Discussion Papers No. 376, April 2004
Statistics Norway, Research Department

Bjart J. Holtsmark and Knut H. Alfsen

Implementation of the Kyoto Protocol without Russian participation

Abstract:
All Annex B parties but Russia, Australia and USA, have ratified the Kyoto Protocol so far. It is still an open question whether Russia will ratify and secure that the Protocol enters into force. This paper therefore analyzes consequences of some proposed alternatives if the Russians decide not to ratify. The paper focuses on two cases where a limited number of the remaining Annex B parties respond to Russian withdrawal by the establishment of a new "mini-Kyoto" agreement whereby these parties commit themselves to the emission caps, the rules for emissions trading, compliance etc. set out in the Protocol. Environmentally, implementation of the Kyoto Protocol without participation from Russia and Ukraine is obviously superior to implementation with Russian/Ukrainian participation, due to the implied withdrawal of hot air based permits from the market. Implementation of the Kyoto Protocol without Russian/Ukrainian participation will, furthermore, imply higher costs to the remaining countries. This paper provides estimates of the permit price and environmental benefits that are likely if the proposed "mini-Kyoto" agreements are implemented.

Keywords: Russia, Kyoto Protocol, Global warming, Emissions trading, CDM

JEL classification: Q30, Q41

Acknowledgement: Comments and suggestions from Torstein Bye and Knut Einar Rosendahl as well as financial support from the Norwegian Research Council (RAMBU) are highly appreciated.

Address: Bjart J. Holtsmark, Statistics Norway, Research Department.
E-mail: bjart.holtsmark@ssb.no

Knut H. Alfsen, Statistics Norway, Research Department. E-mail: knut.alfsen@ssb.no

Discussion Papers comprise research papers intended for international journals or books. As a preprint a Discussion Paper can be longer and more elaborate than a standard journal article by including intermediate calculation and background material etc.

Abstracts with downloadable PDF files of
Discussion Papers are available on the Internet: http://www.ssb.no

For printed Discussion Papers contact:

Statistics Norway
Sales- and subscription service
N-2225 Kongsvinger

Telephone: +47 62 88 55 00
Telefax: +47 62 88 55 95
E-mail: Salg-abonnement@ssb.no

1. Introduction

US withdrawal made the Kyoto Protocol quite toothless in that surplus emission permits from Russia and Ukraine more or less could cover permit shortage in all other countries with binding commitments in the first commitment period 2008-2012, cf. Hagem and Holtsmark (2001).[1] However, Russian ratification has recently become increasingly uncertain. This threatens to block the Kyoto Protocol from entering into force.[2] As a response to this situation several politicians within EU and in other countries with emission caps, have announced that they want their countries to stick to their commitments in the Protocol also in the case that Russia does not ratify.[3] The purpose of this paper is to provide a numerical assessment of consequences of implementation of the Kyoto Protocol without Russian participation with respect to permit prices and environmental benefits.

Although the Kyoto Protocol as a legal instrument to the Climate Convention will not enter into force if Russia decline to ratify, the remaining countries are free to launch a regional multilateral agreement based on the obligations and rules of the Kyoto Protocol and the Marrakech Accords. As a starting point we analyze a situation where the EU-25-countries as well as Bulgaria, Romania, Norway, Switzerland, Japan, New Zealand and Canada stick to their Kyoto-commitments and are parties to a regional "mini-Kyoto" agreement. However, the political enthusiasm for the Kyoto Protocol appears to be greatest within Europe. We therefore, secondly, analyze an agreement where Japan, New Zealand and Canada also opt out if Russia and Ukraine do so. In that case the agreement is implemented basically within an extended EU-region, as Bulgaria and Romania hope to be EU-members from 2007.

With respect to the Kyoto-mechanisms, we have assumed that the regional agreement adopts the rules for emissions trading and joint implementation. As regards the Clean Development Mechanism

---

[1] A number of articles have emphasized the Russian role as a large permit seller which is likely to restrict its permit selling in order to bring about somewhat higher permit prices, a policy which also would strengthen the environmental effect of the agreement, cf. Babiker et al. (2002), Buchner et al. (2002) , Böhringer (2002), Böhringer and Löschel (2003), Chen (2003), den Elzen and den Moor (2003), Grütter et al. (2002), Holtsmark (2003), Jotzo and Michaelowa (2002), Manne and Richels (2001), Nordhaus (2001), and Springer and Varilek (2003).

[2] The terms for the Kyoto Protocol to enter into force were designed as a two-triggered approach. First, the Protocol will have to be signed by at least 55 countries to enter into force. This has already been achieved by a wide margin. Currently (March 2004) some 121 countries, mostly developing, have ratified the Protocol. The other condition for entering into force is, however, trickier to fulfill. It requires industrialized countries listed in Annex B in the Protocol responsible for at least 55 per cent of CO_2 emissions from these countries in 1990 to ratify the Protocol. As of March 2004, with three exceptions, all industrialized countries with emission caps had ratified the Protocol. The three exceptions are Australia, Russia, and USA. The ratifying countries make up 44 percent of total Annex B emissions in 1990. The Russian share of the relevant CO_2-emissions is 17 percent. Given non-participation by USA, entry into force depends on Russia ratifying the agreement. Without a Russian ratification, the Kyoto Protocol will not enter into force as intended.

[3] As a parallel to these political proposals, there is an emerging theoretical discussion of compliance and enforcement issues regional climate agreements, cf. for example Bretteville et al. (2004).

(CDM), which allows the industrialized countries with emission caps to obtain additional emission permits through funding of abatement projects in developing countries, we analyze cases that take this mechanism into account. However, it is not obvious whether it is reasonable to assume that a regional "mini-Kyoto" is likely to adopt this mechanism. The reason is that inclusion of CDM in a regional agreement would imply that also the developing countries had to be involved in the preceding negotiations. That would increase the number of parties to the agreement considerably, which in turn might delay the negotiations. From that point of view, a "mini-Kyoto" agreement might be a more realistic option if it does not include CDM. On the other hand, without permit supply from CDM the implementation costs will increase considerably, and therefore possibly shrink the number of parties with emission caps that are willing to stick to their Kyoto-commitments.

This article applies a partial equilibrium model of the permit market under the Kyoto Protocol and the fossil fuel markets. The demand and supply of fossil fuels give rise to the demand and supply of emission allowances and implicitly abatement costs as lost 'consumers' surplus'. It is not least important that the model include three regional gas markets in order to realistically take account of differing equilibrium effects from the fossil fuel markets in Western Europe, North America and the Pacific region. The inclusion of a regional market for gas in Europe is furthermore important in the present analysis, as it allows us to take into account strategic behaviour of Russia in the permit market when Russian interests in the European gas and oil markets also are taken into consideration. This is important with regard to Russian withdrawal from the Kyoto Protocol, which in this model framework means that the permit market turns from being dominated by one seller to a competitive market. The model is further described in Holtsmark (2003), see also Holtsmark and Mæstad (2002) and Hagem and Holtsmark (2001) for applications of a simplified version of the model.

Due to weak data and in order to enhance analytical transparency we restrict ourselves to emissions of CO_2 only, thus neglecting the other greenhouse gases covered by the Kyoto Protocol. The percentage reduction targets specified in the Protocol are consequently applied to the CO_2 emissions alone. According to Babiker et al. (2002) overestimation of abatement costs and underestimation of the permit supply may result. The permit price estimates might from that point of view be biased upwards. The analysis is based on the scenarios for fossil fuel consumption set out in the International Energy Outlook (DOE 2002) issued by Energy Information Administration, US Department for Energy. DOE (2002) provides high growth and low growth scenarios in addition to a medium growth scenario. While the medium growth scenario doubtless represents the scenario makers' central expectations, the high and low alternatives probably indicate the degrees of uncertainty associated with projections of this nature. As a rule, emission forecasts from DOE have tended to be somewhat higher than corresponding forecasts from IEA. However, the differences are small compared to the degrees of uncertainty related to such scenarios, cf. Vrolijk and Grubb (2000) where the high degree of uncertainty related to emission projections is emphasized.

The paper is organized as follows: Section 2 describes the general features of the model. Section 3 sets out the three applied baseline scenarios of the fossil fuel markets. Section 4 presents model simulations with respect to five cases. The first case assumes that the Kyoto Protocol is implemented with Russian/Ukrainian participation, while the four remaining cases assume that Russia and Ukraine have withdrawn from the agreement.[4] The differences between these four last cases are related to permit supply from CDM and the number of participating countries. Section 5 concludes.

2. Description of the model

The analysis applies a static partial equilibrium model that incorporates the links between the fossil fuel markets and a market for emission permits under the Kyoto Protocol[5]. There are five markets for fossil fuels in the model: global oil and coal markets and, and, due to high transport costs, three regional gas markets (North America, Europe including Russia and Algeria, and the Pacific region). The model does not include markets for non-fossil energy. Inclusion of a market for renewable energy would be an interesting extension of the model reserved for future works.

The version of the model used here divides the world into 12 countries/regions.[6] The three fossil fuels are modelled as substitutes in the demand functions. The assumed production technology yields linear demand functions for all inputs. The consumer prices are equal to the sum of producer prices, end-user taxes and the price of emission permits.

[4] Although Ukraine finally ratified the Kyoto Protocol in February 2004, we have in this paper assumed that Ukraine would choose to opt-out if Russia does not ratify. However, Ukrainian participation in some sort of a mini-Kyoto, as analysed in this paper, could be very attractive for this country due to its considerable amounts of hot air and prospects of higher permit prices. An interesting case not analysed in this paper would therefore be inclusion of Ukraine as a party to a type of mini-Kyoto-agreements. That would mean somewhat lower permit prices and smaller environmental effect of implementation.

[5] In the numerical model applied in this paper FSU is not split into the different Annex B parties. Hence, it has not been possible to take into account that the three Baltic states have ratified the Kyoto Protocol and should be assumed to be parties also to the new agreement. However, due to these countries minor economic importance, this inaccurate simplification should not affect the results significantly.

[6] USA, Canada, Western Europe, Norway, FSU, other economies in transition (EIT), Algeria, OPEC, Japan, New Zealand, Australia, rest of the world.

The model includes an international market for emission permits covering the industrialized countries that are assumed to accept emissions caps. The Clean Development Mechanism (CDM) is included in the model when appropriate by assuming that the developing countries have caps equal to their business-as-usual (BAU) emissions. An improvement of the version of the model applied here is to take transaction costs in CDM into account, cf. the discussion below. [7]

The gas markets in North America and the Pacific region as well as the international coal market are assumed to be competitive. In the European gas market, the oil market and the market for emission permits, it would be unrealistic to ignore market power. In the oil market it is therefore assumed that OPEC behaves strategically (acts as a dominant seller) and restricts its oil supply in order to maximize its net revenue while all other suppliers are price takers (a competitive fringe)[8]. Furthermore, in the European gas market Russia is correspondingly assumed to be a dominant seller and price setter while other suppliers (the fringe) are price takers. Concerning the market for emission permits this market is assumed to be competitive in the cases where Russia is not taking part. On the other hand, Russia and Ukraine is assumed to act as a cartel in the permit market in the cases where these countries are parties to the Kyoto Protocol.

The model determines equilibrium prices in the fuel markets and in the market for emission permits and determines furthermore the different countries' and regions' export and import of fossil fuels and emission permits.

The model is calibrated to three "business-as-usual" (BAU) scenarios of world energy markets in year 2010. The three BAU scenarios are based on the three scenarios set out in International Energy Outlook (DOE 2002).

---

[7] CDM-projects will imply significant transaction costs. For instance, the investors has to produce an application for project approval accompanied by documentation proving that the projects are "additional", which means that the projects would not be carried out on a commercial basis. Furthermore, there has to be negotiations between the host and the investors. The size of these transaction costs influences the elasticities of permit supply from CDM. Because Russian withdrawal from the Protocol would imply that Russian permit supply to some extent has to be replaced by permit supply from CDM, the CDM-model is therefore important for the results with respect to the estimated permit price. In order to improve the model it is therefore here assumed that there will be an average transaction on CDM-projects of 1.7€/tCO_2. Because this numerical assumption could be questioned, an appendix provides sensitivity analyses w.r.t. the size of these transaction costs. Because the version of the model applied in Holtsmark (2003) did not include any transactions costs, the permit supply from CDM will be somewhat smaller in the version of the model applied in this paper. Nevertheless, the difference the simulated permit supply from CDM is in resonable accordance with the CDM-studies by Chen (2003) and Jotzo and Michaelowa (2002).

[8] OPEC is assumed to have constant marginal costs while all other suppliers have increasing marginal costs. In the European gas market FSU correspondingly has constant marginal costs while the other producers have increasing marginal costs.

The design of the model means that abatement costs follow implicitly from parameters of the fossil fuel demand functions, which in turn follow from the price elasticities and composition of the demand for each fuel in each country. There is no consensus in the literature about own-price demand elasticities in fossil fuel markets, cf. Smith et al. (1995), Brubakk et al. (1995), Franzen and Sterner (1995). However, Aune et al. (2001, 2002) provide a thorough discussion of the relevant literature. In the absence of conclusive evidence, we assume initially average own-price elasticities of –0.5 for all fossil fuels. Using detailed information from the IEA (1995), the various elasticities are then adjusted as described in Holtsmark and Mæstad (2002).

As for fuel supply, it is generally recognized that the supply of coal is more elastic than the supply of other fuels. We have followed Golombek et al. (1995) in assuming supply elasticities of 2.0 for coal producers and 1.0 for both competitive gas producers and oil producers. Gas supplies from Russia and Ukraine and oil supply from OPEC are not determined by explicit supply functions, but instead through cartel formations exerting market power in the respective markets.

The supply of permits from CDM turns out to be important when Russia and Ukraine opt-out. The chosen modeling of CDM thus should be discussed. CDM is included in the model by assuming that non-Annex B-countries have assigned amounts equal to their BAU emissions and are free to take part in emissions trading. As CDM is a project-based mechanism, this modeling represents a important simplification, although there is assumed transaction costs related to all CDM-projects equal to 1.7€/tCO_2. It is difficult to judge the reliability of this model of CDM. A key question is how the rules for project approval will be practiced. Findings in Jotzo and Michaelowa (2002) and Chen (2003) indicate that the applied model's estimated CDM potential is reasonable. Nevertheless, because CDM is project based, the mechanism rules out the possibility for cost-effective national measures as carbon taxes. From that point of view the chosen CDM modeling overestimates the potential for CDM, because it may be interpreted as if the developing countries implement carbon taxes in order to be able to export permits. Hence, there are reasons to believe that the chosen CDM modeling exaggerates the likely supply of permits from this mechanism and that the real market for permits will lie somewhere between the simulated cases with and without CDM. On the other hand, there is a risk that several CDM-projects will be approved even if they are profitable on a commercial basis, and consequently would have been carried out in any case. The executive committee for CDM will have the difficult task to evaluate whether projects are "additional" or profitable also without support from the mechanism. Due to the complexity of the related issues, it is very likely that the mechanism will give rise to the creation of emission credits that not are based on emission reductions in the developing countries.

A more detailed description of the model and the applied data set is given in two appendixes in Holtsmark (2003).

3. The scenarios

The three scenarios set out in the International Energy Outlook 2002 issued by US Department of Energy (DOE, 2002) constitute the basis of the constructed baselines. Some key data are presented in Table 1. Estimations of regional quotas under the Kyoto Protocol are based on 1990 DOE emission data.

Table 1 is useful for comparing the predicted 2010 emissions with respect to the aggregated national quotas (assigned amounts). The corresponding differences between the baseline emissions and the national/regional assigned amounts, which constitute the required cutbacks without emissions trading, are presented in Table 2.[9]

First, we provide some remarks on the case when Russia is party to the Protocol. The predicted 2010 emissions in the Annex B countries (having emission obligations under the Kyoto Protocol), but excluding USA and Australia, are 8820 $MtCO_2$ in the medium growth scenario. The sum of the corresponding national quotas is 8854 $MtCO_2$. Hence, the sum of the quotas is larger than the BAU emissions in the medium growth scenario, which implies that available hot air from Russia and Eastern Europe is larger than net demand for permits in the other countries with caps altogether even as the permit price approaches zero, cf. Table 2. On the other hand, in the high growth scenario there is a net cutback requirement of 510 $MtCO_2$, which constitutes approximately 2 per cent of the global emissions. In the low growth scenario there is a surplus of permits corresponding to 660 $MtCO_2$. This means that in the medium and low growth scenarios there will be a positive permit price only if sellers

[9] At the Conference of the parties to the Climate Convention in Bonn in 2001 there was made some "additions and substractions from the assigned amount of a Party resulting from forest management…" cf. UNFCCC (2001a), p. 11. For practical purposes we could consider these as additions or extensions of the assigned amounts (national quotas) specified in the Kyoto Protocol, because commercial forest management in these countries is likely to fulfil the conditions set for the right to take advantage of these additions. The numerical analysis in this paper is based on these extensions of the national quotas.

restrict their sales strategically and/or if there is permit demand (or restricted sales) from entities and countries that are banking emission allowances for future commitment periods.[10]

The four bottom lines of Table 1 and 2 provide information on the importance of the scale of the participation in the agreement.

Second, we note that in the case when Russia is not a party to the Protocol, there will be a significant net demand for permits even in the low growth scenario, cf. the bottom lines of Table 1 and 2. Hence, if Russia is to withdraw from the Protocol, a positive permit price and a significant global emission reduction effect is likely irrespective of what scenario is realized. In the next section we will quantify these effects.

Table 1. CO2 emissions in 1990, in 2010, targets and assigned amounts (MtCO2/year)

		BAU emissions 2010				
	1990 emissions	Low growth	Med. growth	High growth	Kyoto Target (per cent)	Assigned amounts*
USA and Australia	5 252	6 986	7 159	7 369	93.8	4 928
Canada	462	598	634	671	103.5	478
Western Europe excl. Norway	3 376	3 604	3 784	3 967	92.6	3 127
Norway	34	48	48	48	105.9	36
Russia and Ukraine	3 047	1 972	2 193	2 393	104.0	3 169
Eastern Europe	1 104	781	854	917	94.0	1 038
Japan	986	1 144	1 258	1 316	98.9	975
New Zealand	28	46	50	52	110.7	31
Non-Annex B countries	7 077	11 620	13 024	15 189		
World	21 366	26 800	29 003	31 922		
Annex B	14 289	15 179	15 979	16 733	94.7	13 782
Annex B excl. USA/Australia	9 037	8 193	8 820	9 364	95.2	8 854
Annex B excl. USA/Australia and Russia and Ukraine	5 990	6 221	6 628	6 971	92.8	5 685
EU-27, Sw.land, Island and Norway	4 514	4 433	4 686	4 932	93.1	4 201

Source: DOE 2002

* Including RMUs from forest management.

[10] The analysis does not take explicitly into account that there might be permit demand due to the banking option. Hence, if a quite strict new agreement on a second commitment period is negotiated the permit price might be higher in the first commitment period than estimated in this paper.

Table 2. Absolute required cutbacks (MtCO2/year)

	Low growth	Med. growth	High growth
USA and Australia	2 058	2 231	2 441
Canada	119	156	193
Western Europe excl. Norway	477	657	840
Norway	12	12	12
Russia and Ukraine	-1 197	-976	-776
Eastern Europe	-257	-184	-121
Japan	169	283	342
New Zealand	15	19	21
Annex B	1 398	2 197	2 951
Annex B excl. USA and Australia	-660	-33	510
Annex B excl. USA, Australia, Russia, and Ukraine	536	943	1 286
EU-27, Switzerland, Island and Norway	232	485	731

4. Implementation of the Kyoto Protocol without Russia and Ukraine

This section presents model simulations that provide information on the effects of implementation of a "mini-Kyoto" Protocol without participation from Russia and Ukraine. As a basis for comparison, one case with Russian/Ukrainian participation is also presented. Altogether five cases are defined and analyzed, all of which take into account US and Australian non-participation. If nothing is said to the contrary, the discussion is related to the medium growth BAU scenario. Emission permit prices are measured in €/tCO_2.[11]

The upper part of Table 3 sets out the characteristics of the different cases. Case 1 assumes that Russia and Ukraine (labeled FSU) are parties to the agreement and act strategically as a cartel in the permit market.[12] The other cases assume that Russia choose not to ratify the Kyoto Protocol and that Ukraine

[11] Because European countries and companies are going to dominate the permit market under the Kyoto Protocol, we find it reasonable to measure permit prices by Euros. The calculations are based on an exchange rate reflecting the current situation, where one Euro (€) is equal to 1.17 USD ($).

[12] Case 1 here corresponds to case 5 in Holtsmark (2003). The case assumes that the Russia/Ukraine bears in mind how the permit market will influence the oil market and the market for gas in Europe. The point is that the model simulations show that both the oil price and the gas price in the European market would drop as the permit price rise. It follows that if Russia/Ukraine restricts its permit sales in order to boost profits in the permit market, the profits in the oil and gas industries may decline at the same time. If they do so, the simulations indicate that they would probably amplify the permit supply by approximately 150 MtCO_2, followed by a drop in permit price of approximately 1 €/tCO_2. However, the results of case 1 in this paper differ somewhat from the results of case 5 in Holtsmark (2003) because the version of the simulation model applied in this paper take transactions costs in CDM into account. Such costs where not incorporated into the model applied in Holtsmark (2003).

then opt-out. In those cases it is instead assumed that the national assigned amounts serve as the basis for a new (multilateral) "mini-Kyoto" agreement between the other countries that has ratified the Protocol. Different solutions are then possible.

First, the remaining Annex B countries could establish an agreement adopting the full set of assigned amounts set out in the Kyoto Protocol as well as rules for emissions trading, joint implementation, enforcement and so forth, established in the Marrakech Accords (UNFCC, 2001b). However, without participation from the developing countries, CDM has to be ignored. In that case not only permit supply from Russia and Ukraine is eliminated. In addition the permit supply from the developing countries through CDM is dropped. That scenario is labeled case 2 in the following.

Second, there is a possibility that the developing countries could be involved in a new agreement as host countries of CDM-projects. In that case also the rules for CDM specified in the Marrakech accords are assumed to apply. This possibility is labelled case 3 in this paper.

The cases 4 and 5 are variations on the cases 2 and 3, respectively, in that also Japan, Canada and New Zealand opt-out in these cases. While CDM is included in case 5, case 4 disregards permit supply from this mechanism.

Table 3. Case characteristics and estimated permit prices in the various scenarios (€/tCO2)

Case:	1	2	3	4	5
Participation from Russia and Ukraine	✔				
Participation from Japan, Canada, NZ	✔	✔	✔		
Permit supply from CDM	✔		✔		✔
Permit price (€/tCO_2) in the scenarios/cases:					
Low growth	1.6	11.2	5.5	6.7	3.3
Medium growth	2.9	18.3	7.9	13.2	5.1
High growth	3.7	23.8	9.6	18.9	6.6

Table 4. Net permit imports in the medium growth scenario. MtCO2

	Case				
	1	2	3	4	5
Canada	141	55	114	-	-
Western Europe	602	233	488	351	550
Russia and Ukraine	-698	-	-	-	-
Eastern Europe	-219	-413	-279	-351	-246
Japan	253	108	208	-	-
New Zealand	18	17	18	-	-
Non-Annex B	-98	-	-548	-	-303
Annex B	98	0	548	0	303

Table 5. Emission reductions in the medium growth scenario. $MtCO_2$

	Case				
	1	2	3	4	5
USA and Australia	-12	-45	-47	-24	-24
Canada and New Zealand	16	102	43	-1	-2
Western Europe	67	436	181	318	119
Russia and Ukraine	-4	-20	-16	-12	-8
Eastern Europe	35	230	96	168	63
Japan	26	171	71	-3	-3
Non-Annex I	98	-50	548	-25	303
World	225	824	876	420	448

The calculated permit price in the different cases and scenarios is set out in Table 3, while the movements in the market for permits in the medium growth scenario are presented in Table 4. The estimated emission reductions compared to the BAU-scenarios are set out in Table 5 and 6.

In the following discussion the different cases are compared to the three BAU scenarios described in the previous section. If nothing is said to the contrary, the discussion is related to the medium growth scenario.

Table 6. Global emission reductions in the different cases and scenarios. $MtCO_2$

	1	2	3	4	5
Low growth	56	470	498	201	213
Medium growth	225	824	876	420	448
High growth	367	1133	1208	637	681

Concerning case 1, it is assumed that Russia and Ukraine act as a cartel in the permit market; restricting sales in order to maximize the sum of income from permit sales and profits in their oil and gas industries, cf. Holtsmark (2003). The estimated permit price of 2.9 €/tCO_2 in the medium growth scenario in case 1 is in reasonable accordance with most other model-based studies, although at the low end, cf. Springer and Varilek (2003). The global emission reductions in case 1 are 225 $MtCO_2$ in the medium growth case. This represents less than one percent of global CO_2-emissions in this scenario.

Table 5 and 6 set out the emission reductions in the different cases. While Table 5 shows regional emission reductions relative to the medium growth BAU scenario, Table 6 shows global emission reductions in the various cases under different assumptions about the BAU economic growth.

The negative numbers in Table 5 (increased emissions) represent carbon leakage and deserve a comment. The relevant mechanism in the model is that the emissions are slightly increased in countries without emissions caps when the countries with caps carry out abatement. This carbon leakage is due to reduced fossil fuel prices in the new equilibriums. Secondly, the emissions are increased within Russia/Ukraine also in the cases where Russia has ratified the Kyoto Protocol. The reason is that Russia/Ukraine in these cases is not subject to a binding commitment as only a part of the stock of hot air permits are sold on the market. Hence, no abatement policy is implemented in Russia/Ukraine and consequently there will be some carbon leakage in this region due to lower fossil fuel prices at the user end.

The permit price changes are accompanied by corresponding changes in the behaviour of the permit importers and permit suppliers in Eastern Europe. In case 2, where there is no permit supply from CDM-projects, the countries in Eastern Europe increase their permit supply by almost 90 per cent compared to case 1. At the same time the permit price jumps from € 2.9 to € 18.3. Hence, this case may be quite attractive from the point of view of the new EU-members, although the increased permit supply is based on domestic abatement.

If, on the other hand, permit supply from CDM is included in the analysis, the corresponding increased permit supply from Eastern Europe as a result of the Russian/Ukrainian withdrawal is only 27 percent. Moreover, the permit price increase is much smaller in this case. Nevertheless, also this case is attractive from the point of view of the countries in Eastern Europe.

The costs of Russian/Ukrainian withdrawal have to be paid by the permit importers: EU, Japan, New Zealand and Canada, as well as the smaller countries Norway, Switzerland and Island. Their costs will, however, be considerably smaller if the agreement adopts CDM.

Without Russian/Ukrainian participation the environmental effect of a multilateral agreement would be larger, cf. Table 5 and 6. The reason is that withdrawal of almost 700 million tonnes of permits from the market would imply an increased permit price that makes abatement more profitable. It is important to underline that the net environmental effect of the Russian withdrawal cannot be calculated on the basis of the national emission quotas alone, but has to be seen in relation to the Russian/Ukrainian strategic behaviour in the first place (amount of hot air sold) as well as the degree of carbon leakage in the different non-participating regions.

From Table 4 we note that Japan, Canada and New Zealand together represent a considerable share of the demand side of the permit market. Hence, as we move to cases 4 and 5, where we assume that these three countries opt-out, the permit price drops considerably (compared to cases 2 and 3), cf. Table 3. The relative change in total environmental benefit is reduced even more, because the profitability of abatement is reduced while the geographical coverage of the agreement is reduced at the same time.

From the point of view of the EU-15, case 4 and 5 might nevertheless be politically attractive scenarios. In these cases the permit prices are moderate, at least if permit credits from developing countries are accepted. At the same time a considerable part of the income from permit sales are allocated to the new EU-countries.

5. Conclusions

Currently, all Annex B parties except Russia, Australia and USA, have ratified the Kyoto Protocol. With de facto USA and Australia withdrawal, the Kyoto Protocol will only enter into force if it is ratified by Russia. It is still very much an open question whether Russia will do so. This paper has therefore analyzed some available options given that the Russian government decides not to ratify.

The paper focuses on the case where the remaining Annex B parties respond to Russian withdrawal by the establishment of a new multilateral ("mini Kyoto") agreement by which they commit themselves to the emission caps, the rules for emissions trading, compliance etc. set out in the Protocol. We have firstly analyzed the case where this multilateral agreement includes all the remaining Annex B parties, except Ukraine. Secondly, we have analyzed the case where Japan, Canada and New Zealand are not willing to take part in this agreement. In that case the remaining parties consist of only EU-25, Bulgaria, Romania, Norway, Island and Switzerland.

Figure 1 sum up the effects of geographical coverage of a "mini Kyoto" agreement on emissions and permit prices. We note that as Russia and Ukraine opt-out, the environmental benefit of implementation is considerably increased due to the large amounts of hot air, which is then withdrawn from the market (case 1 → case 2,3). However, the final result of Russian/Ukrainian withdrawal might be that important countries with reduction obligations, such as Japan, Canada and New Zealand, also opt-out. To some degree that would neutralize the environmental gain caused by the Russian/Ukrainian withdrawal (case 2, 3 → case 4,5). Nevertheless, the environmental effect of an agreement involving only in EU-27, Norway and Switzerland is still larger than in case 1, where only USA and Australia had left the agreement.

Figure 1: Global emission reductions (MtCO2) and permit price (€/tCO2) in the medium growth scenario. The five cases

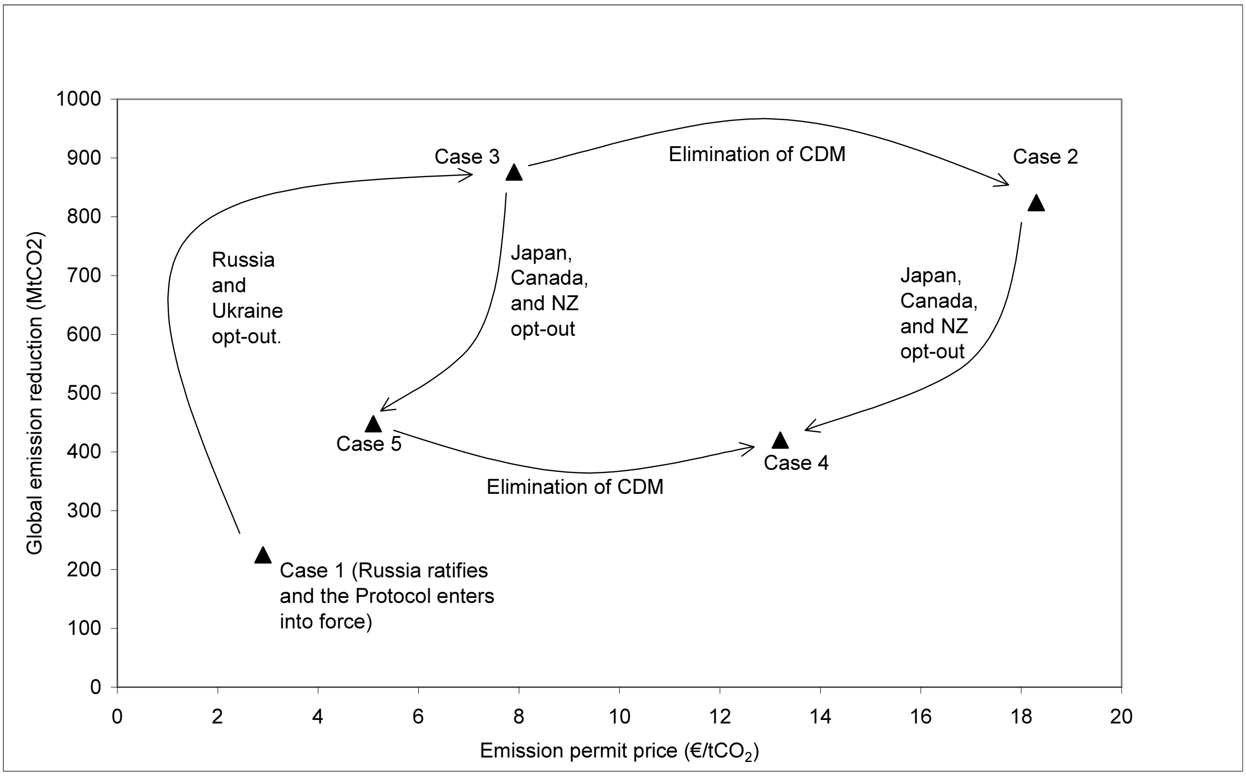


Figure 1 also illustrates to what extent marginal abatement costs change with respect to geographical coverage and the importance of CDM in this respect. As Russia and Ukraine opt-out, the permit price increases from € 2.9 to € 7.9. Furthermore, if the permit supply from CDM is eliminated, the permit price increases to € 18.3, a six fold increase compared to case 1. Hence, to permit importers as EU, Japan and Canada, this “mini-Kyoto” implementation would mean considerably increased costs. If also Japan, Canada, and New Zealand opt-out, however, three permit importers are out of the market. Consequently, the permit price is reduced to € 5.1 and € 13.2 in cases 5 and 4, respectively. In other words, this last alternative would imply smaller costs to EU, which in this case dominates the agreement.

From an environmental point of view implementation of the Kyoto Protocol without participation from Russia and Ukraine is superior to the full implementation of the Kyoto Protocol. The reason is that no abatement is in likely to be carried out in Russia and Ukraine in any case, because these two countries as a result of their large national quotas and exercise of power in the permit market are stuck with more emission allowances than needed to legitimate their emissions. Also in the cases where Japan, Canada and New Zealand opt-out, which imply implementation of a mini-Kyoto Protocol only within EU-27 together with Norway, Island and Switzerland, the solution is environmentally superior to the case where the Kyoto Protocol had been implemented with participation from Russia, Ukraine, as well. However, after the US withdrawal from the Kyoto Protocol, the global environmental effect of implementation is in any case relatively small.

From a European perspective, case 4 and 5 might seem attractive, since in these cases the costs could be considered moderate, while at the same time the new EU-members have considerable gains from emissions trading.

References

Aune, F.R., R. Golombek, S.A.C. Kittelsen and K.E. Rosendahl (2002): Friere energimarkeder i Vest-Europa (Liberalised Energy Markets in Western Europe), *Økonomiske Analyser* 5/2002, Statistics Norway.

Aune, F.R., R. Golombek, S.A.C. Kittelsen, K.E. Rosendahl and O. Wolfgang (2001): LIBEMOD - LIBEralisation MODel for the European Energy Markets: A Technical Description. Working Paper 1/2001. Ragnar Frisch Centre for Economic Research, Oslo.

Babiker, H.B., D.H. Jacoby, J.M. Reilly and D.M. Reiner (2002): The evolution of a climate regime: Kyoto to Marrakech and beyond. *Environmental Science & Policy* **5,** 195-206.

Bretteville, C., J. Hovi and F.C. Menz (2004): Regional versus Global Cooperation for Climate Control, , (unpublished paper).

Brubakk, L., M. Aaserud, M. Pellekaan and W. von Ostvoorn (1995): 'SEEM – An Energy Demand Model for Western Europe' Rapporter 95/24 Statistics Norway.

Buchner, B., C. Carraro and I. Cersosimo (2002): Economic consequences of the US withdrawal from the Kyoto/ Bonn Protocol. *Climate Policy* **2**, 273-292.

Böhringer, C. (2002): Climate Politics from Kyoto to Bonn: From Little to Nothing? *The Energy Journal* **23** **2**, 51-72.

Böhringer, C. and A. Löshel (2003): Market power and hot air in international emissions trading: the impacts of US withdrawal from the Kyoto Protocol. *Applied Economics* **35** **6**, 651-663.

Chen, W. (2003): Carbon quota price and CDM potentials after Marrakesh. *Energy Policy* **31**, 709-719.

den Elzen, M.G.J. and A.P.G. de Moor (2003): Analyzing the Kyoto Protocol under the Marrakesh Accords: economic efficiency and environmental effectiveness. *Ecological Economics* **43**, 141-158.

DOE (2002): *International Energy Outlook 2002*. Energy Information Administration. US Department of Energy. Washington DC.

Franzen, M. and T. Sterner (1995): "Long-run demand elasticities for gasoline". In Barker et al. (eds.): *Global Warming and Energy Demand*. Routledge, London.

Golombek, R., C. Hagem and M. Hoel (1995): Efficient Incomplete International Climate Agreements. *Resource and Energy Economics* **17**, 25-46.

Grütter, J., R. Kappel and P. Staub (2002): The GHG Market on the Eve of Kyoto Ratification. Report. Eidgennössische Technische Hochshule, Zürich, Switzerland.

Hagem, C. and B. Holtsmark (2001): From small to insignificant: Climate impact of the Kyoto Protocol with and without the US. CICERO Policy Note 2001:1. http:/www.cicero.uio.no.

Holtsmark, B. (2003): Russian behaviour in the market for permits under the Kyoto Protocol. *Climate Policy* **34**, 399-415.

Holtsmark, B. and O. Mæstad (2002): Emissions trading under the Kyoto Protocol. Effects on the fossil fuel markets under different regimes. *Energy Policy* **30 3**, 207-218.

IEA (1995): *Energy Prices and Taxes,* OECD, Paris.

Jotzo, F. and A. Michaelowa (2002): Estimating the CDM market under the Marrakech Accords. *Climate Policy* **2**, 179-196.

Manne, A.S. and R.G. Richels (2001): US Rejection of the Kyoto Protocol: The Impact on Compliance Costs and CO_2 emissions. Working Paper. AEI-Brookings Joint Center for Regulatory Studies.

Nordhaus, W. (2001): Global Warming Economics. *Science* **294**, 1283-1284.

Smith, C., S. Hall and N. Mabey (1995): Econometric modeling of international carbon tax regimes. *Energy Economics* **17,** 133-46.

Springer, U. and M. Varilek (2003): Estimating the price of tradable permits for greenhouse gas emissions in 2008-12. *Energy Policy*. In press.

UNFCCC (2001a): Report of the Conference of the Parties on the second part of its sixth session, held at Bonn from 16 to 27 July 2001. FCCC/CP/2001/5/Add.2

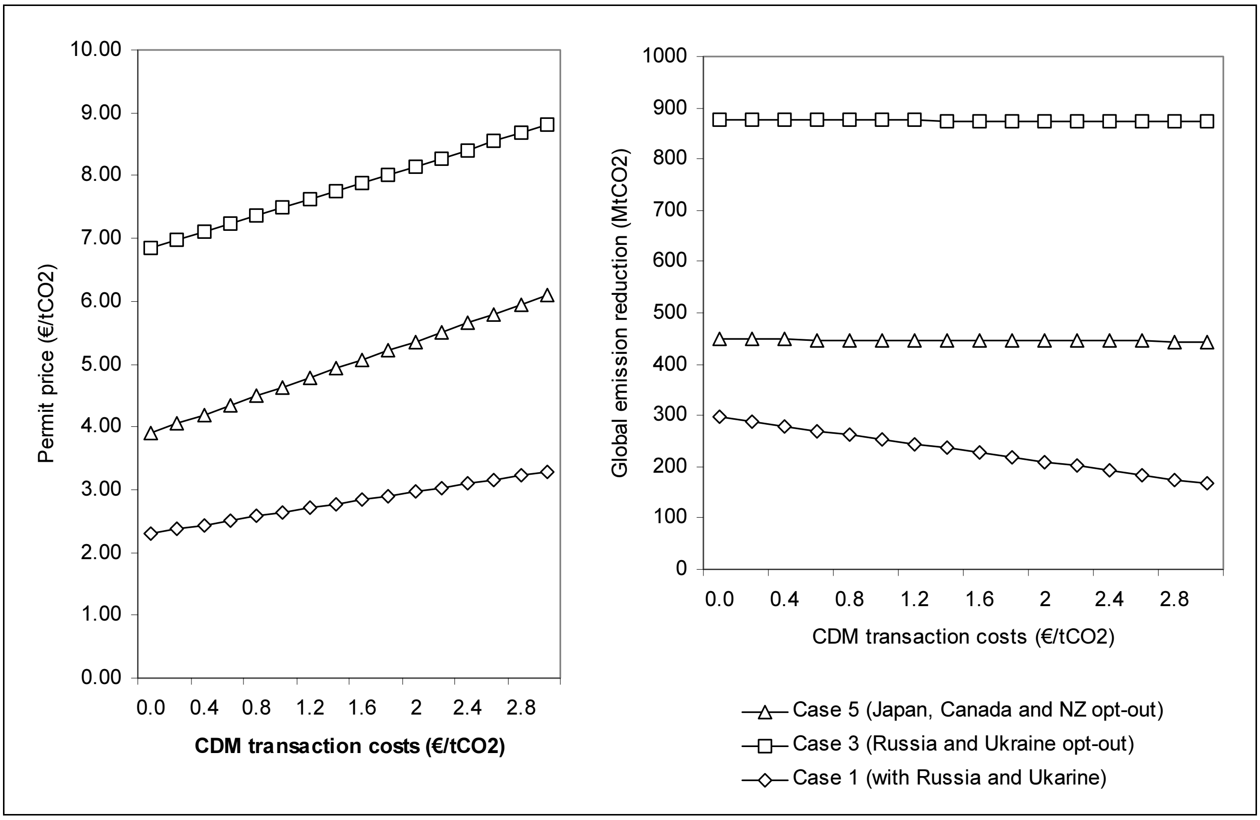
UNFCCC (2001b): The Marrakesh Accords. FCCC/CP/2001/13/Add.1.

Vrolijk, C. and M. Grubb (2000): Quantifying Kyoto. How will COP-6 decisions affect the market? Report. The Royal Institute of International Affairs. London.

Appendix

As illustrated in Figure 1 the permit price is quite sensitive to the supply of CDM generated permits. Hence, any assessment of the permit market under the Kyoto Protocol has to model CDM carefully. Modeling CDM is, however, difficult not least because the mechanism is project based. The fact that the mechanism rules out cost-effective measures such as emission taxes implies a loss of cost-effectiveness. Moreover, there will be additional costs related to the procedures for approval of projects, etc. These types of additional costs could all be labeled as transactions costs. An improvement of the model applied in this paper compared the model applied in Holtsmark (2003) is the incorporation of such transaction costs in relation to CDM. The simulations presented in section 4 assumed transaction costs equal to 1.7 €/tCO_2. Because this numerical choice lacks a firm empirical basis, this appendix provides some sensitivity simulations with respect to the size of the transaction costs of CDM-projects. The permit price and the global emission reductions are calculated as the transaction cost varies from 0 to 3.0 €/tCO_2, cf. figure A.1.

Figure A.1: Global emission reductions (left diagram, MtCO_2) and permit price ((right diagram, €/tCO_2) in the medium growth scenario. The cases that include CDM



As the transaction cost increases the permit supply from CDM is reduced. Consequently, higher permit prices follows, cf. the left diagram of Figure A.1. As the transactions costs are increased from zero to 3 €/tCO_2, the permit price is increased by about 2 €/tCO_2, as far as case 3 and 5 are concerned. In case 1 the permit price increase is less significant. This is because of the role of Russia, which in this case behaves as a dominating seller in the permit market. Due to its market power, Russia finds it profitable to respond to reduced supply of permit from CDM by increased supply of hot air. This also explains while increased transactions costs gives smaller environmental effect of the agreement, cf. the right diagram of Figure A.1.

As far as case 3 and 5 are concerned, the level of the transaction costs does not affect the global emission reductions, because the permit market in these cases are competitive which means that the sum of the assigned amounts (national emission caps) determines the global emission reductions. In that setting, reduced supply of permits from CDM has to be compensated by other suppliers. There are, however, some small differences with respect to global emission reductions due to leakage effects. They are too small to be apparent from figure A.1

Recent publications in the series Discussion Papers

285 L.-C. Zhang (2000): On dispersion preserving estimation of the mean of a binary variable from small areas

286 F.R. Aune, T. Bye and T.A. Johnsen (2000): Gas power generation in Norway: Good or bad for the climate? Revised version

287 A. Benedictow (2000): An Econometric Analysis of Exports of Metals: Product Differentiation and Limited Output Capacity

288 A. Langørgen (2000): Revealed Standards for Distributing Public Home-Care on Clients

289 T. Skjerpen and A.R. Swensen (2000): Testing for long-run homogeneity in the Linear Almost Ideal Demand System. An application on Norwegian quarterly data for non-durables

290 K.A. Brekke, S. Kverndokk and K. Nyborg (2000): An Economic Model of Moral Motivation

291 A. Raknerud and R. Golombek: Exit Dynamics with Rational Expectations

292 E. Biørn, K-G. Lindquist and T. Skjerpen (2000): Heterogeneity in Returns to Scale: A Random Coefficient Analysis with Unbalanced Panel Data

293 K-G. Lindquist and T. Skjerpen (2000): Explaining the change in skill structure of labour demand in Norwegian manufacturing

294 K. R. Wangen and E. Biørn (2001): Individual Heterogeneity and Price Responses in Tobacco Consumption: A Two-Commodity Analysis of Unbalanced Panel Data

295 A. Raknerud (2001): A State Space Approach for Estimating VAR Models for Panel Data with Latent Dynamic Components

296 J.T. Lind (2001): Tout est au mieux dans ce meilleur des ménages possibles. The Pangloss critique of equivalence scales

297 J.F. Bjørnstad and D.E. Sommervoll (2001): Modeling Binary Panel Data with Nonresponse

298 Taran Fæhn and Erling Holmøy (2001): Trade Liberalisation and Effects on Pollutive Emissions and Waste. A General Equilibrium Assessment for Norway

299 J.K. Dagsvik (2001): Compensated Variation in Random Utility Models

300 K. Nyborg and M. Rege (2001): Does Public Policy Crowd Out Private Contributions to Public Goods?

301 T. Hægeland (2001): Experience and Schooling: Substitutes or Complements

302 T. Hægeland (2001): Changing Returns to Education Across Cohorts. Selection, School System or Skills Obsolescence?

303 R. Bjørnstad: (2001): Learned Helplessness, Discouraged Workers, and Multiple Unemployment Equilibria in a Search Model

304 K. G. Salvanes and S. E. Førre (2001): Job Creation, Heterogeneous Workers and Technical Change: Matched Worker/Plant Data Evidence from Norway

305 E. R. Larsen (2001): Revealing Demand for Nature Experience Using Purchase Data of Equipment and Lodging

306 B. Bye and T. Åvitsland (2001): The welfare effects of housing taxation in a distorted economy: A general equilibrium analysis

307 R. Aaberge, U. Colombino and J.E. Roemer (2001): Equality of Opportunity versus Equality of Outcome in Analysing Optimal Income Taxation: Empirical Evidence based on Italian Data

308 T. Kornstad (2001): Are Predicted Lifetime Consumption Profiles Robust with respect to Model Specifications?

309 H. Hungnes (2001): Estimating and Restricting Growth Rates and Cointegration Means. With Applications to Consumption and Money Demand

310 M. Rege and K. Telle (2001): An Experimental Investigation of Social Norms

311 L.C. Zhang (2001): A method of weighting adjustment for survey data subject to nonignorable nonresponse

312 K. R. Wangen and E. Biørn (2001): Prevalence and substitution effects in tobacco consumption. A discrete choice analysis of panel data

313 G.H. Bjertnær (2001): Optimal Combinations of Income Tax and Subsidies for Education

314 K. E. Rosendahl (2002): Cost-effective environmental policy: Implications of induced technological change

315 T. Kornstad and T.O. Thoresen (2002): A Discrete Choice Model for Labor Supply and Child Care

316 A. Bruvoll and K. Nyborg (2002): On the value of households' recycling efforts

317 E. Biørn and T. Skjerpen (2002): Aggregation and Aggregation Biases in Production Functions: A Panel Data Analysis of Translog Models

318 Ø. Døhl (2002): Energy Flexibility and Technological Progress with Multioutput Production. Application on Norwegian Pulp and Paper Industries

319 R. Aaberge (2002): Characterization and Measurement of Duration Dependence in Hazard Rate Models

320 T. J. Klette and A. Raknerud (2002): How and why do Firms differ?

321 J. Aasness and E. Røed Larsen (2002): Distributional and Environmental Effects of Taxes on Transportation

322 E. Røed Larsen (2002): The Political Economy of Global Warming: From Data to Decisions

323 E. Røed Larsen (2002): Searching for Basic Consumption Patterns: Is the Engel Elasticity of Housing Unity?

324 E. Røed Larsen (2002): Estimating Latent Total Consumption in a Household.

325 E. Røed Larsen (2002): Consumption Inequality in Norway in the 80s and 90s.

326 H.C. Bjørnland and H. Hungnes (2002): Fundamental determinants of the long run real exchange rate:The case of Norway.

327 M. Søberg (2002): A laboratory stress-test of bid, double and offer auctions.

328 M. Søberg (2002): Voting rules and endogenous trading institutions: An experimental study.

329 M. Søberg (2002): The Duhem-Quine thesis and experimental economics: A reinterpretation.

330 A. Raknerud (2002): Identification, Estimation and Testing in Panel Data Models with Attrition: The Role of the Missing at Random Assumption

331 M.W. Arneberg, J.K. Dagsvik and Z. Jia (2002): Labor Market Modeling Recognizing Latent Job Attributes and

Opportunity Constraints. An Empirical Analysis of Labor Market Behavior of Eritrean Women

332 M. Greaker (2002): Eco-labels, Production Related Externalities and Trade

333 J. T. Lind (2002): Small continuous surveys and the Kalman filter

334 B. Halvorsen and T. Willumsen (2002): Willingness to Pay for Dental Fear Treatment. Is Supplying Fear Treatment Social Beneficial?

335 T. O. Thoresen (2002): Reduced Tax Progressivity in Norway in the Nineties. The Effect from Tax Changes

336 M. Søberg (2002): Price formation in monopolistic markets with endogenous diffusion of trading information: An experimental approach

337 A. Bruvoll og B.M. Larsen (2002): Greenhouse gas emissions in Norway. Do carbon taxes work?

338 B. Halvorsen and R. Nesbakken (2002): A conflict of interests in electricity taxation? A micro econometric analysis of household behaviour

339 R. Aaberge and A. Langørgen (2003): Measuring the Benefits from Public Services: The Effects of Local Government Spending on the Distribution of Income in Norway

340 H. C. Bjørnland and H. Hungnes (2003): The importance of interest rates for forecasting the exchange rate

341 A. Bruvoll, T.Fæhn and Birger Strøm (2003): Quantifying Central Hypotheses on Environmental Kuznets Curves for a Rich Economy: A Computable General Equilibrium Study

342 E. Biørn, T. Skjerpen and K.R. Wangen (2003): Parametric Aggregation of Random Coefficient Cobb-Douglas Production Functions: Evidence from Manufacturing Industries

343 B. Bye, B. Strøm and T. Åvitsland (2003): Welfare effects of VAT reforms: A general equilibrium analysis

344 J.K. Dagsvik and S. Strøm (2003): Analyzing Labor Supply Behavior with Latent Job Opportunity Sets and Institutional Choice Constraints

345 A. Raknerud, T. Skjerpen and A. Rygh Swensen (2003): A linear demand system within a Seemingly Unrelated Time Series Equation framework

346 B.M. Larsen and R.Nesbakken (2003): How to quantify household electricity end-use consumption

347 B. Halvorsen, B. M. Larsen and R. Nesbakken (2003): Possibility for hedging from price increases in residential energy demand

348 S. Johansen and A. R. Swensen (2003): More on Testing Exact Rational Expectations in Cointegrated Vector Autoregressive Models: Restricted Drift Terms

349 B. Holtsmark (2003): The Kyoto Protocol without USA and Australia - with the Russian Federation as a strategic permit seller

350 J. Larsson (2003): Testing the Multiproduct Hypothesis on Norwegian Aluminium Industry Plants

351 T. Bye (2003): On the Price and Volume Effects from Green Certificates in the Energy Market

352 E. Holmøy (2003): Aggregate Industry Behaviour in a Monopolistic Competition Model with Heterogeneous Firms

353 A. O. Ervik, E.Holmøy and T. Hægeland (2003): A Theory-Based Measure of the Output of the Education Sector

354 E. Halvorsen (2003): A Cohort Analysis of Household Saving in Norway

355 I. Aslaksen and T. Synnestvedt (2003): Corporate environmental protection under uncertainty

356 S. Glomsrød and W. Taoyuan (2003): Coal cleaning: A viable strategy for reduced carbon emissions and improved environment in China?

357 A. Bruvoll T. Bye, J. Larsson og K. Telle (2003): Technological changes in the pulp and paper industry and the role of uniform versus selective environmental policy.

358 J.K. Dagsvik, S. Strøm and Z. Jia (2003): A Stochastic Model for the Utility of Income.

359 M. Rege and K. Telle (2003): Indirect Social Sanctions from Monetarily Unaffected Strangers in a Public Good Game.

360 R. Aaberge (2003): Mean-Spread-Preserving Transformation.

361 E. Halvorsen (2003): Financial Deregulation and Household Saving. The Norwegian Experience Revisited

362 E. Røed Larsen (2003): Are Rich Countries Immune to the Resource Curse? Evidence from Norway's Management of Its Oil Riches

363 E. Røed Larsen and Dag Einar Sommervoll (2003): Rising Inequality of Housing? Evidence from Segmented Housing Price Indices

364 R. Bjørnstad and T. Skjerpen (2003): Technology, Trade and Inequality

365 A. Raknerud, D. Rønningen and T. Skjerpen (2003): A method for improved capital measurement by combining accounts and firm investment data

366 B.J. Holtsmark and K.H. Alfsen (2004): PPP-correction of the IPCC emission scenarios - does it matter?

367 R. Aaberge, U. Colombino, E. Holmøy, B. Strøm and T. Wennemo (2004): Population ageing and fiscal sustainability: An integrated micro-macro analysis of required tax changes

368 E. Røed Larsen (2004): Does the CPI Mirror Costs.of.Living? Engel's Law Suggests Not in Norway

369 T. Skjerpen (2004): The dynamic factor model revisited: the identification problem remains

370 J.K. Dagsvik and A.L. Mathiassen (2004): Agricultural Production with Uncertain Water Supply

371 M. Greaker (2004): Industrial Competitiveness and Diffusion of New Pollution Abatement Technology – a new look at the Porter-hypothesis

372 G. Børnes Ringlund, K.E. Rosendahl and T. Skjerpen (2004): Does oilrig activity react to oil price changes? An empirical investigation

373 G. Liu (2004) Estimating Energy Demand Elasticities for OECD Countries. A Dynamic Panel Data Approach

374 K. Telle and J. Larsson (2004): Do environmental regulations hamper productivity growth? How accounting for improvements of firms' environmental performance can change the conclusion

375 K.R. Wangen (2004): Some Fundamental Problems in Becker, Grossman and Murphy's Implementation of Rational Addiction Theory

376 B.J. Holtsmark and K.H. Alfsen (2004): Implementation of the Kyoto Protocol without Russian participation