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The Price of Non-compliance with the Kyoto Protocol

The Remarkable Case of Norway

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Sammendrag:. For å sikre at internasjonale avtaler overholdes, er det viktig å kunne iverksette straffetiltak mot eventuelle land som ikke overholder sine forpliktelser. Det er imidlertid rimelig å kreve at slike tiltak ikke har betydelige negative virkninger også for andre land. Kyoto-protokollens håndhevingsmekanisme tilfredsstiller ikke dette kravet. Straffetiltakene som spesifiseres i Marrakesh-avtalen, vil ikke bare bli kostbare for land som bryter sine forpliktelser. Også land som overholder avtalen vil bli utsatt for betydelige negative velferdseffekter. Ved hjelp av en numerisk modell viser vi at for Norge kan velferdseffektene til og med bli verre når et annet land (for eksempel Canada, Japan eller Russland) blir straffet enn om Norge selv blir straffet. Også andre land som blir kjøpere i kvotemarkedet vil være utsatt for lignende effekter. Norge rammes imidlertid hardere enn andre kjøperland fordi Norge også er en stor eksportør av olje og gass.

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Abstract: To induce compliance, an international enforcement mechanism needs to authorize the use of punitive consequences against a non-compliant country. However, it is reasonable to require that such consequences do not cause considerable damage to other countries as well. The compliance mechanism of the Kyoto Protocol does not meet this requirement. The Marrakesh Accords instruct the Enforcement Branch of the Compliance Committee to impose punitive consequences on a country that fails to fulfill its commitments. These consequences will not only be costly to the non-compliant country. They will have considerable adverse welfare effects for compliant countries too. Using a numerical model, we show that in the case of Norway, the welfare effects can actually be worse if another country (such as Canada, Japan or Russia) is punished than if Norway itself is punished. Similar effects will also be experienced by other buyers of emission permits. But Norway suffers more than other buyers because it is also a major exporter of fossil fuels.

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1 Introduction

The Kyoto Protocol provides specific targets for reducing emissions of greenhouse gases in the so-called Annex I (i.e., industrialized) countries.[1] These targets are supposed to be met in the first commitment period, which begins in 2008 and ends in 2012. However, in some countries current emissions are significantly higher than their Kyoto targets.[2] Thus, there is a real possibility that not all parties are going to live up to their obligations for the first commitment period.

The Marrakesh Accords – a follow-up to the Kyoto Protocol – provides details for a compliance mechanism for the international climate regime. In particular, it establishes a Compliance Committee with both a Facilitative Branch and an Enforcement Branch. The Facilitative Branch shall provide 'advice and facilitation to Parties in implementing the Protocol', whereas the Enforcement Branch shall determine whether a party is in non-compliance with its emission target, its reporting requirements, and the eligibility requirements for participation in the flexibility mechanisms.[3] The Accords also specify a list of punitive consequences to be imposed by the Enforcement Branch in the second commitment period (2013-2017) on countries that fail to comply in the first period. These consequences are (i) deduction from the party's allowance for the second commitment period of 1.3 times the amount of excess emissions in the first period, (ii) development of a compliance action plan, and (iii) suspension of the eligibility to sell permits under the emissions trading provisions until that right is reinstated.

Views differ considerably regarding the potency of this compliance mechanism. Some authors see it as "unique to international law" (Werksman, forthcoming: 4), pointing out that "the Protocol System seems to be the only one in international law to apply consequences of a penal character" (Ulfstein & Werksman, forthcoming:19). By contrast, one critic argues that the compliance mechanism is "obviously flawed", and that it offers little if any incentive for compliance (Barrett 2002, 2003:383-386). Barrett lists a number of objections to the compliance mechanism. First, if a country which is found by the Enforcement Branch to be in non-compliance in the first commitment period fails to comply in the second period as well, then it must presumably make up for the difference (plus 30 percent) in the third period. However, this implies that the punishment might be forever delayed. Obviously, a punishment that can be forever delayed is a weak deterrent. Second, the anticipation of being punished is likely to induce countries to hold out for a generous allowance in the upcoming negotiations for second period emission targets. If successful, this would reduce the *de facto* punishment. Third, the Marrakesh Accords include no enforcement provisions addressing failure by a non-compliant country to accept the punishment. Hence, the compliance mechanism depends on active cooperation by the non-compliant party. Fourth, any party is entitled to withdraw from the Kyoto protocol giving 12 months' notice. It follows that a country that is being punished might evade the punishment simply by withdrawing from the Kyoto Protocol. Finally, the compliance mechanism is not legally binding, and can be made so only through an amendment which requires a three-fourths majority vote of the Meeting of the Parties. And even if the amendment obtains an affirmative vote, the compliance mechanism becomes binding only on those countries that choose to ratify the amendment.

[1] The fate of the Kyoto Protocol remains uncertain, pending Russia's decision of whether to ratify.

[2] For example, in 2003 Norwegian emissions were 8 percent higher than in 1990, while Norway's Kyoto target allows emissions to be only 1 percent higher than in 1990.

[3] The flexibility mechanisms are (i) emissions trading, (ii) joint implementation and (iii) the clean development mechanism.

The compliance mechanism also suffers from an additional problem. Even though the Marrakesh Accords state unambiguously that (all of) the punitive consequences *shall* be imposed if a country is found not to be in compliance, it is far from obvious that a non-compliant country actually will be punished. The reason is that "determining whether or not a country is non-compliant requires judgment and discretion" (Hagem et al., forthcoming, see also Hagem & Westskog, forthcoming, Rypdal 2003, and Ulfstein and Werksman, forthcoming). Moreover, if punitive consequences are imposed on a non-compliant country, *other* countries will also suffer adverse welfare effects.[4] This creates incentives for strategic behaviour in the Enforcement Branch. If at least some members of the enforcement branch take these effects into consideration, a country that is technically in non-compliance might be able to escape punishment (Hagem et al., forthcoming).

While the above-mentioned weaknesses might undermine the ability of the compliance mechanism to function as intended, its strength will not be definitively tested until the regime has been in full operation for some time (i.e, not until the second commitment period). In the meantime it is of considerable interest to ask what the effects are likely to be *if* some countries fail to fulfill their Kyoto targets and must face punitive consequences as a result of this. Focusing on one minor Annex I country, Norway, this is what we do in this paper. As we shall see, Norway is particularly interesting in this context, because of its combined role a major exporter of fossil fuels and a likely buyer of emission permits (due to high abatement costs).

Using a numerical model, we estimate the welfare effects for Norway if Norway fails to comply. Similarly, we estimate welfare effects for Norway if certain other countries – Canada, Japan, Russia – fail to comply. The latter countries are among the most important remaining Annex I parties after the US decided not to ratify Kyoto. We show that imposing punitive consequences on any one of these other countries can entail considerable costs for Norway as well, even when Norway itself is in compliance. In fact, the effect of punitive consequences being imposed on one of these *other* countries (assuming that Norway is in compliance) can be *greater* than the corresponding effect of punitive consequences being imposed on Norway *itself* for noncompliance (while other countries are in compliance). This is true as long as the relative degree of non-compliance is the same in either case (in each of our scenarios one country exceeds its allowance in the first commitment period by three percent).

That punishing a non-compliant country can entail considerable costs for *complying* countries is likely to pose a legitimacy problem for the Enforcement Branch. The standards of due process require that parties are treated in accordance with existing notions of fairness and justice (Ulfstein & Werksman, forthcoming:3). To suffer because *another* country is punished does not seem easily compatible with such notions. It hardly makes things better that the costs of punishment are very unevenly distributed. For example, if a large seller of emissions permits (such as Russia) faces punitive consequences, other sellers (such as Hungary) benefit from a higher permit price. By contrast, buyers (such as Norway) suffer significantly. In other words, a disproportionate share of the external costs following from the imposition of punitive consequences will be borne by buyers of emissions permits. Norway suffers even more than other buyers because it is also a major exporter of fossil fuels.

The remainder of this paper is organized as follows. Section 2 outlines the welfare effects which are assumed to follow from the imposition of punitive consequences against a non-compliant country. We begin with an overview of general effects on prices, demand and supply, and then focus on the effects for particular categories of countries. Section 3 describes the model and presents and explains the main results. As we shall see, the results are highly

[4] These effects are discussed in detail in section 3.

intuitive in light of the background provided in section 2. Finally, section 4 rounds up the paper with some concluding remarks.

2 Welfare effects of punitive consequences

We first discuss some general economic effects that occur if the Enforcement Branch imposes punitive consequences on a non-compliant country – given the assumptions underlying the numerical model used in this paper. We assume that the Annex I countries will meet their Kyoto Protocol emission reduction commitments primarily through the use of emission trading. In general we assume perfectly competitive markets and include taxes and tariffs, but do not take into account market power in either the emission permit market or fossil fuel markets. Furthermore, in our model we will only concern ourselves with the reduction of CO_2 emissions. The assumptions on which the model is based are discussed in greater detail in the appendix. The purpose of this section is to provide some background which is needed in order to understand the subsequent discussion of effects for particular countries under specific scenarios.

2.1 General effects

When a non-compliant country faces punitive consequences, this has a number of economic effects. Some of these effects apply only to the country that is being punished. Others apply to all parties to the protocol and even to non-parties. The general effects are summarised in table 1.

The imposition of punitive consequences will cause the price of emission permits to increase. There are two reasons for this. First, the reduction in the punished country's allowance means that the combined emission target for the countries trading in the international market for emission permits becomes more stringent.[5] This boosts the demand for permits. And second, suspension of the punished country's right to sell permits reduces the supply of permits on the international market. Both effects tend to drive the price of permits upwards. This price increase is the primary driver of the welfare effects caused by punishment. Note, however, that the price increase for permits pertains to the *international* market. For a country that is a permit seller, the suspension of the right to trade decouples its domestic permit market from the international market. The domestic price of emission permits will therefore in general drop *below* the international price.[6] Nevertheless, it remains true that the price of emission permits will increase on the *international* market.

CO_2 emissions can be reduced through carbon sequestration, increased energy efficiency or reduction in the consumption of fossil fuels. The Kyoto Protocol imposes limits on the use of carbon sequestration as a mitigation option. In addition, the scope for improved energy efficiency is limited, at least in the short-run. Part of the emission reduction will therefore have to be achieved by reducing the use of fossil fuels (in our model this turns out to be a large share of the reductions). Different fossil fuels have different carbon content. Intuitively, one might expect that when overall emissions must be reduced, this will result in substitution of relatively carbon-lean oil and gas for more carbon-intensive coal. The nature of the

[5] Because of the 30% penalty, the global emission ceiling is always reduced when a country is punished. If the punished country is a seller of permits, there will also be fewer permits available *in the market*.

[6] Note that if the domestic price would have been higher than the international price, the country is free to and also would choose to purchase permits on the international market.

substitution effects depends on the market structure in the various markets for fossil fuels, physical and institutional constraints, and the substitutability between different fuels.

An increased permit price will make it more costly to consume fossil fuels. Hence, the *overall* demand for fossil fuels will decrease in Annex I countries. At the same time, the demand for fossil fuel intensive goods can also decrease as the increased energy prices raise the price, implying that the demand for *other* goods can increase (because of substitution effects). A change in the permit price therefore has an impact on the price and production (quantity) of fossil fuels, of fossil fuel intensive goods, and indeed of all other goods (in decreasing order of sensitivity to changes in the permit price). For a broader discussion of such terms-of-trade effects, see for example Babiker et al. (2000).

By itself, this means that fossil fuel exporting countries experience a loss of revenue as the permit price increases, while countries importing fossil fuels gain from the decreased price of fossil fuels.[7] This can also hold true for fossil fuel intensive goods (however, as other inputs in the production of fossil fuel intensive goods might become cheaper, the effect is not always straightforward).

Table 1: General economic effects of punitive consequences

Market	Emission permits	Fossil fuels	Fossil fuel intensive goods
Effects	• Price increases	• Consumer price increases • Overall demand decreases • Possible fuel-switching	• Consumer price might increase • Demand might decrease.

2.2 Welfare effects for individual countries

Largely, the general effects discussed so far take place independently of whether we are looking at compliant or non-compliant countries and whether the country being punished is a permit seller or a permit buyer. We now turn to the effects experienced by particular categories of countries.

As we have seen, punishment invariably results in a higher permit price. In turn, this price increase entails higher costs of meeting the emission targets.[8] This applies to all countries that are permit buyers. This cost increase will be particularly high for a permit buying country that is punished, as the country then also has to buy additional permits. Imposition of punitive consequences allows countries that are permit sellers to obtain a higher price in the international market for permits.[9] But for a permit seller that is being punished the welfare loss can be very large, as all revenue from permit sales is lost. While such a country will always experience a welfare loss, it can be difficult to predict the economic effects in specific markets, especially if the domestic price for emission permits drops below the international

[7] This assumes that OPEC does not maintain oil prices by restraining production, in which case the OPEC countries would bear the greater share of the welfare losses, and the losses of other oil exporting countries would be reduced. See Berg et al. (1997) for a discussion of these effects.

[8] The cost of meeting emission targets will increase irrespective of whether the country buys emission permits at the increased price, or increases domestic abatement efforts.

[9] While the overall demand for permits might decrease, this is not enough to offset the effect of a higher permit price, and the result is increased revenue from permit sales.

price.[10] This is because the punished country then faces a situation where the domestic permit price is lower than it would otherwise have been. Thus, the overall domestic demand for fossil fuels (and possibly also the demand for fossil fuel intensive goods) will increase. At the same time, however, the demand for fossil fuels decreases in the rest of the world. What then happens to fossil fuel prices in the punished country depends on factors such as the extent to which that country is linked to international markets for fossil fuels, whether it is an exporter or importer in those markets, substitutability between fuels, substitutability of fuels imported from different sources, and taxation of fossil fuels. Furthermore, because it at the same time becomes more costly for other countries to reach their emission targets, the country's fossil fuel intensive industries will become more competitive internationally.[11] An increase in exports from these sectors would entail an increase in the demand for fossil fuels within the country that is being punished.

The welfare effects for individual countries are summarised in table 2. Note that the table does not include welfare effects caused by changes in fossil fuel markets.

Table 2: Welfare effects for individual countries by characteristics of the country

	Permit seller	**Permit buyer**
Non-compliant	Welfare loss due to loss of permit sales revenue.	Welfare loss due to more stringent allowance and higher permit price
Compliant	Welfare gain due to increased revenue from permit sales.	Welfare loss due to increased permit price

3 Results

3.1 The DEEP model

The DEEP model is a multi-sector and multi-region intertemporal computable general equilibrium model. The sectors and regions used in this paper are listed in table 3.[12] Details of the model are given in appendix 1, while a full description of the DEEP model, including assumptions on elasticities and the dynamics of the model, can be found in Kallbekken (2004).

For this analysis, the model is run for five periods at five-year intervals (1997-2021). The year 2012 is taken to represent the first commitment period of the Kyoto Protocol, while the year 2017 represents the second commitment period. We assume that the absolute emission targets (i.e. Kyoto targets) remain the same for the two periods, and only CO_2 emissions.

[10] If a country with excess emission permits is punished, the domestic permit price might even fall to zero.

[11] Carbon leakage refers to a situation where a difference in permit prices gives incentives to shift energy intensive activities to countries with the lowest permit price (in this case the country being punished).

[12] Note that while we are interested in the effects of punishment to individual countries, the model requires some aggregation of countries into larger regions. Sometimes we will therefore deal with regions, such as "Rest of Annex B", rather than individual countries.

In the baseline scenario all parties to the Protocol fulfil their emission reduction commitments (the US is assumed not to join in either period). The Kyoto Protocol is implemented through a fully competitive emissions trading market, but without the Clean Development Mechanism or Joint Implementation.

There are five non-compliance scenarios. In each scenario a country exceeds its allowance in the first commitment period by 3%, and is then punished for this non-compliance in the second commitment period.[13,14] The punishment is a 3.9% reduction in its allowable emissions for the second period, *and* loss of the right to sell emissions permits to other countries.

The countries that are non-compliant in each of the five scenarios are Russia, Japan, Canada, Norway and Hungary. To avoid confusion we refer to the scenarios by country-codes and to the countries by their full name.

The Kyoto Protocol allows banking of permits from one period to the next. It is efficient to bank permits if the (discounted) permit price is higher in the second period than in the first. If a country is punished for non-compliance, the permit price will increase in the second period. Thus, expectations that one or more countries are going to be punished make it efficient to bank more permits than if no punishment is expected. Expectations regarding non-compliance and punishment are therefore relevant for decisions about how many permits to bank. It is, however, difficult to predict exactly what kind of expectations are likely to prevail. One extreme is that any non-compliance comes as a complete surprise. The other extreme is that all cases of non-compliance (and punishment) are perfectly predicted. The most realistic situation is probably somewhere between these two extremes. We will, however, use the two extremes as possible banking alternatives. We call these two cases "surprise" and "foresight".

We ran all of the five non-compliance scenarios for each of the two cases. In the "foresight" case all countries make efficient banking decisions based on perfect foresight of punishment in the second period. In the "surprise" case all countries assume that there will be zero punishment in the second period when making decisions about banking. This implies the same level of banking as takes place in the baseline scenario.

3.2 Results and discussion

Our primary concern is the welfare effects of punishing a non-compliant country. Changes in welfare are measured as per cent change in equivalent variation for the entire model horizon.[15]

[13] We could have chosen to model a situation where countries exceed their allowance by an equal number of tonnes of CO_2. This would, however, not be a very interesting situation as the change in the permit price, and all second order effects, would then be the same for all scenarios where permit buying countries are punished.

[14] The reader might object that if a region has incentives to be non-compliant in the first commitment period, then why do we assume that it will comply when it is being punished for this non-compliance? We get around this problem if we assume for example that firms/industries are responsible for the non-compliance through underreporting of emissions, and that the government does not have a sufficiently good monitoring system to detect this in the first period. When this non-compliance is discovered, the monitoring system is improved, and the firms are not able to underreport their actual emissions in the second commitment period.

[15] This explains, to some extent, why the estimated welfare changes are relatively modest. If all changes could be attributed entirely to the final period, which is when the punishment takes place, the welfare changes for that period alone would be roughly five times greater than the numbers for the whole model horizon (with a zero change for all other periods).

However, in order to understand the welfare effects reported below, it is informative to look first at some key variables that affect welfare gains and losses from changes in the permit market. Table 4 shows some key numbers for permit trading in the second commitment period in the baseline scenario. We note that, in this model, Russia and Hungary are the only two sellers in the permit market, and Russia is by far the dominant seller.[16] All other Annex I countries are permit buyers – relying on buying permits to cover around 18-23% of their emissions.

Table 3: Regional and sectoral aggregation

Country code	Country name
FSU	Russia (Former Soviet Union countries)
JAP	Japan
CAN	Canada
NOR	Norway*
HUN	Hungary
RAB	Rest of Annex B
USA	United States of America
ASI	Asia
ALM	Africa and Latin America

Sectors
Services and manufacturing
Petroleum and coal products (refined)
Crude oil
Natural gas
Coal
Electricity
Investment good

** The GTAP region "Rest of EFTA" also includes Iceland and Liechtenstein. Norway, however, accounts for 94% of both GDP and CO_2 emissions in this region.*

Table 4: Total allowance, projected emissions and net permit sales[17]

Country	Total allowance (Mt C)	Projected emissions (Mt C)	Net permit sales (Mt C)	Net permit sales (% of total allowance)
Russia	99,82	70,77	29,05	29,1 %
Japan	26,80	32,00	-5,20	-19,4 %
Canada	11,48	14,16	-2,68	-23,3 %
Norway	1,04	1,23	-0,18	-17,7 %
Hungary	1,92	1,80	0,13	6,7 %
Rest of Annex B	98,80	119,94	-21,14	-21,4 %

To explain the welfare changes in the various scenarios it is also helpful to know what the permit price is in each scenario. Estimated permit prices for the second commitment period are shown in table 5. In the baseline scenario (where no country is punished) the permit price is $9.56. If Russia is punished, and this comes as a complete surprise, the permit price

[16] Eastern European countries are expected to be permit sellers. In the model these countries are, however, part of the Rest of Annex B – which has a net demand for permits.

[17] The "total allowance" figures are the sum of the assumed second commitment period target plus permits banked from the first commitment period.

increases to a very high $59.41. In the "foresight" case, the permit price becomes $25.62 if Russia is punished. In all other non-compliance scenarios, and for both cases, the price increases by less than $1.

Table 5: Second period permit prices (US$1997/ton C) under the different scenarios

	Baseline	FSU	JAP	CAN	NOR	HUN
Surprise	9.56	59.41	10.29	9.87	9.59	9.65
Foresight	9.56	25.62	9.95	9.73	9.58	9.61

The welfare effects of punishing a non-compliant country are shown in table 6 for the "surprise" case, and in table 7 for the "foresight" case. Knowing the structure of permit trading, and the permit price in each scenario, the welfare effects become highly intuitive in every case. First, the country being punished suffers a welfare loss. Second, a permit seller that is punished generally experiences a greater welfare loss than a permit buyer that is punished. The reason is that permit sellers lose all revenue from permit sales in the second period. Third, and unsurprisingly, the welfare effects are greatest if Russia is punished. The explanation is that Russia is by far the largest permit seller, and thus if Russia is punished a large number of permits are withdrawn from the international market. As can be seen from tables 6 and 7, these results are valid for both cases (only the absolute size of the welfare effects differs). In general, the welfare changes are smaller in the "foresight" case than in the "surprise" case. The reason is that with perfect foresight it is possible to bank more permits for what would otherwise have been a more costly second period, and this represents an efficiency gain.

Fifth, and more remarkably, several countries also experience significant welfare effects if *other* countries are being punished. All permit buyers suffer a welfare loss when another country is being punished. At the same time, permit sellers experience a welfare gain.[18] In fact, *some countries experience a heavier welfare loss if certain other countries are punished than if they are punished themselves.* While in the "surprise" case Norway experiences a welfare loss of 0.006% if it is punished itself, it suffers a slightly larger loss if Canada is punished. More impressively, if Japan is punished, the welfare loss for Norway is 0.013% – more than twice the loss it suffers if Norway itself is punished. And if Russia is punished, Norway must endure a massive loss of 0.812%. This large loss, and the corresponding great increase in the permit price, can only partly be explained by the fact that Norway is a permit buyer; the cost to Norway of meeting its Kyoto commitment increases by USD 5 million if Norway is punished itself, and USD 525 million if Russia is punished. For the Rest of the Annex B region, which imports an even larger share of permits than Norway does (about 21% of total emissions), the welfare loss if Russia is punished is only 0.29%. The reason for Norway's comparatively high welfare loss is that Norway is a large exporter of fossil fuels. When the permit price increases, the consumer price of fossil fuels also increases, while the producer price and demand decrease. In the case where Russia is punished, the producer price for crude oil decreases by 0.2%, and demand decreases by a significant 3.6%.[19] This loss amounts to about USD 230 million. For the case where Norway itself is punished the model

[18] Except in some cases where welfare effects are negligible (i.e. no changes observed in the six decimal points that the model can display).

[19] Table 4 shows that if Russian permit exports are taken off the market, the emission cap for the other Annex I countries in effect becomes 14% more stringent. This explains why the demand for crude oil should decrease by a large percentage.

does not register any losses (measured to within 0.1 million USD). The reason why the losses sum to more than the total welfare loss in table 7 is that welfare *gains* are not included.[20]

Table 6: Percentage change in welfare (EV) and welfare loss in millions USD (in brackets). "Surprise" case compared to baseline scenario

	Non-compliance scenario				
Country	**FSU**	**JAP**	**CAN**	**NOR**	**HUN**
	-0.812%	-0.013%	-0.006%	-0.006%	-0.001%
Norway	(-299)	(-5)	(-2)	(-2)	(-1)
	1.331%	0.016%	0.007%	0.001%	-0.118%
Hungary	(140)	(2)	(1)	(0)	(-12)
	-1.444%	0.096%	0.041%	0.004%	0.013%
FSU	(-2467)	(165)	(70)	(6)	(21)
	-0.433%	-0.010%	-0.002%	0.000%	0.000%
Japan	(-4425)	(-105)	(-23)	(0)	(0)
	-0.180%	-0.004%	-0.016%	0.000%	0.000%
Canada	(-276)	(-6)	(-25)	(0)	(0)
	-0.290%	-0.005%	-0.002%	0.000%	0.000%
RAB	(-5915)	(-95)	(-40)	(0)	(0)

Table 7: Percentage change in welfare (EV) and welfare loss in million USD (in brackets). "Foresight" case compared to baseline scenario

	Non-compliance scenario				
Country	**FSU**	**JAP**	**CAN**	**NOR**	**HUN**
	-0.205 %	-0.006 %	-0.002 %	-0.005 %	0.000 %
Norway	(-76)	(-2)	(-1)	(-2)	(0)
	0.284 %	0.005 %	0.002 %	0.000 %	-0.118 %
Hungary	(30)	(1)	(0)	(0)	(-13)
	-1.272 %	0.052 %	0.022 %	0.002 %	0.007 %
FSU	(-2174)	(88)	(38)	(3)	(12)
	-0.145 %	-0.009 %	-0.002 %	0.000 %	0.000 %
Japan	(-1483)	(-90)	(-16)	(0)	(0)
	-0.118 %	-0.004 %	-0.016 %	0.000 %	0.000 %
Canada	(-181)	(-6)	(-24)	(0)	(0)
	-0.136 %	-0.004 %	-0.002 %	0.000 %	0.000 %
RAB	(-2781)	(-82)	(-35)	(0)	(0)

[20] Some of these gains occur in the time periods before the punishment takes place. This is an unfortunate effect of using an intertemporal model - as it allows for intertemporal substitution – a type of perfect foresight that is not well suited to this type of analysis.

These results largely hold true for the "foresight" case as well. However, there are some modifications. With foresight the permit price does not increase quite as much. Consequently, the welfare losses are smaller. In the case where Russia is punished, Norway experiences a welfare loss of "only" 0.205% in the "foresight" case. However, the component of the loss that can be attributed to Norway having to purchase additional permits, remains the same. Therefore Norway's own non-compliance becomes relatively more costly compared to non-compliance by other countries. For example, it is now more costly for Norway that Norway itself is punished than that Canada is punished. Notice, however, that in the "foresight" case too it is even more costly that Japan or Russia is punished.

It is instructive to compare the effects for Norway with those for Hungary. Hungary differs from Norway in that it is a permit seller and a fossil fuel importer. Because of these two characteristics, the welfare effects for Hungary if another country is punished are markedly different from the welfare effects for Norway. While either country suffers if it is punished itself, in all other scenarios Hungary experiences a welfare gain while Norway experiences a loss.

4 Conclusion

To induce compliance, an international enforcement mechanism needs to authorize the use of punitive consequences against a non-compliant country. However, it is reasonable to require that such consequences do not cause considerable damage to *other* countries as well. The compliance mechanism of the Kyoto Protocol does not meet this standard. If the Enforcement Branch imposes punitive consequences, these consequences will not only have an impact on the non-compliant country. They will have considerable welfare effects on *compliant* countries too. We have shown that in the case of Norway, the adverse welfare effects can actually be worse if *another* country (such as Canada, Japan, or Russia) is punished than if Norway itself is punished. Similar effects are experienced by other buyers of emission permits as well. However, Norway suffers more than other buyers, because this country is also a major exporter of fossil fuels.

Kyoto's compliance mechanism does not automatically become legally binding if and when the Kyoto Protocol enters into force. To make it binding requires that the Meeting of the Parties approves an amendment to the treaty. In addition, such an amendment must be ratified by the member countries. The rather remarkable effects that have been demonstrated in this paper add to other weaknesses of the compliance mechanism which are well documented in the literature. Hence, member countries of the Kyoto Protocol might be well advised to think twice before they allow this mechanism to become operational.

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Appendix: The DEEP model

The DEEP model consists of five main elements: Production sectors, emissions trading, an Armington aggregation of domestic and imported goods, a capital and an investment sector, and a representative agent.

The structure of production and demand has been adopted from the GTAP-EG model by Rutherford and Paltsev (2000) – with some modifications. Production is described using two different production functions, one for fossil fuel production, and one for non-fossil fuel production.

Fossil fuel production is a CES-function that includes crude oil, gas and coal. Fossil fuels are produced as an aggregate of a resource and a non-resource input. Non-fossil fuel goods are produced with fixed-coefficient (Leontief) inputs of intermediate non-energy goods and an energy-primary factor composite.

Emissions trading is assumed to be comprehensive (i.e. all sectors take part in emissions trading) and fully competitive. Emissions are modelled as a fixed share input of permits in both production and final demand (more technically it is implemented as a Leontief technology composite of fossil fuel inputs and permits).

The regions are linked though bilateral trade flows. All goods, except the primary factors (labour and capital) and the investment good, can be traded among the regions. The model assumes that goods produced in different countries are not identical (the "Armington assumption"). The importing of goods taxes place in a separtate "Armington" sector. The elasticity of substitution between domestic and imported goods is 4, while the, while the elasticity of substitution among imports from different regions is 8. Each bilateral trade flow requires its own transportation service (with the exception of emission permits). This is modelled as a Leontief technology between the imported good and the transportation good. The transportation margins are proportional to quantities traded.

The representative agent, which is both consumer and government, demands only the consumption good. This good is a constant elasticity aggregate of non-energy goods and energy goods. To pay for this good, the agent is endowed with labour and capital. The labour endowment grows for each year – at the same rate as the growth parameter, while capital is given as an initial capital stock. The representative agent collects all taxes and tariffs specified in the model. The agent is also endowed with emission permits – if the region is assumed to be taking part in a climate agreement. The agent uses the tax revenue and income from endowments to purchase the consumption good – or pay for investment. While the agent gets utility only from the consumption good, investment is driven by the returns to capital generated in the next perod, and a terminal capital constraint.

The structures of the capital and investment sectors are straightforward. The capital sector converts the initial capital stock into returns to captial, and next-period capital stock. The return to capital is determined by the interest rate, while the next-period capital stock is equal to the initial capital stock less depreciation. Investment takes place through the production of an investment good (with the same production strcuture as other non-fossil fuel goods). The output from the investment is next-period capital stock.

The model is an intertemporal model with a utility maximising representative agent. Investment (growth) is endogenous, but investment is not determined, as in many other models, through a time preference rate or savings rate. Instead the time preference rate is implied through an equilibrium growth parameter that defines a growth rate that is optimal for the original equilibrium (baseline). Investment (and thus growth) will vary between the scenarios as the representative agent seeks to maximise utility under the new conditions (the

intertemporal elasticity of substitution is 0.5). The equilibrium growth parameter is differentiated between regions and time periods.

The economic data used in the DEEP model is the GTAP (v5) data base - which provides input-output data for each region, bilateral trade data, and information on taxes and tariffs. These taxes and tariffs are used in the DEEP model. The emissions data is from the GTAP/EPA Project "Towards an Integrated Data Base for Assessing the Potential for Greenhouse Gas Mitigation". The growth and technological change parameters in the model are based on the IPCC SRES A1B scenario (Nakicenovic and Swart, 2000).[21]

[21] The SRES A1B scenario assumes "rapid and successful economic development", where the global economy grows at an average annual rate of 3%, and where technological progress is rapid.