A Credible Compliance Enforcement System for the Climate Regime

Abstract

Previous research has found that Kyoto's compliance enforcement system provides only weak incentives for compliance, and has proposed alternative compliance enforcement systems for a post-Kyoto climate agreement. This article considers problems with Kyoto's compliance enforcement system and with proposed alternative systems, and contributes to the existing literature by outlining for a new climate treaty a compliance enforcement system that is simple, flexible, potent, and credible. The main idea is that each country must deposit a significant sum of money at ratification, and make additional yearly deposits during the preparation stage prior to the commitment period. When the commitment period ends, countries meeting or beating their emissions limitation target will receive a full refund, whereas countries failing to meet their target will forfeit part or all of their deposit. Provided each country's deposit is no less than its abatement costs, this system will effectively deter noncompliance. Numerical illustrations of the required deposits for selected countries are offered.

Keywords: international cooperation, climate regime, Kyoto Protocol, compliance, enforcement, institutional innovation

1. Introduction

Practitioners and scholars alike often argue that a post-Kyoto climate agreement should include provisions for effective enforcement.[1] In preparing for Copenhagen in 2009, the European Commission envisioned a system for climate protection that would be implemented through an international agreement with legally binding commitments and strong compliance provisions (Purvis and Stevenson 2009: 4). Meanwhile, then British Prime Minister Gordon Brown stated, "If we make promises at Copenhagen, we've got to be sure that every country is going to keep them".[2] Similarly, scholars such as Barrett (2008; 2009) consider enforcement essential for a new climate treaty, but argue that Kyoto's compliance enforcement system suffers from fundamental weaknesses and that enforcement via trade restrictions, as proposed by Stiglitz (2006), will also unlikely work. Indeed, it remains an unsettled issue how a post-Kyoto treaty of the same design can be enforced.

We outline a simple, flexible, potent, and credible system for compliance enforcement of a post-Kyoto climate treaty. The main idea is that each member of the next climate treaty must: (1) deposit a significant sum of money in hard currency at ratification; (2) make additional yearly deposits while preparing to undertake actual measures for reaching its emission limitation target; and (3) forfeit all or part of its existing deposits if it declines to make further required deposits or fails to reach its target. Countries reaching their target will receive a full refund when the commitment period ends.

Proposed by Finus (2008a: 24), this deposit system resembles Gerber and Wichardt's (2009) general solution for public goods games; however, we add value in three ways. First, we address problems with Kyoto's compliance enforcement system (section 2) as well as with proposed alternative systems (section 3), and show that a deposit system can likely solve several of those problems (section 4). Second, whereas Finus mentions the deposit system

only briefly, and Gerber and Wichardt analyse a general theoretical model, we provide concrete policy advice by detailing how a deposit system may provide an effective compliance enforcement system for a post-Kyoto climate agreement (section 4). Finally, using an empirical model, we identify the deposit size required for selected countries to ensure their compliance in a post-Kyoto treaty with emissions trading (section 5).

We emphasize that a deposit system can be used only for enforcing *compliance*; enforcing *participation* requires other measures.[3] We do *not* imply that participation enforcement is less important than compliance enforcement is; indeed, Barrett (2008) is probably right that an effective climate agreement must address both, and effective participation enforcement will likely *increase* the need for compliance enforcement (Aakre and Hovi 2010). However, because of space constraints we address only compliance enforcement here.

2. Summary and critique of Kyoto's compliance enforcement system

The Marrakesh Accords established a compliance committee for Kyoto, consisting of a facilitative branch and an enforcement branch (UNFCCC, 2001). The facilitative branch shall provide advice and facilitation to the parties concerning implementation and will not be considered further in this paper. The enforcement branch shall, inter alia, determine whether Annex I Parties comply with their emission target. [4]

The enforcement branch's composition is based on a specific distribution of members across geographical regions and between Annex I and non–Annex I Parties. The adoption of a decision by the enforcement branch requires a majority of members from Parties included in Annex I, as well as a majority of members from Parties not included in Annex I.

Having determined that a country is in noncompliance, the enforcement branch is responsible for applying punitive consequences (Ulfstein and Werksman 2005:41–49). If it determines a

Party to be noncompliant with its emissions target, in the second commitment period it must cover its deficit plus 30 per cent of that deficit (in addition to whatever its target for the second period would be).[5] Furthermore, the noncompliant Party loses its right to sell emission permits until the enforcement branch reinstates such eligibility.

A problem with the first punitive consequence, additional emissions reductions, is that it is not legally binding. Furthermore, even if it were to be made legally binding, the climate regime cannot enforce such additional emissions reductions; only the punished Party *itself* can implement them. Thus, the 30 per cent additional emissions penalty is essentially a form of *self-punishment* (Barrett 2003). Importantly, Kyoto's compliance mechanism provides no second-order punishment for noncompliant countries that fail to implement such self-punishment.[6]

Another problem is that the punitive consequences may entail adverse economic effects for *compliant* countries, which may hurt the compliance system's credibility (Hagem and Westskog 2005; Finus 2008b). Implementing the punitive consequences will cause the permit price to increase, thereby harming large permit buyers. Furthermore, punitive consequences alter market prices on fossil fuels and emission-intensive goods, thereby harming some countries through negative effects on terms of trade. Hence, if countries expect enforcement branch members to determine noncompliance not only on the basis of whether countries actually meet their targets, but also on the basis of how punitive consequences influence the economies of enforcement branch members' own countries, the threat of punitive consequences may not always be credible. Using a numerical model, Hagem et al. (2005) identify situations where the enforcement branch would refrain from implementing punitive consequences if enforcement branch members were to maximize their own country's (economic) self-interest.

3. Summary and critique of alternative compliance enforcement systems

The game-theoretic literature on international environmental agreements (IEAs) considers both participation enforcement and compliance enforcement (e.g., Barrett 2003). The problems concerning participation and compliance are closely related. Because the global climate is a public good, it is possible for a country to free ride on other countries' abatement efforts. This possibility may make some countries reluctant to participate (ratify), and may likewise induce some countries to default on their commitments after they have ratified. It is therefore unsurprising that enforcement mechanisms proposed for enforcing IEA participation often resemble enforcement mechanisms proposed for enforcing IEA compliance. We here consider some such mechanisms.

Punishment through reducing greenhouse gas (GHG) abatement

One strand of the IEA literature studies compliance mechanisms prescribing that a specified group of countries shall punish a noncompliant country by switching to less ambitious emission reduction plans for a certain period after noncompliance is detected. This strand draws on the theory of infinitely repeated games, focusing on weakly renegotiation-proof equilibria (e.g., Barrett 2003; Asheim et al. 2006; Asheim and Holtsmark 2009). We see several problems with such mechanisms.

First, investments in GHG abatement technology often require long lead times, and windmill parks, heavily isolated buildings, or public transportation systems cannot easily be sold for alternative uses. Thus, countries with such technologies cannot sensibly stop using them simply because some other country fails to fulfill its GHG emission reduction commitments. At best, they might cancel or postpone planned emissions-reducing investments.

Second, canceling or delaying emissions-reducing investments would harm the global climate, thereby hurting compliant as well as noncompliant countries and violating Axelrod and Keohane's (1985, 235) condition that effective reciprocity requires an ability to 'focus retaliation on defectors.' Designing a credible (renegotiation-proof) enforcement mechanism along these lines is therefore challenging.[7]

Finally, we would expect special interest groups, such as environmental NGOs and green businesses, to strongly oppose cancellation or delay of planned emissions-reducing investments, thereby making it hard for politicians to defend such enforcement mechanisms.

Restricting access to club goods

Another strand of the IEA literature analyses conditions for stable coalitions (e.g., Finus 2008b). Stable coalitions are generally small; to increase their size, scholars have proposed linking cooperation on climate change to cooperation on some club good such as sharing knowledge created by R&D or participating in free trade.

The same type of enforcement mechanism may be proposed to ensure compliance. However, in our view, enforcing compliance through restricting R&D cooperation and the sharing of R&D findings suffers from two major problems. First, controlling access to new technology is difficult. Knowledge diffuses through several channels – people changing jobs, trade in goods, exchange at conferences, etc. Clearly, many such channels are beyond governmental control. Second, as emphasized by Buchner et al. (2005), it would not be in Annex I countries' interest to deny other countries new, green technology. Selling such technology benefits domestic firms holding patent rights, and emissions reductions caused by technology diffusion benefit *all* countries.

Trade restrictions

The Montreal Protocol is often mentioned as an example of a well-working IEA. According to some observers, trade restrictions have been instrumental in Montreal's success (Barrett 2002; Benedick 1999). Scholars see trade restrictions as a means both to increase participation and to deter noncompliance (e.g., Stiglitz 2006; Karp and Zhao 2009). Trade restrictions could (at least in principle) be incorporated in a new climate treaty without violating GATT rules (WTO/UNEP, 2009). To be credible, trade restrictions must avoid hurting *compliant* countries, which depends on whether trade restrictions can prevent *leakage* (Barrett 1999), i.e., increased emissions caused by the enhanced competitiveness of the non-compliant country's emissions-intensive industries. According to Barrett (1999), the reduced-leakage effect will unlikely suffice to make the threat of trade restrictions credible in the case of climate change.

Scholars are also sceptical to using trade restrictions to enforce IEAs for other reasons. Using trade measures in order to influence environmental policy in other countries will often lead to conflicts since countries differ with respect to their attitude towards environmental protection. Clearly, more frequent trade conflicts will harm the already fragile world trading system.

Fines

Karp and Zhao (2009) propose a compliance enforcement system based on fines. In their system, the noncompliant country must pay a predetermined, country-specific fine, the proceeds of which are shared between all treaty members (including the noncompliant Party).

A deposit system has many similarities with Karp and Zhao's proposal; however, a major difference is that in a deposit system deposits are paid up front, whereas Karp and Zhao

suggest that the fine be paid after noncompliance is detected. According to Karp and Zhao, such posterior payment is not a serious problem for their system, because countries only rarely default on their sovereign debt. However, according to Borensztein and Panizza (2009), countries quite often default on their sovereign debt. Moreover, not paying a fine is not the same as defaulting on sovereign debt, and reputations in one issue area do not necessarily carry over to other issue areas (Downs and Jones 2002). Thus, countries refusing to pay the fine may well be able to continue borrowing money in the international finance markets, and hence avoid the short-term economic losses associated with defaulting on sovereign debt.

4. A credible compliance enforcement system for the climate regime

Once negotiated, a climate treaty goes through three stages; we use these three stages to outline a deposit system for compliance enforcement in a new climate treaty. First, in the *ratification* stage, signatories consider and arrange for the act of ratification. For example, the executive will often assess and explain the need for enabling legislation before asking the legislature's consent to ratification. Whether the legislature will actually consent to ratification may depend on factors such as the depth of the country's commitments and whether neighboring countries or major trading partners have already ratified or can be expected to ratify (Perrin and Bernauer 2010).

In the *preparation* stage, member countries plan for implementing their treaty commitments. For example, the warm-up phase of the European Union's Emission Trading Scheme (EU-ETS) may be considered part of the preparations for implementing EU countries' Kyoto commitments.

Finally, in the *implementation* stage, member countries implement measures to meet their commitments. Examples include the execution of the EU-ETS's second phase, which coincides with Kyoto's first commitment period, use of Kyoto's own emission trading scheme and other flexibility mechanisms, and domestic measures such as carbon taxes, carbon capture and storage, road tolls, and district heating.

A deposit system can easily be adapted to accommodate different arrangements concerning the length of each period, including different lengths for different countries. In particular, the duration of one or more stages may vary from country to country, whereas the duration of one or more other stages may be identical for all countries. For example, Kyoto's ratification stage for a given country ran from Kyoto's conclusion in 1997 to the country's ratification date, which varies significantly; whereas Fiji ratified in September 1998, Australia ratified only in December 2007. Similarly, Kyoto's preparation stage varied across countries, since it ran from the ratification date through 2007. Finally, Kyoto's implementation stage corresponds to the first commitment period, which began in 2008 and ends in 2012, and is hence identical for all member countries.

The Ratification and Preparation Stages

In a new climate treaty using a deposit system for compliance enforcement, each member must: (1) deposit a significant sum of money at ratification, (2) make further yearly deposits during the preparation stage, and (3) forfeit all or part of its deposits should it (a) fail to make further required deposits in the preparation stage or (b) fail to reach its emissions limitation target in the implementation stage.

Note that all countries that ratify will necessarily make at least one deposit. Moreover, if countries that have ratified fail to make further required deposits, they will lose all or part of

their existing deposits. Once they have ratified and made the corresponding first deposit, countries will thus have an incentive to continue paying yearly deposits throughout the preparation stage. Similarly, countries having made the required deposits in the preparation stage will have an incentive in the implementation stage to actually implement sufficient measures to reach their emissions limitation target.

The simplest way to deposit money would likely be to use escrow accounts. Although one might envision other options, it is essential that only reasonably safe options be allowed. If a country's deposits were to be lost, they would obviously no longer provide an incentive for compliance.

A new climate treaty would likely include an entry-into-force clause making commitments binding only when certain conditions are fulfilled. For example, Kyoto's entry-into-force clause states that "this Protocol shall enter into force on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55 per cent of the total carbon dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession" (The Kyoto Protocol, article 25). In a new climate treaty some countries might wish to participate only provided specific other countries also ratify (and hence make deposits). Such conditions referring to specific other countries can be made compatible with a deposit system. Should the new climate treaty fail to enter into force, all deposits should be refunded.

By the end of the preparation stage, a country's total deposits should be no less than the cost of reaching its emissions limitation target. Hence, a country's required yearly deposit will depend on the cost of reaching its emission target and on the combined timeframe of the ratification and preparation stages.

Consider a country having a target that would cost US$ 1 billion to reach. If the ratification and preparation stages last five years in total, a yearly deposit of US$ 200 million in these stages should do (assuming no discounting). By the end of the preparation stage, that country will thus have deposited US$ 1 billion, thus making implementation of its US$ 1 billion commitment economically rational.

A country's costs for reaching its target can only be estimated. If cost estimates are revised, the size of its yearly deposits may need to be adjusted. Unless a country's compliance costs are revised significantly upwards, such cost-estimate revisions should not pose particular problems. Its incentive to continue making deposits would remain because it would otherwise forfeit existing deposits. If compliance costs are revised significantly upwards, so that the country would be better off by forfeiting existing deposits than by making future required deposits, the parties might wish to consider reducing its emission limitation target to a level in line with the cost level expected for that country when the treaty was negotiated and signed. However, preserving the enforcement system's stability requires that such renegotiation be restricted to exceptional cases where all countries agree that a party's compliance costs have been seriously underestimated. To avoid serious underestimation of compliance costs, the parties might also impose a ceiling on the permit price. A ceiling would imply that if the permit price reaches the ceiling, the system would automatically generate additional permits to prevent further price increase.

The Implementation Stage

In the implementation stage, each country undertakes actual emissions reductions (or acquires permits) to reach their targets. Countries reaching their target by the end of the implementation stage will receive a full refund (plus interest from the escrow account).

Failure to reach their target would mean a reduced refund (by an amount corresponding to the estimated cost of reaching the remaining part of the target, plus a penalty).

Alternatively, Parties may opt for refunding deposits gradually during the implementation stage. For example, countries might receive partial refunds at year's end based on their emissions-reducing measures that year. However, countries' remaining deposits should always at least equal the estimated costs of reaching their targets.

If Parties prolong the agreement to another commitment period, they may decide to leave the deposits untouched, thereby causing them to become a compliance incentive in the next commitment period, too.

If the system works perfectly, all participating countries will comply and receive a full refund by the end of the implementation period (unless the Parties prolong the agreement). However, if some participating countries fail to comply, the system will generate a surplus. This surplus could in principle be shared among the compliant countries; however, this option would create a disincentive for fair treatment between the member countries. A better option incentive-wise (as well as climate-wise) might be to spend the surplus on funding extra emissions reductions in poor countries. Both options will benefit compliant countries, individually and collectively. Hence, the threat of not refunding a noncompliant country's deposits will be credible.

Strengths and weaknesses

A deposit system for compliance enforcement has several strengths. First, it is *simple*. Non-experts may find it hard to understand all the intricate aspects of Kyoto's enforcement system; in contrast, nearly everyone can understand a system whereby noncompliance entails forfeiture of deposits.

Second, a deposit system is *flexible*. For one thing, if the estimated cost of implementing a country's commitment were adjusted, appropriately calculating the revised deposits would be straightforward (although actually adjusting them upwards may of course be more difficult, depending on local economic and political factors in the country concerned). A deposit system is also flexible in that deposits can easily be tailored to match countries' different compliance costs (see section 5). Kyoto's compliance enforcement system does not provide comparable flexibility.

Third, withholding deposits does not require cooperation by the noncompliant country, because the climate regime controls deposits. In contrast, Kyoto's enforcement system relies heavily on self-punishment (section 3). Enforcement through self-punishment requires credible *second-order* punishment, which Kyoto fails to provide. A deposit system does not require second-order punishment.

Fourth, provided deposits are high enough, the threatened punishment is *potent;* fulfilling one's commitments will be better than being noncompliant *and* forfeiting one's deposits.

Fifth, the threatened punishment is also *credible.* As Barrett (2003) argues, countries imposing punishment often incur costs, and the more severe the punishment, the higher the costs. More severe punishments are therefore typically less credible. For example, punitive consequences imposed by Kyoto's Enforcement Branch on a noncompliant Party may also harm *compliant* member countries that are net exporters of fossil fuels or net buyers of emission permits (Kallbekken and Hovi 2007). Hence, the Enforcement Branch may not always be able to muster the double majority required to impose punitive consequences (Hagem and Westskog 2005). In contrast, under a deposit system, punishing a noncompliant Party would *benefit* other Parties, individually as well as collectively. Indeed, the more severe the punishment (i.e., the larger the deposit forfeited), the more it would benefit compliant countries.

Sixth, whereas in Kyoto a noncompliant country can escape punishment by withdrawing from the treaty, a deposit system can easily be designed to make such escape infeasible. For example, the treaty might specify that countries withdrawing from the treaty before the first commitment period ends would forfeit existing deposits.

Seventh, a deposit system prevents countries from falling prey to the temptation to push concrete measures into a distant future. Because a Party must make its first deposit at ratification, politicians will not have incentives to feign climate friendliness while effectively failing to take real climate action. Conversely, countries declining to make the required pre-ratification deposit clearly signal that they do not intend to participate, which could entail significant audience costs.

Finally, a deposit system entails an important domestic politics advantage for policy makers. In a democracy, policymakers cannot be certain whether they will stay in power after the next election. By joining an agreement that uses a deposit system, a current government wanting strong action against climate change can effectively tie the hands of future governments that are less eager to take such action.

As with any international architecture, some weaknesses also exist. First, while a deposit system should work well for enforcing *compliance*, we emphasize that one needs other measures to enforce *participation*. A deposit system thus must be complemented by a participation enforcement system.

A second (yet related) point is that a deposit system might even *deter* some countries from participating. Importantly, however, it would most likely deter countries that seriously consider default an option. In contrast, such countries might well wish to participate in a climate agreement with no credible system for compliance enforcement, as joining such an agreement could enable their governments to show a climate-friendly face at little or no cost. Because a deposit system makes participating without complying costly, only countries that

are both able and willing to comply will likely become members. Note that a deposit system should pose no disincentive to participate for countries having such ability and willingness; on the contrary, it should make participation more *attractive* by ensuring that a member's efforts will be reciprocated by other members.

Finally, one might object that the loss of a considerable financial deposit might not only reduce a noncompliant country's capacity and willingness to participate in a future climate agreement, but also reduce its capacity to *comply* even if it were to participate. Hence, to induce a noncompliant country to participate in a successor agreement, it may be necessary to grant it a lenient emissions target. However, recall that only countries that are both able and willing to comply will likely participate in a climate treaty using a deposit system for compliance enforcement. Moreover, because deposits will provide a very strong incentive for compliance, few or even no such participating countries will likely actually be noncompliant.

5. Determining deposit size

The first part of this section considers what should be the starting point for calculation of deposit size in a cap-and-trade agreement. We focus on the two-country case, which captures the most important features of the multi-country case. To assess the deposit system, it is necessary to have estimates of the required deposit size. The second part of this section uses a numerical example to provide such estimates.

(Figure 1 about here.)

Consider a treaty having a competitive international permit market. We will assume that the permit price is known beforehand, that countries do not take into account that their behaviour

influences the permit price, and that countries know business as usual (BAU) emissions and marginal abatement costs.

These assumptions clearly represent simplifications. For example, it is not implausible that asymmetric information will exist regarding abatement costs; each country knows more about its own abatement costs than about others'. Moreover, because future abatement costs will likely be uncertain, agreed deposits might prove smaller than actual costs for some countries, thereby making noncompliance economically rational. An obvious remedy might be to require that deposits be larger than expected compliance costs. The assumption that the permit market is competitive is less sensitive; however, it too simplifies the analysis.

Describing the two-country case, the horizontal axis of Figure 1 measures country 1's emissions from left to right, and country 2's from right to left. Country 1's emissions are zero at point O_1; country 2's are zero at O_2. The length of the horizontal axis represents the sum of the two countries' emission quotas. The distances O_1Q and O_2Q represent country 1's and country 2's quotas, respectively. The distances O_1B_1 and O_2B_2 represent country 1's and country 2's BAU emissions.

Let IB_1 and HB_2 represent country 1's and country 2's marginal abatement costs, respectively. With a competitive permit market, the two countries' marginal abatement costs are equalized. Thus, with a competitive permit market the permit price equals the distance O_1p, and the two countries will reduce their emissions from B_1 and B_2 to E. If in addition country 2 imports permits from country 2 corresponding to the distance QE, both countries will be in compliance.

To comply, country 1 must thus purchase permits corresponding to the distance QE from country 2. As the permit price equals O_1p, country 2's (country 1's) revenue (costs) from permit sales (purchases) equals area C+G. Hence, area C+G is important when calculating the countries' net costs.

The area below a marginal abatement cost curve represents the abatement costs; thus, country 1 (the permit purchaser) incurs abatement costs equal to triangle F. Country 1's total costs equal F+C+G.

Country 2 (the permit seller) incurs abatement costs equal to A+G. Hence, its net compliance costs equal A+G–(C+G) = A–C. If country 2 has a large quota compared to its business as usual emissions (Q close to B_2), its compliance costs (the area A–C) might be negative.

We may now discuss the required deposit size. A country would, if possible, maximize its payoff by undertaking no abatement and selling all its assigned permits. To prevent countries from such behaviour, we recommend a commitment-period reserve as in Kyoto, or a similar mechanism, preventing countries from overselling permits (see Missfeldt and Haites 2002).

With such a mechanism preventing countries from overselling permits, it suffices that countries make deposits equal to their compliance costs, which are F+G+C (country 1, the permit importer), and A–C (country 2, the permit exporter). Hence, the sum of required deposits equals the sum of countries' abatement costs (A+G+F), because the transactions in the permit market sum to zero. However, as mentioned above, for some countries triangle A might be smaller than triangle C, meaning that they experience net gains from participation. Such countries need not make deposits. For example, if a new climate agreement favours developing countries with generous quotas, so that these countries will be permit exporters, they will pay only small or even no deposits.

Numerical illustrations

We now present a simplified numerical illustration concerning a possible agreement between the United States, Japan, Russia, and 'Europe'[8] (a proxy for the EU). Thus, the agreement we

consider covers countries responsible for approximately 43 per cent of current global carbon emissions.

We constructed a simple, calibrated partial equilibrium model with emissions trading. We calibrated the model to the 2020 reference scenario of the International Energy Outlook (IEO) (2009, see Table 1). The simulation model applies quadratic abatement cost functions. Table A2 in the Appendix shows the parameters used in the abatement cost functions. We calibrated the model using simulation results provided by simulations with a global computable general equilibrium model presented in Carbone et al. (2009); see the Appendix for details. Our illustration assumes that the national emission quotas of the United States, Japan, Russia, and Europe correspond to their voluntary commitments in the 2009 Copenhagen Accord.

With these assumptions, the permit price settles at 36 USD/tCO_2.

Tables 1 and 2 about here.

As we argued in the previous section, the deposit size should at least equal the sum of the abatement costs and the permit trade costs. If we consider, say, a five-year commitment period, the deposit should at least equal five times the annual net costs.

As shown by table 2, second column, the United States and Russia are permit sellers, while Europe and Japan are buyers. Consequently, Japan and Europe's combined required deposit corresponds to area C+G+F in Figure 1, while the United States and Russia's combined required deposit corresponds to A–C. In our numerical illustration, Japan and Europe's deposits amount to 61 and 224 billion USD, respectively, or 1.3 and 1.2 per cent of GDP. In contrast, the United States' deposit equals only 32 billion USD, or 0.2 per cent of GDP, whereas Russia does not have to make any deposit at all.

We thus find that relative to GDP levels, deposit size might vary considerably across countries.

We emphasize that the abatement cost estimates presented above are uncertain. As abatement costs determine the required deposit size, an important issue is the sensitivity of the required deposit size to changes in abatement costs. A simple relationship exists here. If real abatement costs prove to be (say) 50 per cent higher than our estimates, the required deposit size will also be 50 per cent higher. We therefore stress that our estimates of the abatement costs are based on simulation results with an empirically based CGE model (Carbone et al., 2009).

However, the general rule is that concerned countries that are willing to accept ambitious national targets must make significant deposits, while less concerned countries that are less willing to accept ambitious targets must make only small or even no deposits.

6. Conclusions

Kyoto's compliance enforcement system suffers from serious problems, and so do proposed alternative systems. In this paper, we outlined a simple, flexible, potent, and credible system for compliance enforcement of a post-Kyoto climate treaty. The main idea is that each member of the next climate treaty must: (1) deposit a significant sum of money at ratification; (2) make additional yearly deposits while preparing to undertake actual measures for reaching its emissions limitation target; and (3) forfeit all or part of its existing deposits if it fails to make a required deposit or fails to reach its target. Countries reaching their target receive a full refund when the commitment period ends. This deposit system solves several problems associated with Kyoto's compliance enforcement system and with proposed alternative systems. We showed that to deter noncompliance, countries' deposits should at least equal

their compliance costs. This requirement means that permit importers may have to make considerable deposits, whereas permit exporters need make only small or even no deposits.

One might rightly question the feasibility of requiring countries to make considerable deposits in the midst of a financial crisis. Clearly, this financial-crisis argument applies to any ambitious post-Kyoto treaty. Financially weak countries will unlikely make new and costly climate commitments that make paying off public debt harder. Hence, any ambitious post-Kyoto treaty, including one with a deposit system for compliance enforcement, presupposes that the current financial problems become less urgent.

Although the numbers may seem high, the required deposits are not discouraging in our opinion. Current total debt in the EU system approximately equals the EU countries' combined GDP; hence, a deposit system would require a debt increase of only 1.2 percent. A different issue is whether deposits might hurt liquidity. Deposits will not impact on *global* liquidity, as they will be reinvested in risk-free assets to make a return. However, deposits will limit individual countries' liquidity, and hence their ability to engage in countercyclical policies. This limitation provides another reason why establishment of a deposit system presupposes that the current financial problems become less urgent.

Parties must be sure that full compliance will actually trigger a full refund. First, a trustworthy and transparent compliance review process is required. Kyoto has already come a long way in accomplishing such a process for Annex I countries; a new climate treaty can probably build on Kyoto's expert review system. Second, a dispute resolution institution is required to resolve disagreements about whether a country is in compliance. Such a system already exists for trade in the World Trade Organization, and it should be possible to construct a corresponding system in a new climate treaty.

As already mentioned, calculating country-specific deposits may be difficult. A topic for further research may be to analyse how a ceiling on the permit price (Karp and Zhao 2009)

could reduce this uncertainty. The upper price limit would then become public knowledge, and thereby eliminate one important source of uncertainty.

Appendix: Calibration method in the numerical example

The numerical illustration in section 5 applies a model that includes the United States, Japan, Russia, and Europe. It assumes quadratic abatement cost functions $(c_i/2)q_i^2$ where the subscript is a country index, c_i is a parameter, and q_i is country i's abatement. With a competitive permit market, the permit price p equals marginal abatement costs in each country:

$$c_i q_i = p \qquad (1)$$

for all i. It follows that if information on permit price and abatement levels is available, the parameter c_i may be calibrated using equation 2:

$$c_i = p/q_i. \qquad (2)$$

Carbone et al. (2009) present a number of simulations using a computable general equilibrium model of the world economy. For our calibration, we applied one of the coalition simulations in their Table 3. Table A1 below shows the relevant figures from this table used in our calibration. Note that while our model is a partial equilibrium model, Carbone et al.'s (2009) model includes general equilibrium effects. However, for emission reductions at the modest levels considered here, such general equilibrium effects are small and thus of little importance.

Table A1 about here.

Applying the countries or regions' emission abatement and corresponding marginal abatement costs in Table A1 to the formula in (2) generates the parameter values for c_i shown in Table A2.

Table A2 about here.

Endnotes

[1] 'Enforcement' here refers to the promise, threat, or use of incentives to ensure that actors observe certain norms, for example, the norm that countries should participate in and comply with their commitments under a global climate agreement.

[2] http://news.bbc.co.uk/2/hi/uk_news/8415424.stm. Accessed 6 December 2010.

[3] In theory, Gerber and Wichardt's (2009) proposed solution provides incentives both for participation and for compliance. However, concerning participation, their solution is extremely fragile; if even a single country declines to participate, the entire agreement breaks down.

[4] For an overview of Annex I Parties and non-Annex I Parties, respectively, see http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php and http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php

[5] When the parties established the compliance committee in 2001, they expected that a second commitment period would follow the first.

[6] A noncompliant Party can also escape punishment by withdrawing from Kyoto, giving one year's notice. Following the election of a minority Conservative government in 2006, Canada would unlikely comply with Kyoto, and gave notice of its withdrawal in December 2011.

[7] Unless punishment is credible, it will likely fail to deter noncompliance. If an enforcement system is renegotiation proof, punishing countries will benefit from the punishment, making the scheme credible.

[8]We apply data from the US Department of Energy (International Energy Outlook 2009). Europe is there defined as the group of OECD countries of Europe.

References

Aakre, S., Hovi, J, 2010, Emission Trading: Participation Enforcement Determines the Need for Compliance Enforcement, *European Union Politics* **11**, 427–445.

Asheim, G.B., Froyn, C.B., Hovi, J., Menz, F., 2006, Regional versus Global Cooperation for Climate Control, *Journal of Environmental Economics and Management* **51**, 93−109.

Asheim, G.B., Holtsmark, B., 2009, Renegotiation-Proof Climate Agreements with Full Participation: Conditions for Pareto-Efficiency, *Environmental and Resource Economics* **43**, 519−533.

Axelrod, R., Keohane, R.O., 1985, Achieving Cooperation under Anarchy: Strategies and Institutions, *World Politics* **38**, 226–254.

Barrett, S., 1999, The Credibility of Trade Sanctions in International Environmental Agreements. In P. G. Fredriksson (ed.) *Trade, Global Policy and the Environment*. World Bank Discussion papers 402.

Barrett, S., 2002, Towards a Better Climate Treaty, Fondazione Eni Enrico Mattei, Nota di lavoro 54/2002.

Barrett, S., 2003, *Environment and Statecraft*. Oxford, Oxford UP.

Barrett, S., 2008, Climate Treaties and the Imperative of Enforcement. *Oxford Review of Economic Policy* **24**, 239–258.

Barrett, S., 2009, Rethinking Global Climate Change Governance. *Economics*3/2009-5.

Benedick, R.E., 1998, *Ozone Diplomacy − New Directions in Safeguarding the Planet.* Cambridge, MA: Harvard UP.

Borensztein, E., Panizza, U., 2008, The Costs of Sovereign Default. IMF Working Paper 08/238.

Buchner, B., Carraro, C., Cersosimo, I., Marchiori, C., 2005, Back to Kyoto? US Participation and the Linkage between R&D and Climate Cooperation. *Advances in Global Climate Change Research* **22**, 173–204.

Carbone, C., Helm, C., Rutherford, T., 2009, The Case for International Emission Trade in the Absence of Cooperative Climate Policy. *Journal of Environmental Economics and Management* **58**, 266–280.

Downs, G.W., Jones, M.A, 2002, Reputation, Compliance, and International Law, *Journal of Legal Studies* **XXXI**, S95–S114.

Environment Canada, 2009, A Climate Change Plan for the Purposes of the *Kyoto Protocol Implementation Act-2009.* Available at: http://climatechange.gc.ca/Content/4/0/4/4044AEA7-3ED0-4897-A73E-D11C62D954FD/2009%20Climate%20Change%20Plan%20for%20the%20Purposes%20of%20the%20Kyoto%20Protocol%20Implementation%20Act%20.pdf

European Commission, 2009, *Towards a comprehensive climate change agreement in Copenhagen.*

Finus, M. 2008a, The Enforcement Mechanisms of the Kyoto Protocol: Flawed or Promising Concepts? *Letters in Spatial and Resource Sciences* **1**, 13–25.

Finus, M. 2008b, Game Theoretic Research on the Design of International Environmental Agreements: Insights, Critical Remarks and Future Challenges, *International Review of Environmental and Resource Economics* 2, 29–67.

Gerber, A., Wichardt, P.C., 2009. Providing Public Goods in the Absence of Strong Institutions, *Journal of Public Economics* **93**, 429–439.

Hagem, C., Westskog, H., 2005, Effective Enforcement and Double-edged Deterrents, in O. S. Stokke et al., eds., *Implementing the Climate Regime: International Compliance*. London: Earthscan.

Hagem, C., Kallbekken, S., Mæstad, O., Westskog, H., 2005, Enforcing the Kyoto Protocol: Sanctions and Strategic Behavior. *Energy Policy* **33,** 2112–2122.

Kallbekken, S., Hovi, J., 2007, The Price of Non-compliance with the Kyoto Protocol: The Remarkable Case of Norway, International Environmental Agreements **7,** 1–15.

Karp, L., Zhao, J., 2009, Suggestions for the Road to Copenhagen, Report to the Expert Group on Environmental Studies 2009:1, Ministry of Finance, Sweden.

Missfeldt, F., Haites, E., 2002, Analysis of a Commitment Period Reserve at National and Global Levels, *Climate Policy* **2**, 51–70.

Mæstad, O., 2001, Efficient Climate Policy with Internationally Mobile Firms, *Environmental and Resource Economics* **19**, 267–284.

Perrin, S., Bernauer, T., 2010, International Regime Formation Revisited: Explaining Ratification Behaviour with Respect to Long-range Transboundary Air Pollution Agreements in Europe. *European Union Politics* **11**, 405–426.

Purvis, N., Stevenson, A., 2010, Rethinking Climate Diplomacy. New Ideas for Transatlantic Cooperation Post-Copenhagen. Brussels: The Brussels Forum paper series.

Stiglitz, J. E., 2006, A New Agenda for Global Warming. *The Economists' Voice* **3** (7), Art. 3. Available at http://www.bepress.com/ev/vol3/iss7/art3

The International Energy Outlook, 2010,US Energy Information Administration Available at: http://www.eia.gov/oiaf/ieo/index.html

Ulfstein, G., Werksman, J., 2005, The Kyoto Compliance System: Towards Hard Enforcement. In O. S. Stokke et al., eds, *Implementing the Climate Regime: International Compliance*. London: Earthscan.

UNFCCC (2005). *The Marrakesh Accords and the Marrakesh Declaration.* http://unfccc.int/cop7/accords_draft.pdf.

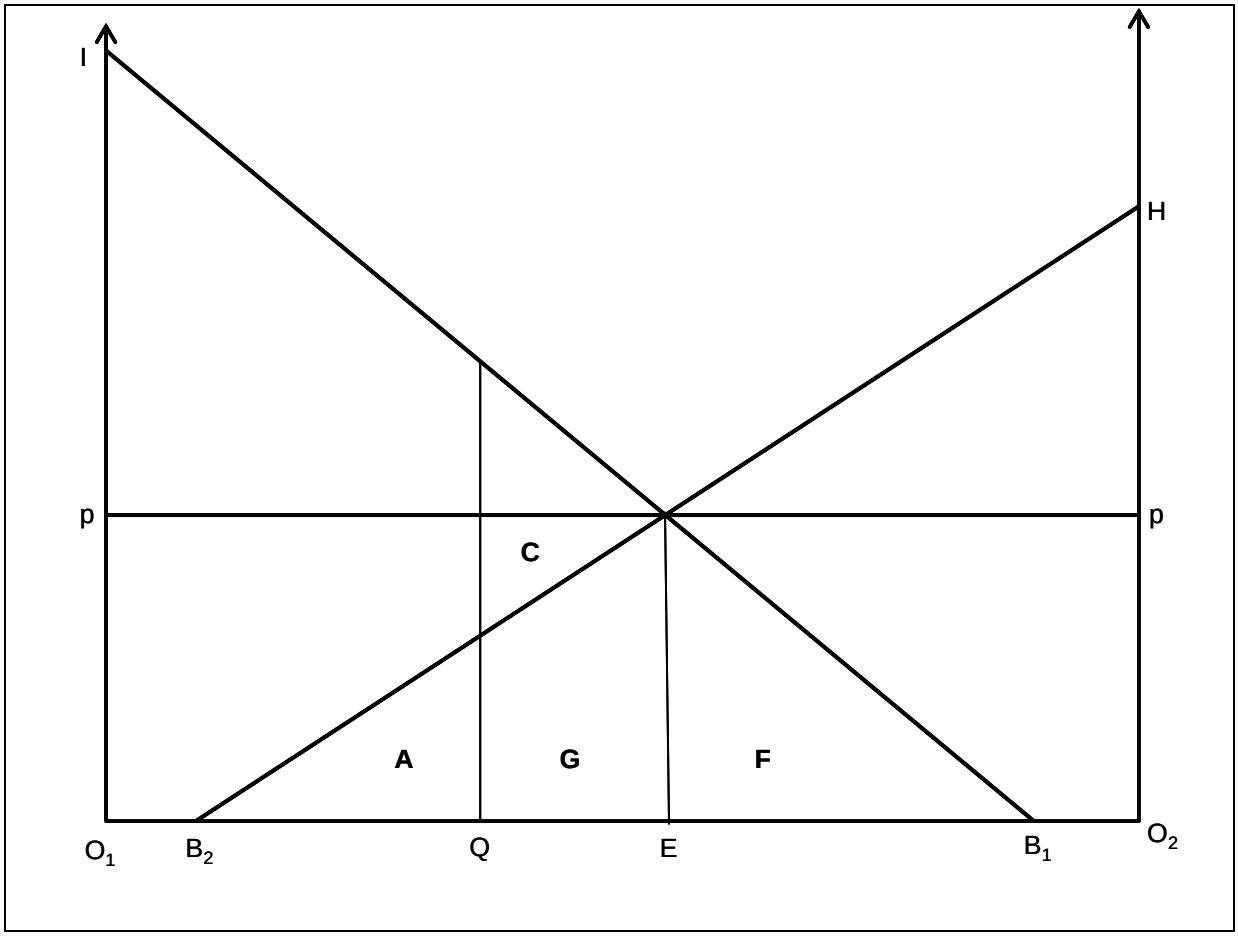

Figure 1. Illustration of an agreement between two countries

Table 1. GDP, emissions in BAU and the national quotas in the 2009 Copenhagen Accord*

	GDP in BAU (Bn USD)	1990 emissions** (MtCO2)	BAU emissions (MtCO2)	National quota (MtCO2)	Emission reduction commitment (%)
United States	17 548	4 989	5 982	4 959	1
Japan	4 601	1 054	1 219	791	25
Europe	18 811	4 149	4 450	2 904	30
Russia	3 331	2 393	1 945	1 914	20
Total	44 291	13 571	13 596	10 568	16

* Source for GDP in BAU (2020), base year emissions (1990 and 2005), and BAU emissions (2020): IEO (2009).
**Japan, Europe, and Russia apply 1990 as their base year. Using 2005 as base year, the United States has submitted an emission reduction target of 17 per cent, corresponding to an emissions reduction of approximately 1 per cent relative to the 1990 level.

Table 2. Simulated emission abatement, permit purchase, and costs

	Emission abatement (MtCO2)	Permit purchase (MtCO2)	Abatement costs (Bn USD)	Trade bill (Bn USD)	Total costs (% of GDP)	Estimated deposit (% of GDP)
United States	1 696	-673	31	-25	0.04	0.18
Japan	191	238	3	9	0.26	1.32
Europe	635	911	12	33	0.24	1.19
Russia	506	-475	9	-17	-0.24	0.00

Table A1. Starting point for calibration of the model

	Emission abatement (%)*	Emission abatement (MtCO2)**	Marginal abatement cost/permit price (USD/tCO2)*
United States	26.9	1 609	34.6
Japan	15.4	188	35.9
Europe	8.5	378	21.7
Russia	15.5	301	21.7

* From Table 3 in Carbone et al. (2009).
** From IEO (2010).

Table A2. Parameter values for c_i

	c_i
United States	0.0215
Japan	0.1912
Europe	0.0575
Russia	0.0721