Discussion Papers No. 436, October 2005
Statistics Norway, Research Department

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Cap-and-Trade or Carbon Taxes?
The Feasibility of Enforcement and the Effects of Non-Compliance

Abstract:
One of the proposed alternatives to Kyoto's cap-and-trade approach is a regime based on an internationally harmonized carbon tax. In this paper, we consider and compare the enforcement problems associated with a tax regime and a cap-and-trade regime, respectively. The paper tries to convey two main points. First, both types of regime require an effective enforcement mechanism. However, such a mechanism is unlikely to be adopted as part of a regime with full participation, because the political process leading up to its adoption tends to water down the enforcement mechanism to a point where it no longer has much bite. And even if this is somehow avoided, countries expecting compliance to be difficult or costly will almost certainly decline to sign – not to mention ratify – the resulting agreement. Second, the implications of non-compliance in a tax regime differ in important ways from the corresponding implications in a cap-and-trade regime. In a cap-and-trade regime emissions trading can make inaction legitimate for buyers of emission permits. In particular, overselling of permits by one (or a few) permit exporting countries might completely undermine the regime's environmental effect. In a tax regime, by contrast, one country's non-compliance can *not* make inaction by other countries legitimate. It follows that an agreement based on a harmonized carbon tax will always have *some* effect, provided that at least one country complies.

Keywords: Climate agreements, compliance, enforcement, emissions trading, carbon taxes.

JEL classification: Q30, Q41

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1. Introduction

Although President George W. Bush declared in March 2001 that the United States would not ratify the Kyoto Protocol, a number of other countries stayed on the Kyoto track.[1] Meanwhile, scholars as well as politicians continue to consider alternative designs for an international climate regime. An important motivation for this is that Kyoto suffers from a number of weaknesses.[2] It is therefore an open question how well it is going to function in practice. Should Kyoto fall short of its ambitions in early commitment periods, proponents of alternative regime designs might gain some ground.

One of the proposed alternatives to Kyoto's cap-and-trade approach is a regime based on an internationally harmonized carbon tax. The advocates of this option argue that the tax approach has a number of advantages over Kyoto's quantitative design.[3] It has been suggested, however, that the tax approach might prove extremely difficult to enforce. Others claim that the enforcement problem can be overcome by way of an appropriately designed compliance system.

In this paper, we argue that the enforcement problem poses a serious challenge both for a cap-and-trade regime and for a regime based on an internationally harmonized carbon tax. We do not dispute that it might be possible to design an appropriate compliance mechanism for a tax regime. Rather, we consider this to be a question that has yet to be settled.

The paper tries to make two main points. First, even if someone should come up with a good proposal for a compliance mechanism, it is unlikely that the proposal would be adopted as part of a tax regime with full participation. The reason is that the political process leading up to its adoption would likely water down the compliance mechanism to a point where it would no longer be effective. And should this somehow be avoided, countries expecting compliance to be difficult or costly would almost certainly decline to sign – not to mention ratify – the resulting agreement. In short, one should expect a tax regime with full participation to be feasible only if there is no effective enforcement mechanism to accompany it. Conversely, an effective enforcement mechanism would likely be adopted only if participation is less than full. Note that these somewhat pessimistic conclusions do not imply that a tax regime would necessarily be inferior to the Kyoto approach. Rather, the two types of regime are likely to share some of the same weaknesses.

Second, the implications of non-compliance in a tax regime differ in important ways from the corresponding implications in a cap-and-trade regime. Because emissions trading can make inaction legitimate for buyers of emission permits, overselling of permits by one (ore a few) parties

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[1]Possible explanations for Kyoto's persistence are reviewed in Hovi, Skodvin and Andresen (2003).

[2]See section 2 for further details on the weaknesses of the Kyoto approach to reductions of greenhouse gases.

[3]See section 3 for an account of the pros and cons of a regime based on a coordinated carbon tax.

might, at least in principle, undermine the entire environmental effect of a cap-and-trade agreement. Non-compliance in the form of what we call 'underbuying' might have equally serious consequences because underbuying makes sellers' permits available to other buyers, lowers the permit price, and consequently makes inaction legitimate. In a tax regime, by contrast, one country's non-compliance can *not* make inaction by other countries legitimate. This is illustrated by some numerical examples in section 6. In fact, an agreement based on a harmonized carbon tax will always have *some* effect, provided that at least one country complies. We thus conclude that enforcement is more important for a cap-and-trade regime than for a tax regime.

The paper is organized as follows. Section 2 briefly reviews possible reasons to look beyond Kyoto's cap-and-trade approach. Section 3 summarizes the main arguments in favour of a regime based on a harmonized carbon tax. Section 4 considers and compares the enforcement problems associated with a tax regime and a cap-and-trade regime, respectively. Section 5 discusses the political feasibility of an enforcement system in a tax regime. Section 6 explores the effects of non-compliance in the two types of regime. Section 7 provides some numerical illustrations of these effects, while finally section 8 closes the paper with some concluding remarks.

2. Why look beyond Kyoto?

If experts on global warming agree on anything, it is that climate change is a global problem that must be solved globally. Greenhouse gases mix almost perfectly in the atmosphere, meaning that mitigation of climate change is a pure public good. In light of this, it is an obvious problem with the Kyoto Protocol that it has failed to achieve universal participation. In particular, the United States – the world's largest emitter of greenhouse gases – has decided not to ratify the protocol. The same is true for Australia. At the same time, Kyoto places no limitations on emissions in China, India, Brazil, or other third world countries.

Of course, it cannot be ruled out that subsequent US or Australian administrations might reconsider and ratify Kyoto at some future stage. Similarly, even if Kyoto currently does not impose quantitative restrictions on developing countries, it is not inconceivable that these countries might accept real commitments later on. Proponents of Kyoto often emphasize that the current treaty is only a first step, and that it must be judged in this light. For example, Michael Grubb argues that Kyoto's "basic intent is to provide the structure for a dynamic, evolving regime that can effectively tackle climate change over the course of the Century" (Grubb 2003, 157). But even if we accept the premise that Kyoto will eventually get closer to full participation, other significant objections remain. Three problems have received particular attention in the literature.

First, and related to the participation issue, Kyoto will do little to alleviate the problem it is designed to solve. The countries for which Kyoto provides binding constraints are responsible for just 19% of global emissions (Barrett 2002:38).[4] And these countries are required to reduce their emissions by only a little over 5%. This will barely have any effect on the climate at all. It has been estimated that compared to a business-as-usual scenario, and without the US, the Kyoto Protocol will reduce global emissions by only 0.9 percent (Hagem and Holtsmark 2001:3).

Second, the global cost of fully implementing the Kyoto Protocol has been estimated to be more than $700 billion in present value (Nordhaus and Boyer 2001:93). The IPCC report estimates that, even with full emissions trading, the reduction of GDP in 2010 will be in the range of 0.1 to 1.1 percent. Even though any estimate of this kind is bound to be highly uncertain, the costs of implementing Kyoto will almost certainly be substantial.

Third, Kyoto is difficult to enforce. True, the Marrakesh Accords provide detailed regulations for a compliance mechanism for Kyoto. However, this mechanism suffers from a number of weaknesses. If a country exceeds its emission target, it is supposed to make up for the deficit, plus an extra 30%, in the next commitment period. If it fails to do this, then presumably another 30% will be added on top of this (thus making the penalty 1.3^2 times the original deficit). But nothing prevents the non-compliant country from postponing the implementation of the punishment for yet another period. Thus, one might reasonably question if the penalty will *ever* be implemented. Another difficulty with the compliance system is that the parties' targets in future commitment periods have yet to be determined. A country expecting that it will be unable to meet its target for the first commitment period will likely bargain for a generous target for the second period. If successful, it might be able to reduce, or even eliminate, the real impact of the penalty. Finally, the enforcement mechanism developed in the Marrakesh Accords is not legally binding. According to Article 18 of the Kyoto protocol, "any procedures and mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this protocol." It is far from clear that we should expect countries that find it difficult to fulfil their obligations to consent to and ratify such an amendment Barrett (2003:386). We shall return to this important point in section 5.

Of course, one can not completely rule out that Kyoto, despite its weaknesses, will work reasonably well in practice. However, one should also be prepared for the opposite outcome. It is therefore important to continue to map and analyze possible candidates for an alternative design of the climate regime. For each alternative one needs to ask (i) to what extent it has the potential to tackle

[4]To see why, recall that the treaty could not enter into force until it was ratified by countries accounting for at least 55% of emissions in Annex I countries. However, Annex I countries account for only about 56% of *global* emissions. Furthermore, many Annex I countries (including Russia) will not have to reduce their emissions at all.

climate change; (ii) if it encourages full participation; (iii) whether it depends heavily on enforcement at the international level, and if so (iv) whether institutions needed for this purpose are likely to be adopted. This paper tries to contribute to answering these (interrelated) questions for one particular alternative to Kyoto's quantitative approach, namely a regime based on an internationally harmonized carbon tax.

3. The Case for Harmonized Carbon Taxes

3.1. The Nature of an International Tax Regime

An international carbon tax regime is likely to have the following characteristics. First, countries would agree to penalize emissions domestically via an internationally agreed-upon and harmonized tax on carbon emissions. Thus, a positive cost is imposed on CO2 emissions, thereby creating a fixed monetary incentive to reduce emissions (Pizer 1999:2). No emission targets, no emissions trading, and no base period emissions levels would be involved (Nordhaus 2001).

Second, participation may (but need not) be made contingent on the level of economic development. One option could be to include a provision that requires countries to participate fully when their income levels reach a given stage.[5] Furthermore, poor countries could be compensated for participation via aid or other transfers. Obviously, similar thresholds and incentives are also conceivable within a cap-and-trade regime.

Third, taxation could in principle be placed on consumption as well as on production. Again, this is largely parallel to a tradable permit system, where the requirement to obtain permits could be placed either on consumers or producers of fossil fuels. In a tax system it seems to be preferable in efficiency terms to tax consumption, but it is conceivable that producer countries would insist that at least part of the tax be placed on production (Nordhaus 2001).

Fourth, if taxes are evened out across all countries, there is no need for tariffs or border tax adjustments in relation to trade among participants. However, if some countries remain outside the regime, these countries would obtain a competitive edge over countries inside the regime. To counteract this effect, border tax adjustments might be required for trade between parties and non-parties.

Finally, an important difference from a tradable permit system has to do with how the system adjusts when costs change unexpectedly. In a permit system such a change would induce a shift in demand or supply. In turn, this would cause the permit price to go up or down, while overall

[5]Nordhaus (2001:11) mentions $10.000 per capita as a possible threshold.

emissions would remain constant (assuming 100% compliance). By contrast, in a tax system total emissions would rise or fall, while the price associated with emissions would remain constant (Pizer 1999:3).

3.2. The Case for Taxes I: Efficiency

Economic theory tells us that if cost and benefit functions are known with certainty, then a price based policy (such as a tax) and a quantitative policy (such as tradable permits) are equivalent from an efficiency point of view. Both types of approach enable policymakers to reach a cost-effective outcome, meaning that the least expensive options for abatement are being used (e.g., see Kopp 1999). However, it is commonly held to be one of the key aspects of climate policy that cost and benefit functions are uncertain. One reason for this is that there is little historical evidence about the costs of obtaining a certain reduction of emissions. In addition, when choosing a particular type of regime we need to consider policies several years into the future, and it is unclear how both baseline emissions and available technologies will change in the meantime (Pizer 1999:4).

When costs and benefits are uncertain, tax based and quantity based regimes are likely to have quite different implications – both for emission levels and for the costs of implementation (Weitzman 1974). The reason is that a tax regime provides a fixed monetary incentive per ton of emissions regardless of the level of emissions, while a regime based on tradable permits provides whatever monetary incentive is needed to deliver a fixed level of emissions (Pizer 1999:4). Thus, with a quantitative regime the cost of implementation can be high or low, depending on both future abatement costs and the development of future emissions in the business-as-usual scenario. In contrast, because a tax regime is based on a fixed monetary incentive, the cost of implementation is likely to fluctuate much less. Pizer reports simulations confirming that costs are much more narrowly distributed with a tax regime (0.2% to 0.6% of global GDP) than with a regime based on tradable permits (0 to 2.2% of GDP). The simulations are based on a global quantity target of 8.5GtC and a carbon tax of $80 per ton. In Pizer's model these two policies are roughly equivalent under a "best guess" scenario.

What are the conditions under which each type of regime is preferable? If every ton of carbon dioxide emissions entails the same amount of additional damage, it makes good sense to use a fixed carbon tax per ton of emissions. To be cost effective, the tax per ton of emissions should be set equal to the marginal damage caused by one additional ton. By contrast, if there is a *known* climate change threshold, beyond which further emissions would have catastrophic consequences, a quantitative approach ensuring that we do not cross the threshold would be preferable. The reason is that a tax regime is unable to deliver a similar type of guarantee. However, the consequences of

climate change depend on the stock of greenhouse gases, not annual emissions. Hence, quantitative limitations on emissions are not equivalent to control of climate change. Furthermore, while there is considerable disagreement on what the target for concentrations of GHGs in the atmosphere should be,[6] few if any experts seem to believe that we are now on the verge of crossing a climate change threshold. Taking into account both the potential long-term damages of climate change and the costs of regulation, Pizer (1999:1) concludes that the expected net gains of a harmonized tax are "fives times higher than even the most favourably designed quantity target". Others conclude along the same lines (Hoel and Karp 2001, 2002). Thus, efficiency seems to provide a fairly strong motivation for choosing a tax regime.

3.3. The Case for Taxes II: Other arguments

A number of other factors that makes a harmonized carbon tax preferable to Kyoto's cap-and-trade regime are listed by Nordhaus (1999). First, as already mentioned, a quantitative regime is likely to show highly volatile prices for emission permits. The reason is that the supply of permits is likely to be inelastic. At the same time, the demand for permits may also be expected to be relatively inelastic, at least in the short run. The history of the sulfur-emissions trading program arguably lends some support to this argument, since prices have varied by more than 50% from one year to the next.[7] Such rapid fluctuations in prices could easily cause a quantitative approach to become very unpopular with industrial leaders and economic policymakers.

Second, a tax based regime has the advantage that it allows the efficiency loss to be left unchanged. However, an important condition is that the imposition of the carbon tax is linked to a corresponding reduction in other taxes that have "approximately the same marginal deadweight loss as the carbon tax" (Nordhaus 2001:16). Against this argument it could be objected that an international cap-and-trade regime in principle does not force the participating countries to implement cap-and-trade regimes domestically. International permit trading at governmental levels might be combined with implementation of taxes domestically. Hence, the reimbursement gains might be harvested at the national level in an international cap-and-trade agreement as well. Moreover, if domestic cap-and-

[6] For example, the EU has recommended 550 ppm (parts per million) as a reasonable target for CO_2 levels in the atmosphere. By contrast, Malte Meinshausen of the Swiss Federal Institute of Technology has recently estimated that if CO_2 levels stabilise at 550 ppm, there would still be a 75% chance of a temperature rise of more than 2°C by 2050. If CO_2 levels stabilize at 450 ppm, the chance of such a temperature rise would drop to 50%, and if levels stabilize at 400 ppm, to 25% (http://www.newscientist.com/article.ns?id=dn6964). Hansen and Nazarenko (2004:427) suggest that the level of dangerous anthropogenic interference "will be set by the need to preserve global coastlines and that this implies the need to keep additional global warming less than ≈ 1°C". However, they add that "others have suggested that the limit on global warming required for ice sheet stability is 2°C or larger". See also Hansen (2004, 2005), Mastrandrea and Schneider (2005), O'Neill and Oppenheimer (2002).

[7] Nordhaus reminds us that in the short run, carbon and sulfur share the characteristics that supply is virtually fixed, and demand is very inelastic.

trade systems are based on auctioning, the reimbursement gains will principally be equal in both types of regimes.

Third, a tax has some advantages in terms of transparency. Whereas a quantitative approach enables policy makers to conceal the economic costs of the chosen policy, this is more difficult with a tax mechanism. Many of us know approximately what our gasoline taxes are, but few have a clear idea of what we pay for ozone abatement. Similarly, we usually know who benefits from a subsidy, but not who gains from "grandfathering" sulphur or carbon dioxide emissions allowances (Nordhaus 2001:16).

Fourth, a tax based regime is arguably less susceptible to corruption than a quantitative approach. Emission permits create a potential for making a profit for those who control the permits. Thus, there is a danger that dictators and corrupt administrators might choose to "sell part of their permits, pocket the proceeds, and enjoy first-growths and song along the Riviera" (Nordhaus 2001:17)". To deter undesirable behaviour, extensive schemes for monitoring and potential sanctions may be needed. However, the more burdensome the ethical restrictions on the sale of permits, the less attractive it becomes to participate, and the less effective the regime is likely to become. With a price approach, there is less room for corruption, because it "does not create artificial scarcities and monopolies" (Nordhaus 2001:17). There are simply no permits that can be sold in order to acquire guns or finance other unwanted activities. Any additional income would come from taxation of fuels, which could also be obtained without any international agreement to combat climate change.

Fifth, a carbon tax avoids many of the problems of determining baseline emission paths. Under the Kyoto protocol, targets were set thirteen years before the beginning of the first commitment period, using historical benchmarks from eighteen years before the beginning of this period. Nordhaus argues that the 1990 base year penalizes efficient countries (like Sweden) as well as rapidly growing countries (such as Korea), while giving a premium to countries with slow growth or historically high carbon-energy use (such as Britain, Russia or Ukraine). By contrast, the baseline with a tax regime would be the level of emissions corresponding to a zero carbon tax (Nordhaus 2001:18). No historical base year of emissions would be needed, and so countries would not be advantaged or disadvantaged by past policies or the arbitrary choice of a particular base year.

Finally, a tax based treaty is likely to reduce the risk that in the future, new administrations might cancel the commitments made by their predecessors, and withdraw from the international climate regime. Using carbon taxes to fund vital public expenditures such as pensions, schools and roads might render such taxes difficult to abolish. This might enhance the credibility of commitments in a tax regime, and could provide the glue needed to sustain the climate regime over time (Nordhaus 2001:19).

4. Enforcement – the Downside of Taxes?

With all these nice arguments in favour of a tax regime, is there a catch? David Victor contends that the major problem with a tax regime is that it might be difficult to administer effectively:

> Monitoring and enforcement are extremely difficult…. In practice, it would be extremely difficult to estimate the practical effect of the tax, which is what matters. For example, countries could offset a tax on emissions with less visible compensatory policies that offer loopholes for energy-intensive and export-oriented firms that would be most adversely affected by the new carbon tax. The resulting goulash of prior distortions, new taxes, and political patches could harm the economy and also undermine the goal of making countries internalize the full cost of the greenhouse gas emissions (Victor 2001:86).

Similarly, Eizenstat (1998:120) argues that countries might seemingly maintain their existing energy taxes, while in practice offsetting the impact of a new carbon tax through other changes in tax or subsidy policies, such as rebates on certain taxes or increased public funding of highway construction. As a result, it might be hard to distinguish permissible from prohibited policies. To do this, it could be necessary to undertake extensive international scrutiny of domestic tax decisions.

Nordhaus believes that the problems of administration and enforcement can be overcome. He argues that the major stumbling block to enforcement is the measurement of "net carbon taxes". The problem is that

> it might be difficult to measure the net level of carbon taxes in the context of other fiscal policies (such as fuel taxes and coal subsidies). For example, suppose that Germany imposed a $50 carbon tax, which would fall primarily on coal. It might at the same time increase its coal subsidies or reduce its gasoline taxes to offset the carbon tax, thereby reducing the level of net carbon taxes. Alternatively, Canada might impose a $10 carbon tax while reducing its gasoline tax and lowering provincial stumpage charges on timber (Nordhaus 2001:20).

The question is how the carbon tax can be calculated in such circumstances. The problem has two parts. The first is to map all relevant taxes and subsidies for each country, in particular taxes and subsidies that relate to energy. Nordhaus considers this problem to be fairly straightforward. In this respect, he is in agreement with another proponent of the tax approach, Richard Cooper (1998), who argues that the imposition of a common carbon tax would be relatively easy to monitor. While acknowledging that monitoring the enforcement of such a tax at the national level might be more difficult, Nordhaus suggests that a possible solution might be to use existing IMF procedures for consultations over the level and composition of member countries' tax revenues. In addition, one might rely on environmental interest groups to monitor internal developments and alert the international community if a country imposes hidden carbon subsidies.

The second problem of calculating the carbon tax is to design an appropriate methodology for combining the different numbers into an overall carbon tax. Nordhaus considers this problem to be more complicated, because it involves several technical issues. For example, one would need rules specifying how to convert energy taxes into their carbon equivalent. Nordhaus believes, however, that calculations of effective carbon tax rates would be relatively straightforward provided that they do not need to involve substitution effects. By contrast, to include substitution effects would not only require assumptions about supply and demand elasticities and cross-elasticities, but might also engender disputes among countries, and should be avoided if possible (Nordhaus 2001:21).

5. The Feasibility of Enforcement

The thrust of Nordhaus' argument is that it is possible to design an enforcement mechanism that is able to curb the incentives for non-compliance created by a tax-based regime. In this respect he is considerably more optimistic than Victor or Eizenstat, although Nordhaus also acknowledges that there are obstacles related to enforcement of a tax regime. For our purposes it is not essential to decide which side is right. The reason is that, even if it should be possible to design appropriate institutions for enforcement of a tax regime, it is unlikely that such institutions would be politically feasible. This section explains this point in some detail.

Scott Barrett (2003) offers interesting accounts of how treaties equipped with mechanisms for enforcement tend to achieve high levels of compliance. At the same time, a number of scholars have observed that remarkably few international environmental agreements have enforcement mechanisms (Chayes and Chayes 1993, 1995. See also Brown Weiss and Jacobson 1998). As Barrett points out, the meaning of this observation is open to interpretation. One possibility is that decisions about compliance are not made on the basis of a calculation of advantage, and that, therefore, enforcement is unnecessary. However, another explanation is that most international agreements only sustain outcomes close to what would have happened in any case (Downs et al. 1996). In the latter case, there is no implication that enforcement is unnecessary to achieve effective cooperation.

Of course, it is tempting to infer from Barrett's account that treaties equipped with a mechanism for enforcement achieve high levels of compliance *because* of these enforcement mechanisms. However, as we shall now see, an alternative explanation is that the correlation is spurious, and that the cost of compliance determines *both* the level of compliance *and* the extent to which institutions for enforcement are compatible with full participation.

In most cases, international mechanisms for enforcement need to be adopted by consensus. More rarely, they can be adopted by some kind of majority vote, but then there is typically some clause specifying that the mechanism applies only to countries that explicitly submit to its

superiority. For example, the Kyoto protocol specifies that "any procedures and mechanisms…entailing binding consequences shall be adopted by means of an amendment to this protocol."[8] Even though such an amendment can – as a last resort – be adopted by a three-fourths majority vote by the Conference of the Parties serving as the Meeting of the Parties (the COP/MOP), the consequences become binding only on those countries that choose to ratify the amendment.

An enforcement mechanism authorized to impose punitive consequences can potentially be very costly to a country that encounters serious compliance problems. Faced with a credible mechanism of this type, such a country might be forced to make a difficult choice between accepting high compliance costs and suffering punitive consequences. Anticipating this, a country that expects to find compliance difficult is unlikely to consent to the establishment of a tough enforcement mechanism in the first place. Instead, it will either (i) object to such a mechanism and refuse to ratify if it is nevertheless adopted; (ii) give its approval only after the mechanism has been watered down to an extent that renders it without teeth, or (iii) insist on the provision of a loophole that renders any remaining teeth harmless to the country in question.

Suppose that a particular country (say, country A) refuses to accept a particular proposal for an enforcement mechanism for treaty T. Furthermore, assume that no alternative proposal for an enforcement mechanism exists. There are then two possible scenarios. First, other countries might move on and adopt the proposal without A. Second, the enforcement mechanism may be watered down, or loopholes added, until all parties (including A) find the result acceptable.[9] In the first scenario, the enforcement mechanism is probably not really needed, because none of the remaining parties are likely to have a strong incentive for non-compliance. If any of these countries *did* have such an incentive, it would have been rational for them to join forces with A and refuse to accept the enforcement mechanism. In the second scenario, the resulting enforcement scheme becomes weak – unable to accomplish much in real terms. In either case, the final treaty allows little room for enforcement in practice.

Most international environmental regimes share two characteristics that make the above logic particularly relevant to such regimes. First, they seek to resolve problems that involve multilateral rather than bilateral interaction. This makes them very different from, say, a trade regime. The compliance system of the WTO is consistent with the above logic in that it does not enable the organization itself to impose punitive consequences on a non-compliant country. However, lack of centralized means of enforcement is not critical for the WTO because non-compliance by one Member can often be effectively punished by another Member. Hence, the WTO can concentrate on ensuring

[8]The Kyoto Protocol, Article 18.

[9]As a special case, the countries might agree to drop the enforcement system completely.

that such decentralized punishment follows the requirements of due process. For example, a Member cannot legitimately withdraw a concession previously made under WTO agreements unless this has been authorized by the Dispute Settlement Body. Because environmental regimes (including the climate regime) regulate multilateral forms of interaction, punishment of non-compliance becomes a public good for compliant countries. Thus, the incentives for individual countries to punish non-compliance are weaker than in a trade regime. Hence, the need for centralized means of enforcement is stronger.

Second, international environmental regimes are typically specialized in the sense that they focus on a single issue (such as climate change). This distinguishes them from more complex organizations (such as the European Union). Because complex organizations regulate a large number of issues, non-compliance is unlikely to be systematically concentrated to one or a few countries. Rather, different countries often have incentives for non-compliance in different issue areas. When this is the case, it might be in the best interest of all member countries to accept a tough enforcement mechanism even if every member see this as undesirable in the particular issue area where it has an incentive for non-compliance.[10]

For environmental (i.e., single-issue) regimes the situation is different, because incentives for non-compliance are more likely to be systematically concentrated to a subset of member countries. For countries that belong to this subset accepting enforcement with punitive consequences would be equivalent to self-punishment.

Interestingly, even the EU countries have had a hard time negotiating a common CO_2/energy tax. After more than ten years of negotiation, and numerous setbacks, agreement was finally reached in 2003. However, the resulting directive was a "watered down version of previous proposals, with very low minimum rates and a long list of exemptions" (Hasselknippe and Christiansen 2003:4). Thus, the directive probably did not create incentives for non-compliance, simply because the directive did not make much of a difference in terms of policy.[11]

We are now able to give an alternative explanation for Barrett's apparent correlation between compliance levels and the existence of procedures for enforcement. Barrett implies that the existence of such procedures tends to *cause* high levels of compliance. An alternative interpretation is that the correlation is spurious, and that the cost of compliance determines *both* the level of compliance *and* the extent to which institutions for enforcement are compatible with full participation.

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[10] Nevertheless, it is interesting to note that the strengthening of the European Court of Justice has not been applauded by all members of the EU. Rather, it seems that the Court has been able to move the enforcement of state compliance "beyond governments' original intentions when delegating supervisory competences" (Tallberg 2000).

[11] As pointed out by an anonymous referee, one might ask what chance there is for world-wide agreement on a harmonized carbon tax when this directive is all that the EU countries can come up with after more than ten years of negotiations.

The argument presented above suggests that international institutions for enforcement are compatible with full participation only in cases where compliance costs are close to zero for all countries. Of course, if compliance costs are close to zero, then it should come as no surprise that compliance levels are high. Zero compliance costs imply that there is no incentive for cheating and hence no need for enforcement. The dismal conclusion is this: In cases where there is a real need for an enforcement mechanism based on punitive consequences, such institutions are unlikely to be politically feasible. Conversely, in cases where such an enforcement mechanism is politically feasible, there is likely not much need for it.

The negotiation process leading up to the Marrakesh Accords is illustrative in this regard. Werksman (2005) describes the political landscape of these negotiations, the main focus of which was the enforcement procedures. Unsurprisingly, the central dynamic of the negotiations developed amongst the industrial countries to which these procedures would actually apply. At the second part of the sixth Conference of the Parties (COP-6) in Bonn in July 2001, ministers consented to the need for punitive consequences and "agreed terms that described the application of these consequences in clear and mandatory terms. They failed, however, to agree on how to bring the compliance system into force" (Werksman 2005:32). The disagreement reflected differences over the legal form of the Compliance Procedure, and the issue was deferred to the first COP/MOP to "decide on the legal form of the procedures and mechanism relating to compliance" (Werksman 2005:32).

This means that even though Kyoto's compliance mechanism may be tough on the face of it, it is far from clear whether the punitive consequences will be legally binding. And even if the COP/MOP should eventually pass an amendment that makes the compliance system legally binding (which requires a three-fourths majority vote among the parties present and voting), it becomes binding only on those parties that choose to ratify the amendment. In addition, the compliance mechanism suffers from a number of other weaknesses.[12] It is thus unlikely that in the end Kyoto's seemingly sophisticated compliance system will significantly promote the effectiveness of the protocol.

It is characteristic that the countries least eager to accept a tough compliance system were those foreseeing that they could experience compliance problems, meaning that they might actually have to face punitive consequences themselves. The developing countries had previously opposed the introduction of a tough enforcement system, and did not change their mind until it became crystal clear that the compliance mechanism would apply only to Annex I countries. Furthermore, Annex I countries' choice between a purely facilitative and an enforcement approach depended, at least in part, on the perceptions of the delegations. Some delegations' negotiating stances "seemed to be predicated

[12]See section 2.

on the assumption that it would always be a country other than their own that would find itself facing the enforcement branch" (Werksman 2005:25). For example, despite domestic assessments that the costs of reaching its target could be considerable, the US delegation "consistently sent the message that once the US commits to a target, the robustness of its domestic legal and regulatory system, in combination with the market mechanisms, would deliver the results (Werksman 2004:25)". By contrast, the Australian, Japanese and Russian delegations were more willing to envisage the possibility of their own country's non-compliance. Unsurprisingly, these countries were very reluctant to accept enforcement. As we have seen, the result was a compliance system with a number of deficiencies, one of which is that its legal status remains unclear.

6. The Effects of Non-compliance

A simple test for a proposed regime design is to ask if it requires enforcement to be effective. If it does, it is likely that a different design – one that is largely independent of enforcement – is better. The Kyoto cap-and-trade regime fails to pass this test. The reason is that emissions trading make it possible for a country to be in compliance with its Kyoto obligations even if no abatement is actually carried out domestically, due to another country's non-compliance. The reason is the possibilities for overselling and underbuying. We consider overselling first.

Suppose that country A sells emission permits to country B that enable country B to be in compliance with its Kyoto commitments without undertaking any abatement domestically. Furthermore, suppose that later on it is revealed that this sale was not matched by a sufficient amount of abatement or sufficient amounts of hot air in country A. Note that this will be of no concern to country B if the trade has already been approved by the regime. In addition, country A might sell permits that are not matched by domestic abatement or hot air to other countries as well. In this way, non-compliance by one (or a few) permit selling countries might, at least in principle, undermine the entire environmental effect of a cap-and-trade regime.

Underbuying might be an even more serious problem in a cap-and-trade agreement, because overselling to some extent could be prevented by requirements like the commitment period reserve (CPR), see the discussion below. Suppose again that country A is a permit seller. Furthermore, suppose that both country B and country C need to buy permits in order to be in compliance. If country B ignores its commitment to buy permits, more permits from country A becomes available to country C (at a lower price). Thus, non-compliance by country B legitimates inaction by country C. In this way, non-compliance by a permit buyer might undermine the environmental effect of a cap-and-trade agreement.

As mentioned above, the Marrakesh Accords impose CPR requirements in order to limit the possible severe consequences of non-compliance with the Kyoto Protocol. The CPR requires each party to hold its stock of allowances equal to the lower of (a) 100% of the party's recently reviewed emissions inventory and (b) 90% of the party's Assigned Amount (AA, the national quota). Unfortunately, this clause in the Marrakesh Accords is insufficient to rule out all types of non-compliance that legitimate inaction by other parties. Furthermore, it is difficult to see how the CPR or corresponding requirements could be developed or redesigned in order to prevent serious non-compliance – with potentially severe consequences – in a cap-and-trade system. In particular, the CPR does not prevent non-compliance due to underbuying. The CPR means that trades will be disapproved if they imply that the number of allowances held by selling parties drop below CPR requirements. Hence, the CPR might in some (not all) cases effectively prevent parties from overselling. However, the CPR requirements can not compel a party to buy allowances. As discussed above, underbuying might entail the serious consequence of legitimating inaction by other parties.

According to Missfeldt and Haites (2002), elimination of non-compliance due to overselling requires that the 100% and 90% specifications of CPR must be increased to 105% and 100%, respectively. The reason is, among other things, that there will be a time lag between emissions and publication of reviewed emissions inventories. Hence, the most recent emissions inventories might be misleading with respect to the seller countries' final need for allowances in order to be in compliance. As a consequence, despite the CPR requirements there might be overselling which could undermine the environmental effect of the Kyoto Protocol.[13,14]

It is less clear to what extent a regime based on a harmonized carbon tax requires effective enforcement. A tax-based agreement resembles Kyoto's cap-and-trade regime in that both types of regime are likely to entail incentives for non-compliance. In particular, participating countries in a tax regime might be enticed to counteract the impact of the carbon tax by reducing other taxes, by increasing existing subsidies, or by introducing new ones. Obviously, the higher the carbon tax, the stronger the incentive to adjust other taxes and subsidies becomes.[15] Moreover, such means of adaptation might be difficult to discover. All of this calls for effective surveillance and enforcement.

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[13] That the 105% and 100% requirements were not adopted may be explained by the need for liquidity in the international market for emission allowances in order to enable the market to perform efficiently.

[14] We should add that Missfeldt's and Haites's calculations presuppose that there is a two years lag with respect to inventories, e.g., 2006-inventories are available and constitutes the basis for calculation of the commitment period reserves in 2008. However, according to the rules provided by the Marrakesh Accords, the parties are committed to submit their inventories of for example 2006 no later than 15 March 2008. A review/approval process then follows. Hence, with current procedures the 2006-inventories will not be approved until towards the end of 2008 at the earliest. Hence, the time lag should be three years instead of two. The consequence is that Missfeldt and Haites (2002) probably underestimate the parties' potential for overselling in cases where emissions are increasing during the commitment period.

[15] Downs et al. (1996) show that the deeper the level of international cooperation, the stronger the need for enforcement.

On the other hand, the potential gains from non-compliance will be smaller in a tax regime than in a cap-and-trade regime. First, the countries in a cap-and-trade regime might be tempted not only to tolerate larger domestic emissions than allowed by their targets, but also to carry out over- or underselling in order to make a potentially substantial profit. By contrast, in a tax regime non-compliance will at best enable a participating country to save domestic abatement costs. Second, while in a cap-and-trade regime one country's non-compliance can make inaction by other countries legitimate this is not possible in a tax regime. Thus, a tax regime will always have at least *some* environmental effect provided that at least one country complies.[16] And if several major countries comply with the agreement, a tax regime will have a significant environmental effect even if a number of other countries fail to comply.

7. Numerical Examples

In this section we present some numerical examples that illustrate the effects of non-compliance in the two types of regime discussed in this paper. The commitments of the Kyoto Protocol are taken as a starting point for the numerical examples. However, Kyoto is unlikely to give rise to any significant emission reductions. Therefore, in order to produce valuable numerical examples, the AAs have been stipulated to 95 percent of their true size (Table 1, second column). After these adjustments the total required cutback is assumed to be 4.07 $GtCO_2$ (Table 1, third column from right).

To derive the numerical examples, we use a simple model of emissions trading/harmonized emissions taxes. The model can be described as follows. The 'demand' for emissions within each country is assumed to be a linearly decreasing function of the price of emissions. The price of emissions in the business-as-usual (BAU) scenario is assumed to be 75 €/tCO_2. This price reflects the average market price of fossil fuels and other costs related to combustion of such fuels. Implementation of an agreement implies that a permit price or a harmonized tax is added to this price. The elasticity of emissions with regard to the price is set to -0.3 in BAU.[17]

[16]Of course, this is only true if the tax regime imposes real obligations on the compliant country. If the country in question would impose a carbon tax at or above the treaty level in any case (cf. the existing carbon taxes in the Netherlands and the Nordic countries), then 'compliance' by this country obviously has no environmental effect.

[17] With linear demand functions the elasticity varies along the demand function.

Table 1. Starting point for the numerical examples. Quotas, BAU-emissions and simulation of full compliance. $GtCO_2$

	Original AAs	Adjusted AAs	BAU emissions 2008-2012	Hot air	Cut backs	Permit import	Abate-ment
Canada	2.81	2.67	3.36	-	0.68	0.50	0.19
France	2.79	2.65	2.40	0.25	-	-0.38	0.14
Germany	4.78	4.54	4.90	-	0.37	0.09	0.28
Italy	2.49	2.37	2.40	-	0.03	-0.10	0.14
Netherlands	1.02	0.97	1.18	-	0.21	0.14	0.07
Poland	2.69	2.56	2.59	-	0.04	-0.11	0.15
Romania	1.31	1.25	1.03	0.22	-	-0.28	0.06
Russia	15.20	14.44	14.55	-	0.11	-0.72	0.82
Spain	1.73	1.65	1.81	-	0.16	0.06	0.10
Ukraine	4.53	4.30	3.88	0.42	-	-0.64	0.22
United Kingdom	3.32	3.15	3.42	-	0.27	0.08	0.19
Rest of Europe	7.15	6.80	7.35	-	0.55	0.14	0.42
New Zealand	0.36	0.34	0.42	-	0.08	0.05	0.02
Japan	5.82	5.53	7.10	-	1.57	1.17	0.40
Total	56.00	53.20	56.39		4.07	-0.00	3.19

The two right-hand columns in table 1 show the simulation results in the case of full compliance of a cap-and-trade agreement. The equilibrium permit price is 14.1 €/tCO_2. In the following an emission permit legitimating emissions of one ton CO_2 is denoted an Assigned Amount Unit, AAU. It follows that the same distribution of abatement could be achieved with a harmonized carbon tax of the same size as the equilibrium permit price. Hence, the last column of table 1 might be interpreted as the result of implementation of a carbon tax of 14.1 €/tCO_2 in all relevant countries.

We are now ready to look at the consequences of non-compliance. As a starting point, table 2 shows detailed simulation results in case Japan does not comply. With respect to the cap-and-trade case, we distinguish between 'active' and 'inactive' non-compliance. 'Active' non-compliance will be defined below. In the 'inactive' case no abatement is carried out in Japan, nor is any permits imported to this country. On the other hand, Japan does not sell any permits either.

In the harmonized tax case, we assume that Japan takes no action, while all participating countries except Japan implement the emission tax of 14.1 €/tCO_2. As a result, Japan does not carry out any abatement, whereas the other countries undertake abatement corresponding to full compliance. Tables 1 and 2 (last columns) show that passive non-compliance by Japan results in a total emission reduction

of 2.79 €/tCO_2, assuming full compliance by other countries. In contrast, with full compliance by *all* countries the emission reduction is 3.19 – a difference of 0.40 $GtCO_2$.

Table 2. Simulation results. Japan does not comply. $GtCO_2$

	Cap-and-trade						Taxes	
	Inactive non-compliance			Active non-compliance				
	Emissions	Permit import	Abate-ment	Emissions	Permit import	Abate-ment	Emissions	Abate-ment
Canada	3.25	0.57	0.11	3.28	0.61	0.07	3.17	0.19
France	2.32	-0.33	0.08	2.35	-0.30	0.05	2.27	0.14
Germany	4.74	0.21	0.16	4.80	0.26	0.11	4.63	0.28
Italy	2.32	-0.05	0.08	2.35	-0.02	0.05	2.26	0.14
Netherlands	1.14	0.17	0.04	1.15	0.18	0.03	1.11	0.07
Poland	2.51	-0.05	0.08	2.54	-0.02	0.06	2.44	0.15
Romania	0.99	-0.25	0.03	1.01	-0.24	0.02	0.97	0.06
Russia	14.07	-0.37	0.48	14.23	-0.21	0.31	13.72	0.82
Spain	1.75	0.10	0.06	1.77	0.12	0.04	1.71	0.10
Ukraine	3.76	-0.55	0.13	3.80	-0.50	0.08	3.66	0.22
United Kingdom	3.31	0.16	0.11	3.35	0.20	0.07	3.23	0.19
Rest of Europe	7.11	0.31	0.24	7.19	0.40	0.16	6.93	0.42
New Zealand	0.41	0.06	0.01	0.41	0.07	0.01	0.40	0.02
Japan	7.10	-	-	7.10	-0.55	-	7.10	-
Total	**54.77**	**0.00**	**1.62**	**55.32**	**0.00**	**1.06**	**53.60**	**2.79**

In the cap-and-trade case, Japan's AA is 1.57 $GtCO_2$ smaller than Japan's BAU emissions. The first three columns of table 2 show the results if Japan does not carry out any abatement domestically and does not buy any permits. Because this passive non-compliance causes demand to be smaller than otherwise, the permit price becomes 8.2 rather than 14.1 €/AAU. This entails a correspondingly weaker incentive for abatement in other participating countries. As a result, the total emission reduction becomes only 1.62 $GtCO_2$, assuming full compliance in all other countries. This is 1.57 $GtCO_2$ less than in the case with full compliance in *all* countries.

So far, we have ignored the fact that, even if Japan does not carry out any abatement and does not buy any credits, it might nevertheless be able to *sell* credits. In the following, we call this 'active' non-compliance. The important point here is that there is no mechanism to force any country to withdraw AAUs that have already been sold, when it becomes clear that overselling has taken place. In order to stipulate the opportunities for such overselling, we need to estimate Japan's CPR. For this

purpose, we have applied background data from Haites and Missfeldt (2004) and Missfeldt and Haites (2002), who provide an emissions scenario for Japan (as well as for other Annex B countries). Moreover, we have applied the CPR-rules of the Marrakesh Accords. The Accords commit Japan to maintain a CPR of 90 percent of its AA, as during the whole commitment period Japan's AA is smaller than five times Japan's most recent inventory, according to the scenario in Haites and Missfeldt (2004) and Missfeldt and Haites (2002). Consequently, Japan could sell 10 percent of its AA, or 553 million AAUs. The three middle columns of table 2 show the effects of such overselling. The permit price now becomes only 5.39 €/AAU and the global emission reduction is down to 1.06 $GtCO_2$. Hence, if Japan chooses active non-compliance in the cap-and-trade regime, the environmental effect of the agreement is reduced by 67 percent compared to the case with full compliance by all countries. By contrast, the corresponding reduction caused by Japan's non-compliance in the tax regime (where active non-compliance is impossible) was only 13 percent.

Table 3. Simulation results. Russia does not comply. $GtCO_2$

	Cap-and-trade			Harmonized taxes	
	Emissions	Permit import	Abatement	Emissions	Abatement
Canada	3.24	0.56	0.12	3.17	0.19
France	2.32	-0.33	0.09	2.27	0.14
Germany	4.73	0.19	0.18	4.63	0.28
Italy	2.31	-0.05	0.09	2.26	0.14
Netherlands	1.14	0.17	0.04	1.11	0.07
Poland	2.50	-0.06	0.09	2.44	0.15
Romania	0.99	-0.26	0.04	0.97	0.06
Russia	14.55	-1.59	-	14.55	-
Spain	1.75	0.10	0.06	1.71	0.10
Ukraine	3.74	-0.56	0.14	3.66	0.22
United Kingdom	3.30	0.15	0.12	3.23	0.19
Rest of Europe	7.09	0.29	0.26	6.93	0.42
New Zealand	0.41	0.06	0.02	0.40	0.02
Japan	6.84	1.32	0.25	6.69	0.40
Total	**54.89**	**0.00**	**1.50**	**54.02**	**2.36**

We now turn to Russia, which is another important Kyoto country. To analyse Russia's potential overselling, we need to stipulate its CPR. Once again we use the scenario described in Haites and Missfeldt (2004) and Missfeldt and Haites (2002), according to which Russian emissions increase

during the period 2005-2009, with a level of 2.57 in 2008. According to this scenario, the Russian CPR in 2008 will be five times 2.57 $GtCO_2$, which equals 12.86 $GtCO_2$. Russia's AA is assumed to be 14.44 $GtCO_2$ (Table 1). This means that in 2008, Russia may sell 1.59 billion (10^{12}) AAUs with approval, which entails a permit price of 8.94 €/AAU. The result is weaker incentives to carry out abatement in other countries. In the case of passive non-compliance, Russia fails to carry out abatement domestically (0.82 $GtCO_2$, Table 1). As a result, Russian non-compliance in the cap-and-trade case diminishes global emission reduction by 1.69 $GtCO_2$ (Table 3). The corresponding consequence of Russian non-compliance in the tax case is a reduced environmental effect of the agreement of 0.87 $GtCO_2$ (Table 3).

We argued in previous sections that non-compliance by one or a few parties might, at least in principle, undermine the entire environmental effect of a cap-and-trade agreement.

Table 4. Simulation results. Neither Russia nor Japan do comply. $GtCO_2$

	Cap-and-trade			Harmonized taxes	
	Emissions	Permit import	Abatement	Emissions	Abatement
Canada	3.36	0.68	-	3.17	0.19
France	2.40	-0.25	-	2.27	0.14
Germany	4.90	0.37	-	4.63	0.28
Italy	2.40	0.03	-	2.26	0.14
Netherlands	1.18	0.21	-	1.11	0.07
Poland	2.59	0.04	-	2.44	0.15
Romania	1.03	-0.22	-	0.97	0.06
Russia	14.55	-1.51	-	14.55	-
Spain	1.81	0.16	-	1.71	0.10
Ukraine	3.88	-0.42	-	3.66	0.22
United Kingdom	3.42	0.27	-	3.23	0.19
Rest of Europe	7.35	0.55	-	6.93	0.42
New Zealand	0.42	0.08	-	0.40	0.02
Japan	7.10	-	-	7.10	-
Total	**56.39**	**-**	**-**	**54.42**	**1.96**

This claim might be illustrated by our numerical model, by assuming that neither Japan nor Russia complies. As explained above, at the start of the first commitment period Russia might sell 1.51 billion AAUs with approval. Assume that Russia does this. Furthermore, assume that both Japan and Russia fail to carry out any abatement domestically, and that Japan ignores its commitment to buy

permits. The consequence is that the permit price converges towards zero. As a result, no abatement is carried out in any country (Table 4).

By contrast, if Japan and Russia fail to comply in the tax regime, then the global emission reduction caused by the regime is 3.19 $GtCO_2$ with full compliance (table 1), and 1.96 $GtCO_2$ if neither Russia nor Japan comply. Hence, with the tax regime 62 percent of the environmental effect of the agreement is maintained even if Japan and Russia do not comply. In contrast, in the cap-and-trade regime non-compliance by these two countries completely eliminates the regime's environmental effect (Table 4).

To further substantiate this point, consider the consequences of the United States' withdrawal from the Kyoto protocol. It has been well documented that this withdrawal removed almost all of the treaty's environmental effect (e.g., Böhringer 2002, Hagem and Holtsmark 2001). The fact that that we are dealing with a withdrawal from the agreement rather than non-compliance is largely unimportant for our purposes. Assuming that withdrawal causes a country to not undertake any domestic abatement, then (in terms of environmental effect) withdrawal is equivalent to what we have previously called 'passive' non-compliance.

8. Conclusion

An international climate agreement based on a uniform CO2 tax is likely to be superior to a cap-and-trade regime in terms of efficiency. There are also other advantages of a tax based regime. However, to achieve high degrees of compliance both types of regime need an effective enforcement mechanism, which is unlikely to be compatible with full participation. However, we have argued that the enforcement problem is more severe for a cap-and-trade regime than it is for a tax regime. A tax regime will have at least *some* environmental effect as long as at least one country complies. In a cap-and-trade regime, by contrast, non-compliance by one or a few permit selling countries could completely undermine the regime's environmental effect.

In conclusion, it is an important challenge to design an international regime that is able to tackle climate change effectively *without* requiring a tough enforcement mechanism.[18] Even if a tax regime does not fully satisfy this requirement, it has an advantage over Kyoto's cap-and-trade regime, because a tax regime is considerably less dependent on enforcement.

[18]A possible example of such a regime is an arrangement based on technology agreements and network externalities along the lines suggested by Barrett (2003). See also Aldy, Barrett, and Stavins (2003).

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