MAC curves. Given that the EU abatement cost curve is widely perceived as relatively steep (see, e.g., Weyant and Hill, 1999; Viguier et al., 2003), this may help explain the European Union's keenness on linking (EU Commission, 2009).

The second distributional aspect relates to the ancillary benefits associated with emission abatement, which include reduced local air pollution, increased energy security due to reduced dependency from fossil fuel imports, encouragement of R&D, and the general economic stimulus

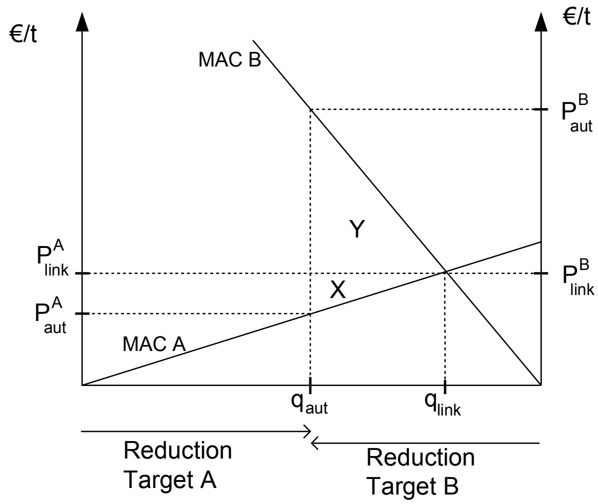

FIGURE 1 Distribution of efficiency gains when linking two cap-and-trade systems

Note: If marginal abatement cost (MAC) curves are linear, the system with the steeper MAC curve-here system B-always obtains more benefits from linking, i.e. we have Y>X

that goes along with low-carbon investments (e.g. Westskog, 2002). If linking leads to a substantial outsourcing of abatement to other regions, these co-benefits - which are not internalized in the allowance price - will be lost. Considerations of this type may carry some weight in the perception of policy-makers and the public (see, e.g., California, 2007), in particular if linking is expected to significantly shift domestic abatement abroad. Unfortunately, a balanced appraisal of this argument is impeded by the fact that these ancillary benefits are 'external' to emission abatement, and hence not easily quantifiable in economic terms. However, such co-benefits will usually be addressed by additional targeted policy instruments, e.g. air pollution standards.

Third, and finally, game-theoretic approaches have analysed whether and how the prospect of a linked carbon market creates an incentive for regions to adjust their allowance endowment, i.e. emissions cap, so as to increase their expected benefits from linking. For instance, using a standard emissions game framework, Helm (2003) found that linking creates an incentive for permit sellers (low-damage countries) to relax their cap in order to sell even more permits. Since, in compensation, permit buyers (high-damage countries) tend to choose fewer allowances, linking creates a distributional shift in favour of the seller countries. However, with appropriate instruments, in particular import quotas, buyers can contain the sellers' expansionary tendencies (Rehdanz and Tol, 2005). The picture changes when players are assumed to anticipate the impact of their quota allocation on international markets for goods and allowances (Carbone et al., 2009): in line with oligopolistic behaviour, the incentive of net permit sellers to raise permit prices by increasing the stringency of their cap can outweigh the incentive to relax the cap.

Arguing less formally, it can be expected that the incentive to relax caps when linking will be weakened for several reasons: the potential reputational damage, the threat of import quotas or other penalties, and the fact that linking partners could defect from cooperation in other policy areas as well. In any case, to make the choice of allowances assessable and transparent, mid- to long-term cap schedules should be defined prior to linking.

3. Political implications

We find that linking has three distinct political implications: an ambivalent effect on the international climate policy agenda, facilitating the acceptance of climate policy at the domestic level, and, third, it can work as a signalling mechanism in the context of global burden-sharing.

First of all, linking represents an instrument of international cooperation and, as such, signals a commitment to long-term climate policy and multilateralism. However, it has an ambivalent impact on the UNFCCC process, as linking could be seen both as a complement or substitute thereof (Flachsland et al., 2009): as far as linking confirms the framing of climate change as a global issue and demonstrates how climate policy can be implemented in an efficient way, it can help to reinforce the UNFCCC process and accelerate the adoption of mid- to long-term climate policy targets. But linking may also be seen as weakening the UNFCCC, by breaking its political monopoly and providing a viable back-up option in case the negotiations fail or drag on too long.

Second, inasmuch as linking is seen as an effective means to address the politically sensitive issue of competitive distortions between countries with different prices of carbon (e.g. Houser et al., 2007; Reinaud, 2009), it can facilitate the acceptance of climate policy among domestic business actors and the general public. The relevance of this point is manifest in business and labour associations' calls to 'level the carbon playing field' (e.g. BDI, 2008; Blue Green Alliance, 2009), emphasizing the importance of harmonizing carbon prices among major international competitors. Evidently, linking offers no remedy against the competitive super-advantage of third countries without any price on emissions at all, such as China, which might constitute the more serious problem.[6]

Third, linking constitutes a way of signalling approval towards other systems' underlying level of effort. Conversely, a linking offer could be declined - despite the tempting efficiency gains - if the prospective linking partner's efforts are perceived to be unacceptably low. As an example, consider the option of linking the EU ETS and the RGGI system: even though cost savings would be expected, it is hard to imagine the EU agreeing to link to a system, which would - thanks to its overallocation[7] - sell 'hot air' allowances into the EU ETS. The implicit endorsement of the low level of ambition of RGGI would be in contradiction with the European Union's official climate policy goals.

While the development of a common metric for comparing different 'levels of effort' in climate policy remains a complicated and unresolved issue (see den Elzen et al., 2008), it is obvious that the linking of emissions trading systems forms part of a general meta-game on the burden-sharing of global emission control. Thus, the assessment of a linking option might be determined more by questions of fairness in the level of effort than by who will become net seller or buyer. From this point of view, a UNFCCC-administered agreement on international burden-sharing that takes into account the principle of comparable but differentiated efforts (UNFCCC, 2008) would eliminate a potential barrier to linking trading systems.

4. Regulatory implications

Several authors have emphasized the regulatory challenges involved in the linking of regional cap-and-trade systems (Egenhofer, 2007; Victor, 2007). Below, we argue that design differences between to-be-linked trading systems are problematic only insofar as they imply a conflict over policy priorities. In addition, we discuss the implications of the loss of regulatory flexibility which each system incurs due to linking.

4.1. Conflicting policy objectives

To ensure the proper functioning of a linked system, some basic design features require harmonization; namely the provisions for monitoring, reporting and verification (MRV) of emissions, enforcement and penalty mechanisms, and the registry system (e.g. Sterk et al., 2006; Jaffe and Stavins, 2007; Mace et al., 2008). Beyond these fundamentals, linking will generally lead to a 'mixing' of system designs (Tuerk et al., 2009a), which may create a conflict if the resulting 'mix' happens to be too much out of line with the system's original policy priorities. To illustrate this point, consider first the following four policy objectives which can be associated with an ETS:

1. *Reducing GHG emissions*: The very reason why cap-and-trade systems are introduced is to achieve a specific emission reduction.
2. *Supplementarity*: Four reasons are commonly cited for why a certain share of abatement should be realized at home (see, e.g., Westskog, 2002): (i) the need to demonstrate leadership, particularly vis-à-vis developing countries; (ii) the co-benefit of reduced air pollution; (iii) the co-benefit of reduced dependency on fossil fuel imports; and (iv) the co-benefit of creating an internationally competitive domestic industry in the field of low-carbon technology.
3. *Inducing technological change*: Only a stable and sufficiently high price of carbon is expected to induce (via R&D) the technological change that is essential for making climate stabilization economically feasible (Edenhofer et al., 2006).
4. *Cost minimization*: Overall costs associated with climate policy, particularly reduction targets, should be kept at a minimum.

These - and possibly more - policy objectives can be promoted by choosing the design parameters of an ETS appropriately. For instance, consider the following five design features,[8] and how their setting relates to the above policy objectives:

1. *Emission reduction target*: A more stringent reduction target increases the amount of required overall abatement and thus increases the permit price.
2. *Price cap*: This places an upper limit on the permit price and, thereby, also on total abatement costs. On reaching the price cap level, additional allowances are issued,

leading to more emissions than originally envisaged (Jacoby and Ellerman, 2004). Clearly, the lower the price cap, the more likely its activation becomes.

3. *Price floor*: A price floor, by contrast, guarantees a minimum price for emission allowances. If this mechanism is triggered, which is more likely if the price floor is set to a high level, the government contracts the volume of marketable allowances, thus leading to less emissions than originally envisaged (Grubb, 2009).
4. *Restrictions on credits*: A limit on importable credits - in particular from the CDM - implies that relatively more abatement has to be achieved at home, which can raise the allowance price.[9]
5. *Borrowing*: We assume that the possibility of borrowing permits from future commitment periods induces a downward pressure on current prices. There are concerns, however, about a possible relaxation of future reduction targets, if - due to heavy borrowing in early periods - permit prices eventually rise to unacceptably high levels (Boemare and Quirion, 2002; Australian Government, 2008, pp.8-15).

Table 1 summarizes the functional relationships between policy objectives and ETS design features, and highlights how the setting of some parameters necessarily involves a trade-off between the

TABLE 1 Functional relationship between ETS design parameter and policy objectives

		ETS PARAMETERS				
		Reduction target	**Level of price cap**	**Level of price floor**	**Credit (e.g. CDM) import restriction**	**Borrowing**
POLICY OBJECTIVES	**Promote emission reduction**	**Ambitious target**	**High level**	**High level**	**Indifferent (restrict if concerns about additionality)**	**Restrict**
	Promote *domestic* abatement	**Indifferent**	**Indifferent**	**Indifferent**	**Restrict imports**	**Indifferent**
	Induce technological change	**Ambitious target**	**High level**	**High level**	**Restrict imports**	**Restrict**
	Minimize costs	**Modest target**	**Low level**	**Low level**	**Allow unrestricted use**	**Allow**

Note: ETS design parameters (vertical columns) and policy objectives (horizontal rows). The presence of **bold** and *italic* type with the same columns signals an inherent goal conflict in the setting of the respective parameter: for example, credit imports should be restricted to promote domestic abatement, but should remain unrestricted in order to lower abatement costs.

different policy objectives. For instance, a price cap helps to confine abatement costs, but may compromise the stimulation of technological change. If, and at what level, the price cap will eventually be set becomes a question of which of the two involved policy goals prevails. Therefore, implementing an ETS and setting its design parameters forces policy-makers to prioritize (at least implicitly) some policy objectives over others.

This issue comes into play whenever two systems with different policy priorities engage in linking: when establishing the link, the overall system's properties will become a 'mix' of the single system's features. This 'mix', however, might undermine the original priority ranking of one or both of the regions. For example, consider a system with a high priority on cost minimization and thus without restrictions on CDM-like credit imports, and with a price cap at some intermediate level. Another system, the prospective linking partner, puts a higher priority on substantial emission cuts and therefore has no price cap, and some quantity restriction on CDM credits. If the two systems engage in joined trading without further provisions, the newly established linked system - de facto - features a global price cap and an unrestricted inflow of CDM credits. Thus, one linking partner would experience a dilution of its original policy objectives, which might induce it to opt out of the linking project.

4.2. Reduced control and regulatory flexibility

From the point of view of the single country or region, linking implies that part of the formerly exclusive control and authority over the carbon market is ceded (Jaffe and Stavins, 2008). Smaller schemes, for instance, will experience a one-sided convergence towards the larger partner's permit price. But even smaller systems may strongly affect the overall market behaviour by exporting some of their ETS design features ('contagiousness'): for example, price caps in one system automatically propagate throughout the entire linked market. Moreover, under joined trading, price shocks originating in one region will affect the entire market, thus increasing the domestic economy's exposure to external factors (McKibbin et al., 2008).[10]

Especially in view of the latter, the question arises whether a joint regulation of the carbon market can at all times optimally serve the individual needs of each linking partner. In fact, inasmuch as their economies remain idiosyncratic, it might be preferable for each country to be able to respond to temporary shocks (e.g. business cycle related) independently, for example through an adaptive setting of price corridors, or a temporary modification of banking and borrowing rules.[11] Somewhat analogous to the theory of optimum currency areas (Krugman and Obstfeld, 2000), linking involves a trade-off between increased overall efficiency and reduced leeway for regulatory interventions. On economic grounds, the net effect can be expected to be positive whenever the expected efficiency gains are large and price shocks arrive to some extent simultaneously, which would be the case if the economies of the two prospective linking partners, in particular their emission-intensive energy sectors, are already strongly integrated.

As a general point, the imminent concerns about the loss of full domestic control over the carbon market imply that adequate joint governance arrangements and mutual trust constitute an important prerequisite for any linking project (on institutional arrangements when linking, see Mehling and Haites, 2009; Tuerk et al., 2009a).

5. Policy application: benefits and disbenefits of a transatlantic link

Along the lines of our analytical framework, we now discuss the prospects of a link between the EU ETS and a future US cap-and-trade system as defined by the Waxman-Markey (WM) proposal.[12] For brevity, we do not exhaustively address all of the issues mentioned above, but instead highlight the key points.

First of all, perhaps the most high-profile question regarding the expected efficiency gain from linking remains largely undeterminable, given the lack of quantitative studies on the subject. However, the widespread assumption (e.g. Weyant and Hill, 1999; Viguier et al., 2003) that the marginal abatement cost curve of the EU is steeper than that of the USA, would imply that such gains can indeed be expected.[13] On the other hand, assuming a higher allowance price in the EU ETS, the resulting shift of abatement from the EU to the USA would also lead to a redistribution of the co-benefits from abatement in the same direction. One could then point to the EU's currently high tolerance towards large CDM credit imports as an indicator that this would nevertheless be acceptable. Also, additional policy objectives such as reduction of air pollution are often addressed by complementary policy instruments, e.g. the IPPC Directive in the European Union (European Union, 2008).

As a positive economic effect, linking can be expected to help climate policy to consolidate its status as 'irreversible' in both regions, spur additional R&D, and thus improve the dynamic efficiency of climate policy. However, specific numbers are - again - elusive. As the final aspect on the economic side, the benefits from increased market liquidity do not loom large in view of each system's large individual size.

The second aspect, the political implications of linking, might very well be the category where the largest benefits from a transatlantic link would materialize. A joint commitment by the two largest integrated economic areas in the world would send a strong political signal, and could become a first step towards a closer cooperation with major developing countries. In fact, an EU-US carbon market could serve as the test case for the engagement of China, India and other developing countries, which remains the sine qua non for resolving the problem of global climate change. In addition, appeasing concerns about unfair competitive conditions by harmonizing carbon prices across the fairly close trading partners EU and the USA will certainly boost the general acceptance of carbon pricing in both regions, even if the actual economic relevance may be less certain.

Third, in terms of regulatory issues[14] the EU ETS design reflects a strong preference for achieving the environmental target, and abstains from price control mechanisms that may alter the cap. The WM proposal, by contrast, places a higher weight on avoiding excessive costs, allowing - under certain conditions - the auctioning of additional allowances from a reserve pool. Another key difference concerns the treatment of credits from offset programmes: the WM proposal foresees the use of international credits from measures reducing emissions from deforestation and forest degradation (REDD), which is ruled out in the EU ETS. Also, MW uses a discount factor of 20% in the accounting of all credits. From the EU's point of view, accepting a price control and REDD credits would constitute the most controversial issue, while the USA might be reluctant to accept the EU's 100% recognition of credits.

Finally, given the clearly stated desire of EU policy-makers to link the EU ETS to other schemes (e.g. Steinmeier and Gabriel, 2008; EU Commission, 2009), the loss of regulatory control is apparently not seen as a drawback in the EU. This contrasts with the fact that the limited integration of the two economies - especially of their energy sectors - would instead suggest the retention of full domestic regulatory control over the carbon market.

To sum up, the major trade-off in a link between the EU and a Waxman-Markey US ETS resides in the benefits of the political signal, uncertain but possibly positive efficiency gains, enhanced domestic acceptance of carbon pricing, and reinforced credibility of climate policy on the one hand. On the other hand, drawbacks include the loss of regulatory control, as well as the potential conflict over differences in system design and policy priorities. In fact, the major benefits might already materialize once the credible prospect of a transatlantic link, perhaps by 2015-2020, has been created.[15]

6. Conclusions

By systematically going through all the major issues involved in the linking of regional cap-and tradesystems,[16] we have identified a framework for assessing linkages from the policy-makers' point of view. Table 2 provides an overview of the potential benefits and disbenefits. When considering a specific linking proposal, policy-makers will have to quantify and weigh up the impact of each issue to determine the net effect, and whether to link or not to link their cap-and trade system.

As an illustration, we considered the case of a link between the EU ETS and a US cap-and-trade system along the lines of the Waxman-Markey proposal. In the face of limited knowledge about the prospective efficiency gains and negligible benefits from the increased market size, we identified the political signal for international and domestic climate policy and the effect as commitment mechanism as the most tangible benefits of a transatlantic link. On the other side, differences in system design signal a potential incompatibility in the priority ranking of cost containment versus environmental effectiveness. Also, the absence of a close integration of the two economies suggests that keeping the right of unrestricted regulatory intervention on the home market might entail some value.

These trade-offs resemble those involved in the deliberation about common currency areas, where increased economic efficiency (reduced transaction costs and exchange rate uncertainty, higher price stability) and the wider political benefits are weighed against the costs of ceding discretionary regulatory control over the domestic economy. In the case of the single European currency, economists arrived at a negative verdict, denying that the European economy qualifies as a so-called optimum currency area (Krugman and Obstfeld, 2000). However, the expected political benefits turned out to be of overriding importance, and the Euro was eventually adopted.

TABLE 2 Potential benefits and disadvantages of linking regional cap-and-trade systems, as seen from the point of view of domestic policy-makers

Potential Benefits	Potential Disbenefits
Economic • Short term efficiency gains: - Gains from trade (magnitude uncertain) - Improved liquidity (smaller schemes) - Reduced volatility • Dynamic efficiency gains: - Enhanced credibility of commitment **Political** • Signaling of multilateral commitment • Enhanced domestic policy acceptance	**Economic** • Loss (or negligible gain) from linking due to pre-existing distortions • Adverse distributional impacts: - Loss of co-benefits - Regions may expand emission caps to increase permit sales • Exposure to other regions' market shocks **Political** • Risk to endorse reduction targets that are inconsistent with a fair global burden sharing **Regulatory** • Possible violation of prioritized policy objectives due to incompatible designs • Reduced regulatory leeway

To inform the assessment of prospective bilateral linkages, economic modelling exercises on the expected changes in regional welfare will be highly desirable. The political dimension will generally be much more difficult to judge in an objective manner, and depends on the overall state of climate policy - e.g. whether or not a global carbon trading system is seen as an important long-term target of climate policy, as emphasized by ICAP (2007) and the EU Commission (2009). Fixing mid- to long-term cap schedules prior to linking will help to stabilize expectations and place subsequent negotiations over cap adjustments on a transparent basis. Finally, with regard to the technical issue of regulatory compatibility, a rich body of literature is now emerging, which can readily inform assessments of linking (e.g. Tuerk et al., 2009a, and other articles in this Special Issue).

In summary, while linking may appear to be a straightforward issue at first sight - enabling international trade in allowances should be of benefit to all - it turns out that a number of sometimes complex caveats have to be taken into account. Careful and case-specific analysis will be required to determine whether the balance of evidence combined with wider normative assumptions warrants a decision to link or instead not (yet) link two trading systems.

Acknowledgements

We would like to thank Steffen Brunner, Michael Jakob and Andreas Tuerk for helpful comments and discussions.

Notes

1. For detailed descriptions of the emerging regional systems, see the case studies in this Special Issue of Climate Policy and Tuerk et al. (2009b).
2. In this article, we only consider direct bi- and multilateral links between cap-and-trade systems with binding absolute targets. A bilateral link means that two emissions trading systems mutually accept their allowances for compliance (Haites and Mullins, 2001). We do not deal with voluntary schemes or systems based on intensity targets. Also, we assume that such links occur in absence of a government-level trading scheme such as the trading scheme set up under the Kyoto Protocol. For an overview and analysis of different carbon market architectures, see Flachsland et al. (2009).
3. OECD countries and other major emitters adopt the emission reduction targets proposed by the EU, i.e. 30% reductions below 1990 for developed countries (on aggregate) by 2020, and 20% reduction below 2020 baseline emissions for major developing countries.
4. For example, the Swiss system covers only 3 Mt of annual emissions, and the New Zealand scheme is expected to cover 62 Mt annually, as compared to the roughly 2,000 Mt annual emissions of the EU ETS (Carbon Market Data, 2009; Jotzo and Betz, 2009; Point Carbon, 2009a).
5. This bears some analogy with the 'importing price stability' argument in the theory of optimum currency areas (see, e.g., Krugman and Obstfeld, 2000, p.613).
6. From an economic point of view, the competitive distortions caused by asymmetric carbon prices appear to affect only few sectors, which account for a relatively small share of GDP (e.g. Reinaud, 2005; McKinsey and Ecofys, 2006; Hourcade et al., 2007; Morgenstern et al., 2007); the reason being that carbon is only one among several factors of production for which prices differ. Thus, a significant impact on investment decisions across two capped economies appears unlikely - in particular if the permit prices of the cap-and-trade systems are not too different.
7. RGGI has an estimated overallocation of 17%, i.e. actual emissions in 2008 were well below the cap (Point Carbon, 2009b).
8. The list of design parameters is not meant to be exhaustive. Banking, for example, constitutes another important design feature, but banking does not raise the issue of trade-offs in scheme design, because it supports all of the policy objectives discussed here.
9. Credit imports may also be restricted for concerns over additionality (Schneider, 2007; Wara, 2007), which is not discussed further here.
10. In fact, McKibbin et al. (2008) warn that economic losses due to imported carbon market volatility might erode its political support, possibly discrediting the entire approach.
11. The current state of research does not allow for a definite conclusion on whether or not such features are needed for an optimal functioning of greenhouse gas cap-and-trade systems - a priori, however, it does not seem implausible.
12. The WM system proposed on 31 March 2009 would commence in 2012 and cover ~68% of US GHG emissions in the initial year 2012 (rising to a share of 85% in US GHG emissions in 2016), with a cap of 4,770 $MtCO_2e$. The cap would decline to 20% below 2005 emission levels by 2020, and, eventually, 83% below 2005 emissions by 2050. Covered entities can make up to 15% of their needed allowances by means of domestic offsets (including LULUCF activities), and another 15% by international offsets, but both are subjected to a 20% discount factor. See Sterk et al. (2009) and Point Carbon (2009c) for more details.
13. Of course, pre-link carbon price asymmetries and corresponding efficiency gains from linking are not only determined by the shape of marginal abatement cost curves, but also by the emission reduction targets.
14. See Sterk and Kruger (2009) for a detailed analysis of regulatory issues when linking the EU ETS to the system proposed by Waxman-Markey.
15. Given the possibility of banking, markets will price in expectation of future linkages. This reaffirms the need for actively managing market expectations on future political developments, in order to avoid the volatility induced by policy uncertainty over linkages.
16. Our analysis omitted two other economic implications of linking, both relating to the economic consequences of adjustments in allowance prices when linking. First, a changing regional allowance price might affect the rate of carbon leakage, depending on the affected industries' elasticity of leakage with respect to the carbon price (Jaffe and Stavins, 2007). Second, allowance price changes will

translate into adjustments of commodity (e.g. fuel) prices, the value of freely allocated allowances, as well as auctioning revenues, with corresponding distributional implications.

References

Anger, N., 2008, 'Emissions trading beyond Europe: linking schemes in a post-Kyoto world', *Energy Economics* 30, 2028-2049.

Australian Government, 2008, *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future*, White Paper, 15 December [available at www.climatechange.gov.au/whitepaper/report/index.html].

Babiker, M., Reilly, J., Viguier, L., 2004, 'Is international emissions trading always beneficial?', *Energy Journal* 25(2), 33-56.

BDI (Federation of German Industries), 2008, Positionspapier: *Erwartungen der Deutschen Industrie an die Klimakonferenzen 2008 und 2009*, 4 December [available at www.bdi-online.de/de/fachabteilungen/1398.htm].

Blue Green Alliance, 2009, *Blue Green Alliance Policy Statement on Climate Change Legislation*, March, NRDC Document Bank [available at http://docs.nrdc.org/globalWarming/glo_09032601.asp].

Boemare, C., Quirion, P., 2002, 'Implementing greenhouse gas trading in Europe: lessons from economic literature and international experiences', *Ecological Economics* 43(2-3), 213-230.

California, Market Advisory Committee, 2007, *Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California: Recommendations of the Market Advisory Committee to the California Air Resources Board*, 30 June [available at *www.climatechange.ca.gov/publications/market_advisory_committee/2007-06-29_MAC_FINAL_REPORT.PDF*].

Carbon Market Data, 2009, *Swiss ETS Database* [available at www.carbonmarketdata.com].

Carbone, J.C., Helm, C., Rutherford, T.F., 2009, 'The case for international emission trade in the absence of cooperative climate policy', *Journal of Environmental Economics and Management* 57, doi:10.1016/j.jeem.2009.01.0001.

Chichilnisky, G., Heal, G., 1995, *Markets for Tradeable CO_2 Emission Quotas: Principles and Practice*, OECD Economics Department Working Paper No. 153.

Copeland, B.R., Taylor, M.S., 2005, 'Free trade and global warming: a trade theory view of the Kyoto Protocol', *Journal of Environmental Economics and Management* 49(2), 205-234.

den Elzen, M.G.J., Höhne, N., van Vliet, J., Ellermann, C., 2008, *Exploring Comparable Post-2012 Reduction Efforts for Annex I Countries*, PBL Report 500102019/2008.

Edenhofer, O., Lessmann, K., Kemfert, C., Grubb, M., Köhler, J., 2006, 'Induced technological change: exploring its implications for the economics of atmospheric stabilization: Synthesis Report from the Innovation Modeling Comparison Project', *Energy Journal*, Special Issue *Endogenous Technological Change and the Economics of Atmospheric Stabilization*, 57-108.

Edenhofer, O., Flachsland, C., Marschinski, R., 2007, *Towards a Global CO_2 Market: Expertise for the Policy Planning Staff in the Federal Foreign Office*, Potsdam Institute for Climate Impact Research, May.

Edenhofer, O., Luderer, G., Flachsland, C., Fuessel, H.M., Popp, A., Knopf, B., Feulner, G., Held H., 2008, *A Global Contract on Climate Change*, Background paper for the conference *A Global Contract Based on Climate Justice: The Need for a New Approach Concerning International Relations*, 11 November, Brussels.

Egenhofer, C., 2007, 'The making of the EU Emissions Trading Scheme: status, prospect and implications for business', *European Management Journal* 25(6), 453-463.

Ellerman, D.A., Buchner, B.K., Carraro, C., 2007, 'Unifying themes', in: D.A. Ellerman, B.K. Buchner, C. Carraro (eds), *Allocation in the European Emissions Trading Scheme: Rights, Rents and Fairness*, Cambridge University Press, Cambridge, UK, 339-369.

EU Commission, 2009, *Towards a Comprehensive Climate Change Agreement in Copenhagen: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*, COM(2009) 39/9, Brussels.

European Union, 2008, Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (codified version) [available at http://eur-lex.europa.eu/

Flachsland, C., Marschinski, R., Edenhofer, O., 2009, 'Global trading versus linking: architectures for international emissions trading'*, Energy Policy* 37, 1637-1647.

Garnaut, R., 2008, *Garnaut Climate Change Review*, Cambridge University Press, Cambridge, UK [available at http:// www.garnautreview.org.au/domino/Web_Notes/Garnaut/garnautweb.nsf].

Grubb, M., 2009, *Reinforcing Carbon Markets under Uncertainty: The Role of Reserve Price Auctions and Other Options*, Climate Strategies Issues and Options Brief, 4 March [available at www.climatestrategies.org/].

Haites, E., Mullins, F., 2001, *Linking Domestic and Industry Greenhouse Gas Emission Trading Systems*, Prepared for EPRI, IEA and IETA.

Helm, C., 2003, 'International emissions trading with endogenous allowance choices', *Journal of Public Economics* 87, 2737-2747.

Helm, D., Hepburn, C., Mash, R., 2005, 'Credible carbon policy', in: D. Helm (ed), *Climate Change Policy*, Oxford University Press.

Hourcade, J.C., Demailly, D., Neuhoff, K., Sato, M., 2007, *Differentiation and Dynamics of EU ETS Industrial Competitiveness Impacts*, Climate Strategies Report.

Houser, T., Bradley, R., Childs, B., Werksman, J., Heimayr, R., 2007, *Leveling the Carbon Playing Field*, Peterson Institute for International Economics and World Resources Institute.

ICAP (International Carbon Action Partnership), 2007, *Political Declaration*, 29 October, Lisbon
[available at www.ecapcarbonaction.com].

Jacoby, H.D., Ellerman, D.A, 2004, 'The safety valve and climate policy', *Energy Policy* 32(4), 481-491.

Jaffe, J., Stavins, R.N., 2007, *Linking Tradable Permit Systems for Greenhouse Gas Emissions: Opportunities, Implications and Challenges*, prepared for International Emissions Trading Association, November.

Jaffe, J., Stavins, R.N., 2008, *Linkage of Tradable Permit Systems in International Climate Policy Architecture*, Discussion Paper 2008-07, September, Harvard Project on International Climate Agreements, Cambridge, MA.

Jotzo, F., Betz, R., 2009, *Linking the Australian Emissions Trading Scheme*, Environmental Economics Research Hub Research Report No.14, February.

Krugman, P.R., Obstfeld, M., 2000, *International Economics: Theory and Policy*, 5th edn, Addison-Wesley.

Kydland, F.E., Prescott, E.C., 1977, 'Rules rather than discretion: the inconsistency of optimal plans', *Journal of Political Economy* 85(3), 473-492.

Lipsey, R.G., Lancaster, K., 1956, 'The general theory of second best', *Review of Economic Studies* 24(1), 11-32.

Mace, M.J., Millar, I., Schwarte, C., Anderson, J., Broekhoff, D., Bradley, R., Bowyer, C., Heilmayr, R., 2008, *Analysis of the Legal and Organisational Issues arising in Linking the EU Emissions Trading Scheme to Other Existing and Emerging Emissions Trading Schemes*, FIELD/IEEP/WRI Study commissioned by the European Commission DG-Environment, Climate Change and Air, Final Report, May.

McKibbin, W.J., Shackleton, R., Wilcoxen, P.J., 1999, 'What to expect from an international system of tradable permits for carbon emissions', *Resource and Energy Economics* 21, 319-346.

McKibbin, W.J., Morris, A., Wilcoxen, P.J., 2008, *Expecting the Unexpected: Macroeconomic Volatility and Climate Policy*, Discussion Paper 08-16, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, November.

McKinsey & Company, Ecofys, 2006, EU ETS Review. Report on International Competitiveness [available at ec.europa.eu/ environment/climat/emission/pdf/etsreview/061222compreport.pdf].

Mehling, M., Haites, E., 2009, 'Mechanisms for linking emissions trading schemes', *Climate Policy* 9, 169-184.

Montgomery, W.D., Smith, A.N., 2007, 'Price, quantity, and technology strategies for climate change policy', in: M.E. Schlesinger, H. Kheshgi, J.B. Smith, F.C. de la Chesnaye, J.M. Reilly, T. Wilson, C. Kolstad (eds), Human- Induced Climate Change: An Interdisciplinary Assessment, Cambridge University Press, Cambridge, UK.

Morgenstern, R.D., Aldy, J.E., Herrnstadt, E.M., Ho, M., Pizer, W.A., 2007, *Competitiveness Impacts of Carbon Dioxide Pricing on Manufacturing*, RFF Backgrounder, September.

Paltsev, S., Reilly, J.M., Jacoby, H.D., Tay, K.H., 2007, 'How (and why) do climate policy costs differ among countries?', in: M.E. Schlesinger, H. Kheshgi, J.B Smith, F.C. de la Chesnaye, J.M. Reilly, T. Wilson, C. Kolstad (eds), Human- Induced Climate Change: An Interdisciplinary Assessment, Cambridge University Press, Cambridge, UK, 282-293.

Point Carbon, 2009a, 'Analysts predict 2bn EUAs were allocated in 2008', 3 April [available at www.pointcarbon.com/news/1.1091038].

Point Carbon, 2009b, 'RGGI 2008 emissions 17% below cap: report', 11 March [available at www.pointcarbon.com/news/1.1075025].

Point Carbon, 2009c, *A US Cap-and-Trade Program: Options for Compliance*, Carbon Market Analyst North America, 2 April.

Putnam, R.D., 1988, 'Diplomacy and domestic politics: the logic of two-level games', *International Organization* 42(3), 427-460.

Rehdanz, K., Tol, R.S.J., 2005, 'Unilateral regulation of bilateral trade in greenhouse gas emission permits', *Ecological Economics* 54, 397-416.

Reinaud, J., 2005, *Industrial Competitiveness under the European Union Emissions Trading Scheme*, IEA Information Paper, February.

Reinaud, J., 2009, *Trade, Competitiveness and Carbon Leakage: Challenges and Opportunities*, Chatham House Energy, Environment and Development Programme Paper 09/01, January.

Russ, P., Ciscar, J.-C., Saveyn, B., Soria, A., Szábó, L., Van Ierland, T., Van Regemorter, D., Virdis, R., 2009, *Economic Assessment of Post-2012 Global Climate Policies: Analysis of Greenhouse Gas Emission Reduction Scenarios with the POLES and GEM-E3 Models*, EU Commission Joint Research Centre Report.

Samuelson, P.A., 1949, 'International factor-price equalization once again', *Economic Journal* 59, 181-197.

Schneider, L., 2007, *Is the CDM Fulfilling its Environmental and Sustainable Development Objectives? An Evaluation of the CDM and Options for Improvements*, Report prepared by Öko-Institut e.V. for WWF.

Steinmeier, F.W., Gabriel, S., 2008, 'Wer, wenn nicht wir?', *Frankfurter Allgemeine Zeitung* (in German), 29 September.

Sterk, W., Kruger, J., 2009, 'Establishing a transatlantic carbon market', *Climate Policy* 9(4) Special Issue *Linking GHG Trading Systems*, 389-401.

Sterk, W., Braun, M., Haug, C., Korytarova, K., Scholten, A., 2006, *Ready to Link up? Implications for Design Differences for Linking Domestic Emission Trading Schemes: Joint Emissions Trading as a Socio-Ecological Transformation*, JET-SET Project Working Paper I/06.

Sterk, W., Mehling, M., Tuerk, A., 2009, *Prospects of linking EU and US Emission Trading Schemes: Comparing the Western Climate Initiative, the Waxman-Markey and the Lieberman-Warner Proposals*, Climate Strategies Working Paper, 24 April [available at http://climatestrategies.org/our-research/category/33/143.html].

Stern, N., 2007, *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, UK.

Stern, N., 2008, *Key Elements of a Global Deal on Climate Change*, London School of Economics and Political Science [available at www.lse.ac.uk/collections/granthamInstitute/publications/KeyElementsOfAGlobalDeal_30Apr08.pdf].

Tuerk, A., Mehling, M., Flachsland, C., Sterk, W., 2009a, 'Linking carbon markets: concepts, case studies and pathways', *Climate Policy* 9(4) Special Issue *Linking GHG Trading Systems*, 341-357.

Tuerk, A., Sterk, W., Haites, E., Mehling, M., Flachsland, C., Kimura, H., Betz, R., Jotzo, F., 2009b, *Linking of Emissions Trading Schemes: Synthesis Report*, Climate

Strategies, 8 March [available at www.climatestrategies.org/our-research/category/33/126.html].
UNCTAD, 1992, *Combating Global Warming: Study on a Global System of Tradable Carbon Emission Entitlements*.
UNFCCC, 2008, *Report of the Conference of the Parties on its Thirteenth Session, held in Bali from 3 to 15 December 2007*, FCCC/CP/2007/6/Add.1, 14 March.
Victor, D., 2007, 'Fragmented carbon markets and reluctant nations: implications for the design of effective architectures', in: J.E. Aldy, R. Stavins (eds), *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*, Cambridge University Press, Cambridge, UK, 133-160.
Viguier, L., Babiker, M., Reilly, J., 2003, 'The costs of the Kyoto Protocol in the European Union', *Energy Policy* 31, 459-481.
Wara, M., 2007, 'Is the global carbon market working?' *Nature* 445(8), 595-596.
Waxman, H.A., Markey, E.J., 2009, *American Clean Energy and Security Act of 2009* [available at http://waxman.house.gov/News/DocumentSingle.aspx?DocumentID=116749].
Westskog, H., 2002, 'Why should emissions trading be restricted?', *Climate Policy* 2, 97-103.
Weyant, J.P., Hill, J.N., 1999, 'Introduction and overview', *Energy Journal* Special Issue The *Costs of the Kyoto Protocol: A Multi-Model Evaluation*, vii-xliv.
Zapfel, P., 2007, 'A brief but lively chapter in EU climate policy: the Commission's perspective', in: D.A. Ellerman, B.K. Buchner, C. Carraro (eds), *Allocation in the European Emissions Trading Scheme: Rights, Rents and Fairness*, Cambridge, University Press, Cambridge, UK, 13-38.