Compliance with the Kyoto Protocol

Macroeconomics of emissions trading joint implementation, and the clean development mechanism

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Abstract

We analyse the economic impacts of regional CO_2-emission constraints under the assumption that on the medium term the Annex-1 region (OECD regions and Economies in Transition) will make abatement efforts to comply with the Kyoto Protocol. The paper focuses on the role of flexible instruments. Next to the polar cases with no or full Annex-1 emission trade, we first analyse emission trade within two separated markets in Annex-1 (the first block contains Europe, including Central European countries, and all other Annex-1 countries as the second block). The second case concerns a restriction on the reductions to be achieved abroad. Third, we analyse the case in which Annex-1 countries may jointly implement investments in non Annex-1 countries. The applied general equilibrium model WorldScan is used to analyse macro-economic impacts for several different regimes and cases.

Keywords: International Agreements, CO_2-emissions, Climate change, tradeable permits, joint implementation, clean development mechanism, cost-effectiveness

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1 Introduction

The Kyoto Protocol was adopted during the third Conference of Parties to the Framework Convention on Climate Change (COP-3 of the FCCC) in December 1997. The Protocol defines commitments for developed country (Annex-1) Parties with a view to reduce their overall greenhouse gas emissions by an average of at least 5.2 % below their 1990 levels in the five years after 2008 (the first budget period). The commitments differ among the Annex-1 Parties - every party has a different level of so-called 'Assigned Amounts' (AA's) of greenhouse gas emissions. The EU committed to 8%, the USA to 7% and Japan to 6%, while Australia, Norway and Iceland committed to levels above 1990 emissions and New Zealand stabilises emissions. Of the Central European Countries listed in Annex-1, most share the EU reduction target, except for Poland (6%), Hungary (6%) and Croatia (5%). Russia and the Ukraine have only committed to a stabilisation at 1990 levels.

The Parties to the FCCC have introduced three new instruments under the Protocol, allowing Parties (or entities) with emission limits to achieve emission reductions outside their national borders. There are three mechanisms for transferring the emissions internationally under the protocol: Joint Implementation (JI), Clean Development Mechanism (CDM) and International Emission Trading (IET).

- Joint Implementation (JI) concerns project-level credits, labelled Emission Reduction Units (ERU's) as defined in Article 6, transferrable among Annex 1 Parties - ERU's can be earned and traded only in the budget period itself.
- Clean Development Mechanism (CDM) concerns Certified Emission Reductions (CER's), as defined in Article 12, transferrable from non Annex 1 Parties to Annex 1 Parties - CER's can be earned in projects from 2000 onwards, and be used to enlarge AA's in the first budget period
- InternationalEmission Trading, (IET) as defined in Article 17 of the Protocol, concerns transfer of the AA's among Annex-1 Parties, which are applicable in the first budget period, running from 2008 till 2012. These AA's are corrected for CER's obtained from CDM projects.

From an Annex 1 perspective, the reason for introducing these instruments has been to reduce the total costs of emission reductions - costs are generally lower outside OECD countries and through flexibility, these can be used to reduce total costs at the benefit of all Parties. From an Annex 1 perspective, CDM is mainly an extension of this flexibility to the global level - the perceived costs of emission reduction are even lower outside the Annex 1 area and clearly global flexibility should further reduce costs. From a global perspective, CDM also could prevent leakage from Annex 1 to non-Annex 1 and stimulate sustainable development (Article 12.2 of the Protocol).

The Protocol states that the contribution of IET and JI should be "supplemental" to domestic action. Generally, introducing such an additional policy goal requires using another instrument. Restrictions might be imposed on the international trade in emissions in order to stimulate - or better: force - domestic action. Indeed, the European Union statement resulting from the Environment Council in June mentions 'concrete ceilings' on the flexible instruments. Although concrete can be interpreted in different ways, many interpret it as absolute ceilings on the amount of emissions that can be traded.

Another type of limitation is reflected by the possible emergence of sub-groups of countries, restricting the emission trade to the members of this group - an example may be the Umbrella Group, consisting of Japan, the United States, Canada, and New Zealand (JUSCANZ) and the Russian Federation - within the Annex 1 group.

The principles, rules and guidelines for using the instruments will be the subject of further negotiations during the fourth meeting of the Conference of Parties (COP-4 of the FCCC) in Buenos

Aires, Argentina, in November 1998.

The basic argument in favour of flexible instruments such as IET and JI - their efficiency gains as compared to a situation in which each country has to achieve its own reduction target domestically - are well-known and widely accepted (see IPCC, 1996 for a review). The difference between IET and JI is that in the former case one uniform price of emissions will exist, while in the latter for each project a separate price might be negotiated. The uniform price in case of IET will equal the marginal cost of reducing emissions in the Annex-I region. The prices in case of JI will equal the marginal cost of reducing emissions in the individual projects, which are generally lower than the marginal costs of the whole Annex-I region. In this paper we will not focus on the potential difference between IET and JI. Instead, we will take both mechanisms as parts of the same system with one uniform emission price. This comes down to asuming that ERU's (resulting from JI projects) are traded internationally, so that the price for these and AA's are uniform.

Our focus in this paper will be the analysis of restrictions on trade in emission permits. Both ceilings and trade within restricted clubs will be discussed. Furthermore, we will discuss different aspects of CDM. Especially the certification of reductions resulting from CDM projects is a central issue, because non-Annex-I countries do not have overall emission targets. With this analysis of CDM and restrictions on IET/JI this paper addresses issues on the agenda in Buenos Aires. We use the applied general equilibrium model WorldScan to analyse the quantitative effects of the different cases, taking an Annex-I perspective and focussing on regional differences within this group.

The rest of this paper is organised as follows. Section 2 provides a general analysis of the three issues. Section 3 contains information on how we used WorldScan. Section 4 presents the results of the model simulations. Section 5 draws the main conclusions of the outcomes.

2 Analysis

In a fully competitive emission trading (IET) system, marginal abatement costs are equalized across borders (modelling details on permit trade can be found in Box 1 in the Technical Appendix) . Emissions cannot be reduced at lower costs than in case emissions are tradeable against one uniform price. This implies an efficient reduction of emissions in the Annex 1 region as whole - i.e. total abatement costs for the Annex 1 are minimized. When IET is not allowed, the Annex 1 countries must achieve their reduction targets domestically. In such a case, the marginal abatement costs will not be equalized and the resulting emission reduction is not or less efficient than with IET. Total abatement costs will lie above the minimum costs of the IET system.

The regional distribution of the total costs - the total burden - depends on more than simply the reduction target in each country.

- First, reduction targets in Kyoto are defined relative to a base year. The economic burden depends on the target in deviation from a baseline without climate policies. The expected economic burden is higher if countries are expected to grow fast after the base-year.
- Second, the economic burden depends on average abatement costs instead of marginal abatement costs. Therefore, if a country has low average abatement costs, relative to the marginal cost for the region as a whole, then it will have a relatively low economic burden.
- Third, the economic burden depends on the possibility to trade emissions internationally. Clearly, regions with high marginal costs will tend to import more, and therefore gain more from trading and vice versa

Especially the second and third aspects are very important. They imply that the discussion on how much emission trading to allow will affect the burden sharing, even when the Kyoto targets (and their translation to EU member state targets) are maintained.

Restriction on IET, either by imposing absolute ceilings on trade or by limiting trade to certain clubs in which certain countries are not allowed to participate, make emission reductions sub-optimal (they increase the total costs for Annex 1) and changes the distribution of economic burdens across countries. The latter aspect may even jeopardize the enforcement of the treaty, because countries may be inclined to re-open the negotiations about the targets.

An extension of flexibility is achieved through the CDM (see Box 2 of the technical appendix for modelling details). Clearly, allowing emissions to be reduced via the CDM will lead to lower costs in Annex 1 as well as a change in the distribution of the burden, see Bollen and Gielen (1997) for the macro-economic consequences. As the CDM concerns non-Annex 1 countries, which in the Kyoto Protocol have no emission reduction targets, it poses some additional challenges related to industry relocation and carbon leakage. In this paper we will focus on these challenges.

Below we will discuss the impact of restrictions on trading for the burden of sub-regions. The formation of clubs and ceilings will be discussed respectively. The Clean Development Mechanism (CDM) will be discussed at the end of this section.

Two emission trading clubs

As opposed to a fully competitive IET system among all Parties - where a unique price exists for all emissions[2] - a non-competitive system and/or a system in which not all Parties join may have many prices. To illustrate this point, we assume that there will be two clubs. We assume a competitive market within both clubs, so that there is no price discrimination within the clubs. This leads to two carbon prices - one price for each club. The existence of two prices implies an efficiency loss compared to trade among all Parties. We assume that there is a club with high marginal costs - the high price club - and one with lower marginal costs - the low-price club.

In the high-price club, the exporters of permits will have a gain compared to a full trade case. They benefit from the fact that other exporters with lower marginal abatement costs are excluded from trade. That means that the exporters in the club can export more, against a higher price. The net importers in the high-price club suffer a loss compared to full trade, because their imports become more expensive.

The reverse story goes for the low-price club. In that club, the importers may gain, because other importers with higher marginal costs are excluded from the club. The price for their imported permits is now lower than in a full trade case so that importers can reach their target at lower costs. Net exporters in the low-price club are worse off compared to the full-trade case.

It is possible that importers in the full-trade case become exporters if they join the high-price club. In that case the impact on the burden is ambiguous. The exports in the club are profitable, but those countries have to achieve their own target completely domestically and lose the opportunity to achieve the target through cheap imports. Similarly, exporters in the full-trade case may become importers if they join the low-price club. Also in that case the impact on the burden is ambiguous. These countries gain cheap options to achieve their target, but they lose profitable export opportunities.

Clearly, as compared to a no-trade case, the clubs may prove to be a step forward towards higher efficiency: the overall costs are lower than if each country has to achieve its own target. On first sight, clubs are also Pareto-optimal compared to a no-trade case. No country can have higher costs to achieve its target as a result of cooperation in clubs. However, clubs may also give rise to some

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2 See IPCC (1996) for a concise overview of the basic analysis of IET, and the relevant literature.

serious problems. The change of relative burdens may lead to problems with the compliance and enforcement of the agreement. It may even lead to the desire to re-negotiate the targets. If burdens become more unequal, even if all burdens are lower compared to the no-trade case, this may lead to undesirable distortions in competitiveness of countries.

Setting Ceilings

The condition that IET should be supplemental to domestic action has led to discussions on limits to IET. We take one rule for etting such limits - percentages of the assigned amounts - but there are many alternative approaches. Assume that 10% of the AA may be imported from abroad. If net importers of emission permits would import more than 10% in case of unrestricted emission trading, these countries will now be rationed in their demand. Therefore, they will have to reduce domestic emissions more than in case of unrestricted trade, so that trading is indeed supplemental.

Ceilings will generally have an asymmetric impact on the burden sharing. Clearly, when countries are rationed in their demand for emission permits, they will have to revert to domestic abatement options which have a higher marginal cost. Given that the abatement cost curves differ across countries, the marginal abatement costs will diverge again. This indicates an efficieny loss for the group as a whole. Furthermore, the differences in abatement cost curves imply that this efficiency loss will be asymmetrically distributed.

The exporters of permits will now export less - because total demand is lower - thus reducing their domestic abatement efforts and leading to lower marginal abatement costs. In a competitive market for permits, these lower abatement costs are passed through in the price for traded permits. Therefore, these exporters suffer a terms of trade loss (lower export price, lower exports). The net importers experience a terms of trade gain because of the lower import price. However, due to the ceiling and their higher domestic costs, they will generally have a higher burden due to ceilings[3].

Thus, the additional policy goal - supplementality of trading - is reached through an additional instrument - quantitative ceilings - at the cost of an efficiency loss, which is asymmetrically distributed over participating countries.

Still, there is an exception, which brings in a stronger asymmetry. When 10% of the assigned amounts lies above the imports of a country when trade is unrestricted, the restriction does not affect its import demand directly. Domestic effort not stimulated nor is the burden of this country affected directly by the restriction on trade. What is more, the indirect effect of the restrictions - the lower price for traded permits - works in the opposite direction. The lower price for emissions implies that this country can now import more than with unrestricted trade. This leads to less domestic abatement (so that ceilings have a perverse impact) and a decrease in the burden (while other countries experience an increase in the burden).

The above analysis on clubs and ceilings shows that, although the quotas have been agreed in Kyoto, the burden sharing is still highly dependent upon the rules and guidelines. The principle of supplementality could lead to different relative burdens. Like in the case of clubs more unequal burdens and larger differences between domestic abatement costs may be the most important drawback of ceilings compared to the full trade case. Inequality will affect competitiveness and international trade patterns, which are becoming important issues in the debate. When restrictions

[3] The analysis above assumes that supply of emission permits is competitive, so that the uniform price for tradeable permits is determined by the region with the lowest marginal abatement costs. Then the competitive import price of permits can lie below the domestic price of the importing regions. Therefore, the part of demand for permits that countries are allowed to import can for many countries be traded at a lower price than domestic marginal costs. The price for traded permits can actually become very low when supply is fully competitive.

imply marginal abatement costs diverging across regions, the pressure from industry on the negotiations will become more severe: because the competitive position of industry in the rationed region will be negatively affected compared to the non-rationed region. This relates to one of the major benefits of IET. The equality of marginal abatement costs across regions will not only lead to an efficient emission reduction. Perhaps more importantly, IET is fair from a competitive point of view. It will even remove existing distortions, e.g. in the form of carbon taxes already implemented by some regions. The IET approach leads to a more levelled playing field for international trade and environment issues.

The Clean Development Mechanism (CDM)

CDM investments are very similar to JI projects[4]. The aim of the investments is to reduce emissions in countries with low abatement costs. The investments are paid by countries with high abatement costs. In return, the funding country can add all certified reductions to its domestic emission target. Like JI and IET, CDM is an instrument to reduce global emissions in a cost efficient way, i.e. to reduce emissions at locations where abatement costs are lowest. The main difference between CDM, as defined in the Kyoto protocol, and JI is that in case of CDM projects, the host country has no emission targets, while in case of JI the host country entered into the Annex-I agreement. That difference makes the implementation of CDM more difficult and the impact more uncertain.

The first problem with CDM is that it is difficult to assess a business as usual world without subsidies. A technology may be subsidized that would be applied even without subsidy. In this case the subsidy will be a mere income transfer, instead of a tool to reduce emissions. That problem cannot occur with JI, because then the host country is forced to reduce its domestic emissions, since emission reductions contributed to JI are subtracted from the host country's assigned amount.

A second problem with CDM is that, instead of lowering emissions, it may even increase emissions in the host country. Due to the subsidy, unit production costs of energy intensive production could decrease, so that the host country's output of energy-intensive industries can be expanded at the cost of investor country market share. That can imply that lower energy intensity in the host country goes hand in hand with higher total energy use. This is a perverse type of carbon leakage: effectively the investment has not led to emission reduction, but it has yielded emission credits. The perverse effect can be that global emissions grow due to such projects.

CDM has also some advantages, compared to JI. First of all, the most efficient options for emission reduction can be found outside the Annex-I region. Secondly, CDM may show countries outside the Annex-I region the benefits of entering into a climate agreement, because CDM projects are profitable for the host countries. CDM could be an attractive first step towards a more global agreement on reduction of emissions. Given these advantages, it is worthwhile to explore the options for CDM projects, while minimizing the disadvantages.

To avoid, or at least limit, the carbon leakage effects of CDM projects, the projects should probably be focussed on the replacement of existing capacity by cleaner production technologies that can produce the same amount of products - e.g. the replacement of a power station using coal by a power station which produces the same amount of electricity, but uses gas or other cleaner energy sources, could be an attractive CDM project. Such a replacement does not change total capacity in the receiving country and it does not change the costs of new capacity. Therefore, the probability of serious leakage is low. Also the business as usual scenario is rather straightforward, at least as long as the existing capacity was not about to be scrapped because of economic or technical reasons.

In WorldScan, we therefore analyse CDM projects only in the form of investments that replace

[4] A difference with JI is that CDM is explcitly aimed at stimulating sustainable development, capacity building and financing adaptation.

existing capital or change input intensities of existing capacity. Such investments are assumed not to affect the overall production capacity. For the investor, the incentives for such CDM investments are derived from the marginal abatement costs in alternative locations, and its marginal investment costs. As long as the marginal cost of CDM investment is lower than the marginal cost in alternative locations, it will be profitable for the investor to continue expanding its CDM activities in the host country. The investor earns credits which it can add to its current assigned amounts[5]. The incentives for the host country are determined by the revenues of the project. If the total costs of the project are paid by the investor, the host country will fully take advantage of the decrease in production costs. Production costs are reduced because the investments make the existing capital stock less energy-intensive.

Although carbon leakage is reduced by focussing on existing capital, it cannot be completely excluded. For example, the replacement could increase future capacity if the life expectancy of the new capacity is longer than of the old one. Leakage can also occur if there are costless technology spill-overs due to such investments to other investments in the host country. A third source of leakage is related to possible regional differences in energy prices. If part of the Annex-I target is reached outside the Annex-I area, non-Annex-I energy demand is reduced, while Annex-I energy demand is increased. The energy demand reduction in non-Annex-I countries affects the regional energy markets. If energy markets are not entirely globalized (due to transportation costs, e.g. for coal) the lower domestic energy demand leads to lower domestic energy prices. These will lead to leakage (more energy use) within the non-Annex-I region. Investments outside the CDM projects will then become more energy intensive.

3 Model, baseline, and policy assumptions

In this section, we discuss some features of the world economic model WorldScan and the assumptions on the baseline and the policy cases.

Figure 1 World regions and Annex 1 regions in WorldScan

1: United States, 2: Japan, 3: Western Europe, 4: Rest OECD, 5: Central Europe, 6: FSU, 7: Middle-East and Northern Africa, 8: Rest of Africa, 9: Latin America, 10: China, 11: Dynamic Asian Economies, 12: Rest Asia. The Kyoto agreement contains emission reduction targets for the regions 1 to 6 (the “Annex 1 countries”; in white) .

[5] As with all recursive dynamic models with an explicit distinction between existing and new capacity, the emission reductions during a certain period will have effects after the end of the relevant period. Thus, when we analyse IET in Kyoto’s first budget period we should be aware of the effects that such IET has on the capital stock. Even after the end of the budget period, emissions will be lower than in the baseline because the capital stock has become less energy-intensive. By making the same assumption for CDM/JI projects, the policy cases are comparable.

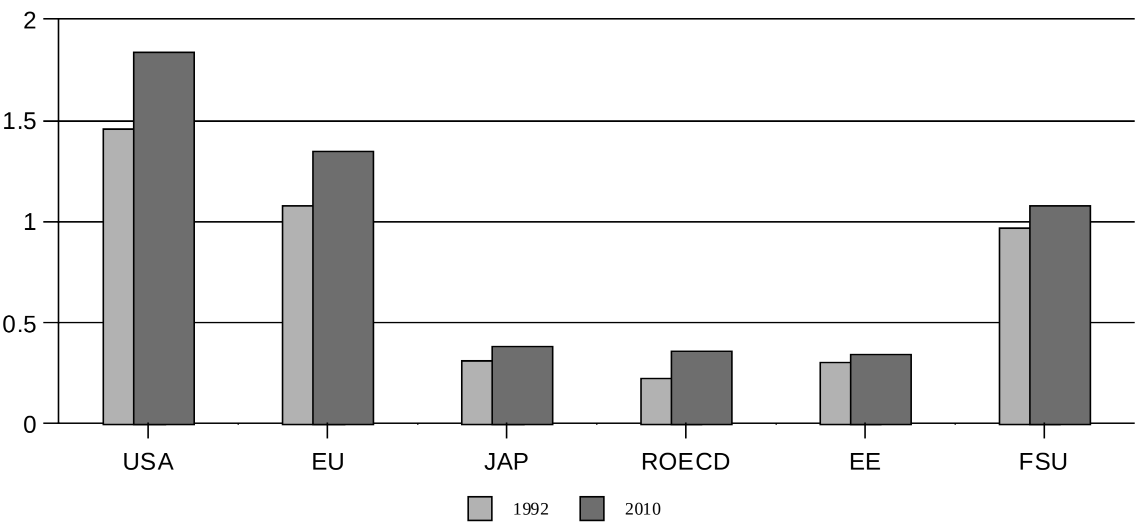
3.1 Model specification

WorldScan is a numerical scenario and policy simulation model. It is based on general equilibrium theory. This implies that economic sectors - and the agents in those sectors - interact in the macro economy. The macroeconomic feedbacks through prices affect production, employment, and value added in all sectors of the economy. In WorldScan, these macroeconomic feedbacks also cover international trade in commodities, financial capital, and emission permits. It has a recursively dynamic structure in which investment in physical capital stock is made every year with a one-year planning horizon. Trade is modelled assuming that sectoral commodities are differentiated according to the region of origin. This implies that there is international bilateral trade in the commodities of each sector. Furthermore, the model distinguishes between newly installed capital - to be used in the next and following periods - and the existing capital stock. The latter can be changed to a limited extent in order to reduce input costs - modelled as retrofit investments - while the former is more easily adjustable. We refer to Geurts *et.al.* (1997) for an extended discussion of WorldScan. The appendix provides more detailed information on the model. There are six different Annex 1 regions and six non Annex 1 regions. These do not perfectly match the Annex groups, but make a fair approximation. Figure 1 shows the world map with the WorldScan regions.

3.2 Baseline projections

As reduction targets were set with 1990 as a reference year, the regional impacts in 2010 depend on growth in a no-policy or baseline projection, shown in figure 2. The Annex 1 target of a 5% cut compared to 1990 levels amounts to a 22% cut compared to emissions in 2010. In our baseline scenario, all OECD regions have to reduce their emissions by more than this average. Clearly, there are differences of opinion on baseline projections. Although there can be conventional wisdom, alternative baseline scenarios can help sketch out different futures in order to deal with uncertainties.

Figure 2 Baseline emissions in 1992 and 2010 in GtC per annum



3.3 Policy cases

Clearly, there is a strong difference between the two reference years. On the one hand, most reductions appear to become more severe for the OECD regions, due to strong economic and emissions growth in the baseline. On the other hand, the rather low growth in emissions in EE and

FSU implies that reduction targets are not very severe. For FSU, the stabilisation target under the Protocol could even imply some growth compared to the baseline[6]. The policy instruments to achieve these targets are presented in table 1.

Table 1 Policy cases

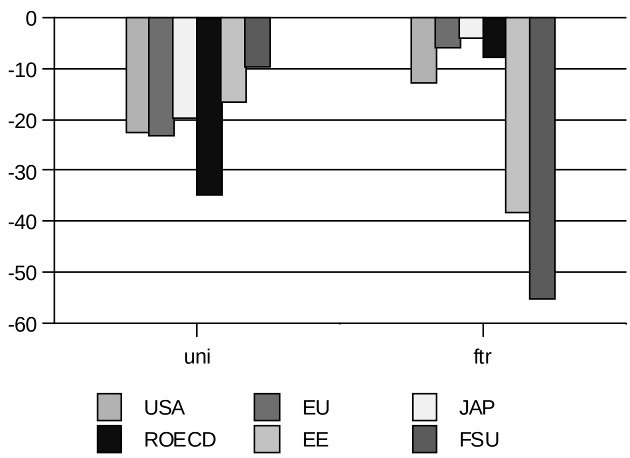
Case	*Abbreviation*	*Description*
No trade	*UNI*	Kyoto targets, to be reached within Annex 1 by each model region separately.
Full trade	*FTR*	Kyoto targets, to be reached within Annex 1 with one emissions price and transfers based on Kyoto quotas.
Clubs	*CLUB*	Kyoto targets, to be reached within Annex 1 with two trading clubs (EU/CE and the rest of Annex 1), with transfers within clubs but not between clubs.
Restricted trade	*RTR90*	Kyoto targets, to be reached within Annex 1 with trade up to 10% of the quota in all Annex 1 regions, and transfers based on this 10% (at maximum).
Restricted trade	*RTR85*	Kyoto targets, to be reached within Annex 1 with trade up to 15% of the quota in all Annex 1 regions, and transfers based on this 15% (at maximum).
Clean Development Mechanism	*CDM90*	90% of the Kyoto targets to be reached within Annex 1, without trade among Annex 1 and with investment subsidies from Annex 1 to non Annex 1 equal to investment needed to reduce emissions.

6 If emissions decline by 10% from 1990 to 2010, stabilisation at 1990 levels in 2010 is the same as allowing 100/90 - 1 = 11% growth.

4 Simulation results

This section presents main results of the cases simulated with WorldScan. We discuss the impact on realised emissions and the real marginal cost of carbon abatement[7]. Figures 3 and 5 present annual carbon emissions in 2010 compared to the level in the baseline for all cases[8]. Figure 4 presents the marginal abatement cost in real dollars of 1992 per ton of Carbon ($/tC) in 2010. The comparison of UNI with FTR shows that an efficient distribution of emission reduction via FTR differs strongly from the agreed targets (illustrated by UNI) given our baseline assumptions. OECD reductions - especially those in the ROECD region - should be less from an efficiency point of view. Clearly, with emission trading in FTR, this can be achieved, where burden sharing is restored through the side payments concerned with permit trade. See Gielen and Koopmans (1998), and Gielen and Bollen (1998) for a discussion of the economic impacts of these two cases.

Figure 3 Domestic emissions compared to baseline in 2010 (%), UNI and FTR



Now turn to the other three cases - restrictions to imports of 10% of the assigned amounts (RTR90), two trading clubs (CLUB), and allowing limited use of the Clean Development Mechanism up to 10% of the Annex-1 assigned amounts (CDM90). Figure 4 shows the real carbon prices in 2010 in 1992 dollars. Figure 5 shows the emission reductions in these cases.

4.1 Permit trade clubs - CLUB

Looking at Figure 4, the club of EU and EE appears to be the high-price club - high demand for permits by the EU drives up the price. In that club, the net importer - i.c the EU - suffers a loss compared to the FTR case, because the permit price is higher, thus increasing the domestic marginal abatement costs. At the same time, the EE countries gain from the higher carbon price, and because demand is higher - as can be seen from comparing Figures 3 and 5, they will now reduce more. Clearly, the other club - the low-price club - also has winners and losers compared to a FTR case. The net importers gain because the price at which they can import permits is lower than in FTR, also implying a lower domestic marginal cost and thus lower total costs.

7 We do not include results on macroeconomic and sectoral changes, but instead focus on distribution of emissions and the level of carbon prices in order to focus on the big picture. In a follow-up to this paper, we also focus on the macroeocnomic and sectoral impacts.

8 Note that there is no hot air in these projections, as FSU and EE also have to reduce emissions.

Figure 4 Carbon prices in all cases, in real $/tC in 2010

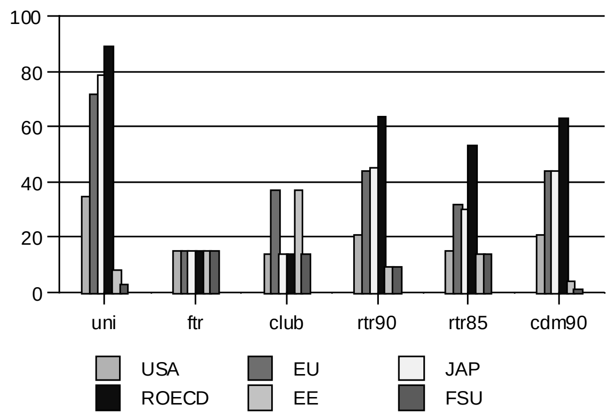
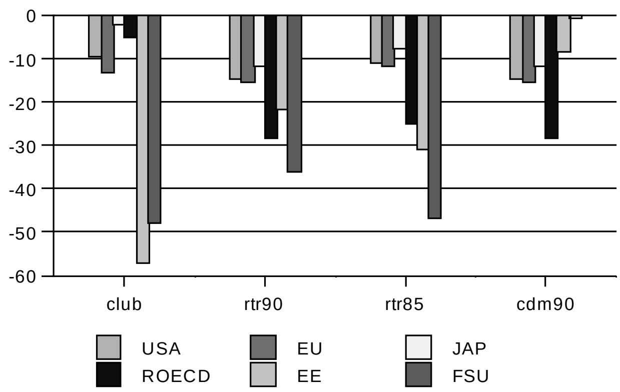


Figure 5 Emissions compared to baseline in 2010 (%), CLUB, RTR90, RTR85, and CDM90

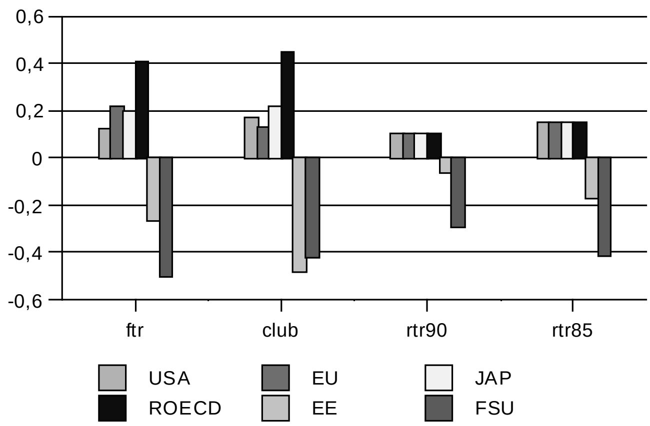


4.2 Ceilings within Annex-1 - RTR90 / RTR85

The demand for traded emission permits has decreased in the RTR cases, so that the price for traded permits has decreased, as is shown in Figure 4. Figure 5 shows that each of the 4 OECD regions reduce more domestically than in the FTR case - this is the target of the policy, and at a 10% restriction it also works this way. Figure 6 shows the percentage of assigned amount that is imported from abroad. Clearly, in he RTR90 case, this is at most 10% for all Annex-1 regions.

The cut-off points at which import demand is rationed are equal to the import shares in the FTR case. Clearly, ROECD wants to import most and will be hurt most by a binding restriction, even when it is as high as 40%. For the EU and Japan, these shares are around 20%, while the USA's cut-off point lies at 12%. Thus, when the restriction percentage is between 12 and around 20%, the USA will not suffer any loss from the restriction, while the other OECD regions will be rationed. This holds for the RTR85 case. The decrease in the carbon price due to lower demand in OECD regions (especially ROECD) implies a gain for the USA: they can import more permits, and at a lower price, so that domestic marginal (and thus total) costs will decrease.

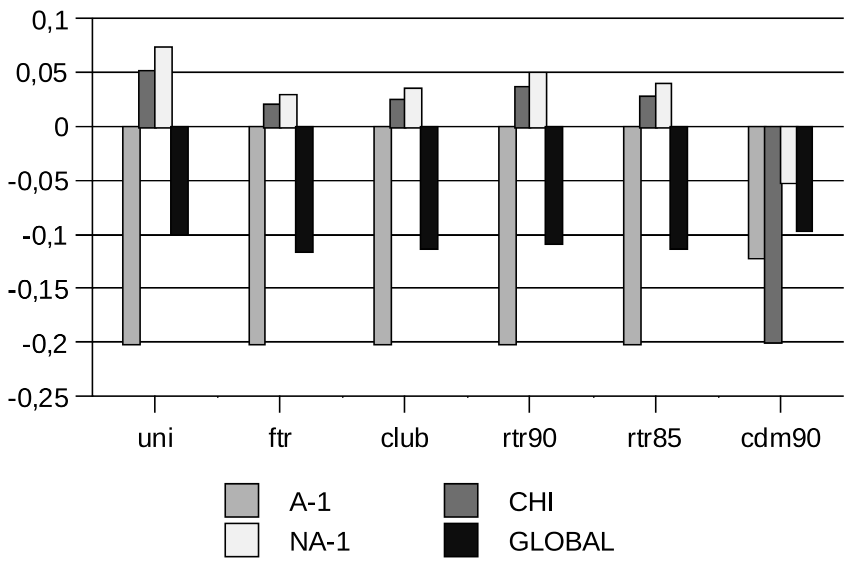
Figure 6 Net permit imports as share of assigned amount in 2010 (exports negative)



4.3 Ceilings on the Clean Development Mechanism - CDM90

We analyse the CDM assuming that there is no IET within the Annex 1. Looking at Figure 4, we see that the CDM projects offer opportunities to earn certified reductions that increase the domestic emission allowances. Because the marginal abatement costs are lower outside the Annex-1, this implies that even EE and FSU now import permits. Carbon prices in the UNI case are higher than in the CDM case. This is due to the realisation of targets through CDM investments outside the Annex-1. The prices decline for all regions, because of the less stringent domestic targets.

Figure 7 Emission reductions in 2010 compared to baseline - selected regions



The most important result illustrated by Figure 7 is that global emission reduction is less when CDM is implemented without additional requirements on non Annex-1 countries. We see that global emission reduction without CDM is somewhat higher than that with CDM - compare the UNI with the CDM case. The perverse leakage is therefore only limited, but it is present at the global level. The region CHI (China) will take up the bulk of the CDM projects. Clearly, emission reduction in China is now substantial. However, the offsetting increase in assigned amounts of Annex 1 is larger.

5 Conclusions

Given the projections for emissions in the baseline, the Kyoto targets do not reflect an efficient distribution of emission reductions. Marginal abatement costs differ strongly across regions affecting the competitive position of the regions, and leading to high abatement costs. Emission trade based on the Kyoto targets can reduce the costs for the Annex 1 group as a whole, and can also make all separate regions better off. In a fully competitive market, regions with either relatively high or relatively low cost of abatement will gain the most. The requirement that 10% of the agreed assigned amount may be imported from abroad is restrictive for all OECD regions compared to the full trade case, but in the 15% case the USA is not restricted in contrast to the EU. Limiting trade will lead to diverging marginal costs across regions and the total Annex-1 abatement costs will be higher than in a fully competitive trade case. Also, an increasing percentage of allowable emission permit imports will have asymmetric impacts on the different Annex-1 regions. As soon as the restriction is not binding for one of the Annex-1 regions, this region can be gaining compared to a full emission trade case. When compared to full emission trade, two separate clubs of emission trading will be costly to the Annex 1 as a whole: again, the marginal abatement costs will diverge. Compared with a case without emission trade, however, clubs could provide a profitable step in the right direction. From a macroeconomic point of view, the most important difference between Annex 1 flexibility through Joint Implementation and emission trading on the one hand, and global flexibility through the CDM on the other, is the absence of national targets in the case of CDM[9]. This absence leads to a danger of CDM leading to carbon leakage. This leakage can be enlarged when technological spill-overs take place via CDM projects. CDM-related carbon leakage can be minimised by focussing the CDM primarily on replacement investments, and on sectors which are sheltered from international competition. The non-OECD regions in the Annex 1 stand to lose from CDM without emission trade, as compared to Annex 1 IET. This is because they become net importers of permits. This is worse than being a net exporter of permits to the Annex 1 in case of competitive Annex 1 emission trading. The majority of CDM projects will take place in China. A very limited amount of carbon leakage takes place when CDM is implemented.

[9] The model used has limitations which limit the scope of the conclusions. One of the major reasons to have JI and the CDM is that international IET requires institutional development as well as political will. We explicitly view both JI and CDM as precursors to emission trade. This should be the long run focus for the climate change policy approach. Another limitation placed by the model is that is assumes flexible adjustments. On the medium term, this implies that the overall level of macroeconomic costs will be higher than presented here.

Technical appendix: International Emission Trading in WorldScan

The discussion on ET, JI and CDM in section 2 leads to two distinct approaches in the model. For ET and JI in the first budget period, we take the Kyoto targets for emission levels as the emission permits allocated to each region. In the model, we take energy price increases as the policy instrument in these cases. This will reduce energy demand and in so doing lead to lower CO_2-emissions. In order for the emission target to be achieved, we use of a standard procedure to calculate the corresponding shadow price. This shadow price can be interpreted as tradeable emission permits or tradeable JI credits. Especially at the inter-regional level in the model, this price will then be uniform across a set of regions. Such a uniform price will lead to another distribution of the total emissions over regions than the targets. Thus, when we project that Central Europe will reduce not 8% as compared to 1990 but 18%, it will export 10% of 1990 levels as permits to other regions. The income obtained from this export of permits is equal to the volume (in tC) multiplied with the uniform shadow price (in $/tC). The box below shows the equations in the model to calculated the shadow price and the payments.

Box 1: ***Modelling IET in WorldScan***

The WS model calculates the equilibrium carbon shadow price P^* using an iterative process, in which the value of P^* is calculated from that in the previous step - P - increased by the difference between the targeted emission *TAR* and the resulting emission *EM*. As long as the emissions are not equal to their target level, P^* will not be equal to P. The equilibrium value of $P^*=P$ is obtained when $EM=TAR$. Thus,

$$CTAX^* = CTAX + (EM - TAR) / TAR$$

with the following identities

EM	=	$\Sigma_r (EM_r)$	r = countries in the abatement coalition (from 1 to 12)
TAR	=	$\Sigma_r (TAR_r)$	r = countries in the abatement coalition (from 1 to 12)
EM_r	=	$\Sigma_f (EM_{fr})$	f = coal, oil/gas
EM_f	=	$EQN_f * \Sigma_s (Q_{f,s})$	s = energy demand sectors
PD_f	=	$PS_f + TAX_f + CCT_f$	
CCT_f	=	$EQN_f * CTAX^*$	
TRA_r	=	$CTAX * (EM_r - TAR_r)$	

with

$CTAX$	=	the uniform carbon tax in US$ / tC
EM_r	=	CO_2- emissions in tC of region r in the abatement coalition
TAR_r	=	CO_2- permits in tC of region r in the abatement coalition
EM_{fr}	=	CO_2- emissions due to fuel f in region r in tC
EQN_f	=	CO_2- emission factor of combusting fuel f in tC / GJ
QD_{fs}	=	demand for fuel f by sector s in GJ
PD_f	=	user price of oil/gas and coal ($ / GJ)
PS_f	=	supply price of oil/gas and coal ($ / GJ)
TAX_f	=	domestic taxes on oil/gas and coal ($ / GJ)

With IET, the net transfers via the current account are determined by the difference between targets and realised emissions, and the carbon shadow price, as in

$$TRANSFER_r = (TAR_r - EM_r) * CTAX$$

with

$TRANSFER_r$ = the net transfers via the current account due to IET.

This value is negative for net importers and positive for net exporters. Note that in case of IET, the sum of the transfers within the trading block is zero (it is pure reallocation of income and emissions).

Technical appendix: CDM in WorldScan

WorldScan contains two options to change production technologies of existing capacity. One option is to scrap part of existing capacity and to replace it by capacity with new technology. The other option is what we named retrofitting of existing capacity: By adding more capital one can reduce one of the other input, keeping total capacity unchanged. WorldScan includes the retrofitting option, because it is a relevamnt mechanism: it is normally more efficient than scrapping existing capacity and replacing it by completely new capacity. It might be expected that such a CDM is efficient in the sense that it actually decreases energy demand in the receiving country compared the a business-as-usual baseline. Efficiency in terms of location of CDM projects will be achieved in the model by assuming equal marginal costs of emission reductions.

*Box 2: **Implementation of CDM in WS***

Retrofitting investments change input intensities, but do not alter the size of output capacity. Substitution possibilities of retrofitting investments are specified as a CES function with a substitution elasticity of 0.5. This leads to the following isoquant.

$$E = \left[1 - \frac{\alpha_k R}{\alpha_e K_0 + R}\right] E_0 \qquad R \geq 0$$

where E energy input after retrofitting; E_0 energy input before retrofitting; R retrofitting investments; K_0 capital stock before retrofitting

In each region and each sector cost minimization, under restriction of the isoquant, determines the optimal amount of retrofitting investments. In formulas:

min! $C = p_e E + p_k R$

where p_e = energy price,
p_k = capital cost
p_k = $(r + \delta)\, p_i$
with r = real interest rate
δ = rate of depreciation
p_i = price of investment goods

This results in R^*, which minimizes the costs of retrofitting investments

$$R^* = \max\left\{0, \left[\frac{a_k p_e E}{\alpha_e p_k K}\right]^{1/2} - 1\right\}\alpha_e K$$

The purpose of CDM is to reduce CO_2 emissions by financing retrofitting investments. Optimal retrofitting investments from this perspective are derived from minimization of a different cost function:

min! $C = p_c\, q\, E + p_k R$

where p_c (shadow) price of carbon emission
q emission coefficient

This results in R',equal to the optimal CDM investments

$$R' = \max\left\{0, \left[\frac{a_k p_c q\, E}{\alpha_e p_k K}\right]^{1/2} - 1\right\}\alpha_e K$$

The actual retrofitting investments equal

$$R = \max\left\{R^*, R'\right\}$$

A necessary condition for CDM-investments is that those investments would otherwise not be made. Actual CDM-investments are therefore defined as additional investments.

$$R^{JI} = R - R^* \quad \text{with} \quad R^{JI} = \sum_f R_f^{JI}$$

Transfers to the host country are the yearly capital costs to finance the CDM-investments

$$T = \sum_f (p_k)_f R^{JI}$$ where T transfers to compensate for CDM-investments

Emission rights that are earned because of CDM are computed as the additional emission reduction, compared to the situation with only normal retrofitting investments.

$$Z = q\left[E\left(R^{JI}\right) - E\left(R^*\right)\right]$$ with Z emission rights, earned because of CDM

Transfers from the donor countriesequal the regional share of GDP times the total transfers to NA-1:

$$T_r = Y_r / \sum_a Y_a \cdot \sum_q T_q$$ with a the subset of A-1 countries and q the NA-1 countries

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