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Trading Hot-Air

The Influence of Permit Allocation Rules, Market Power and the US Withdrawal from the Kyoto Protocol*

Abstract: After the conferences in Bonn and Marrakech it is likely that international emissions trading will be realized in the near future. Major influences on the permit market are the institutional detail, the participation structure and the treatment of hot-air. Different scenarios do not only differ in their implications for the demand and supply of permits and thus the permit price, but also in their allocative effects. In this paper we discuss likely institutional designs for permit allocation in the hot-air economies and the use of market power and quantify the resulting effects by using the computable general equilibrium model DART. It turns out that the amount of hot-air supplied will be small if hot-air economies cooperate in their decisions. Under welfare maximization more hot-air is supplied than in the case were governments try to maximize revenues from permit sales.

Keywords: CGE Model, DART, Emission Trading, Hot-Air, Kyoto Protocol, Market Power, Permit Allocation.

JEL classification: C68, D58, F18, Q48

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1 Introduction

The Kyoto Protocol marks the first instance in which a multinational and potentially global emissions trading system has become part of an international treaty. The introduction of emissions trading has long been advocated by economists because of its efficiency aspects. Yet, the theoretically appealing concept has undergone several adjustments and refinements in the international political practice and it turned out to be more complicated in practice than expected. As a consequence, it is not at all clear what the emissions trading scheme will bring in terms of effectiveness, i.e. how much emission reduction will it eventually achieve, and in terms of its economic performance, i.e. what allocation effects are to be expected. Several studies have already attempted to narrow in on the range of prices of emission permits and on the resulting savings of marginal abatement costs for different regions (Weyant 1999; Boehringer 2002; Boehringer and Loeschel 2001; den Elzen and de Moor 2002). So far, the narrowing has not been too successful as Klaassen and Percl (2002) find in their paper.

The divergence of results has many causes: modelling philosophies, complications of the definition of reduction commitments during the Bonn-Marrakech-Accords, the withdrawal of the United States from the Kyoto Protocol, and finally the issue of excess emission rights (hot-air) in the countries of the former eastern block. In this paper we try to identify the impacts as well as the interactions of three of these aspects which we believe to constitute important determinants of the likely effects of international emissions trading (IET) according to the Kyoto rules. These are the institutional details of the permit allocation especially in countries with hot-air, the likely supply of hot-air in the first commitment period of the Kyoto Protocol and the participation of the US in international emissions trading. All three aspects are closely linked. The permit allocation within the suppliers of hot-air, has repercussions on the global permit market, and at the same time it influences the ability of these countries to strategically control the global permit market. Similarly, the participation or non-participation of the US in global trading influences the permit market and the benefits from strategic restrictions of hot-air supplies.

This paper mainly focusses on the welfare and revenue effects in the hot-air economies. The main results can be summarized as follows. First, the allocation rule, i.e. government trading or company trading, determines the degree to which market power can be exercised. Second, if market power can be exercised, it matters for the amount of hot-air supplied whether governments seek to maximize welfare or revenues from permit sales. In addition, the optimal hot-air supply depends significantly on the decision whether domestic emitters are restricted in their emissions and whether they participate in emissions trading.

The paper is organized as follows. The next section presents a qualitative discussion of the interactions discussed above and tries to give some intuition for the likely allocation effects of the trading regime agreed so far. Section 3 then presents some practical aspects of determining the size and the functioning of the market for greenhouse gas permits. The selection and exact definition of the scenarios for emissions trading is described in Section 4. Section 5 presents the results of the simulations with the CGE model DART with respect to the likely supply of hot-air and also comments on the role of the US. The paper ends with some conclusions and an appendix which gives a description of the DART-Model.

2 Allocation Effects in the International Market for Greenhouse Gas Emissions

Institutional Details of International Trading

At first sight and according to standard partial equilibrium theory, the way in which emission permits are allocated in each state - whether through auctioning, grandfathering, or updating - should not make a difference in terms of its allocation effect (Baron and Bygrave 2002). In a general equilibrium setting, however, different allocation rules will lead to different distributional effects within as well as across economies. In turn, these will result in different general equilibrium effects which are particularly strong for those participants of an international emissions trading regime with a considerable amount of hot-air. There are essentially two states which have been allocated about two thirds of the hot-air in the Kyoto Protocol and the Bonn-Marrakech-Agreements, Russia and the Ukraine (they are subsumed in the simulations later under Former Soviet Union and Eastern Europe FSU/EEC).

As the FSU/EEC is the largest seller of permits in the case of unrestricted emissions trading, it is obvious that the FSU/EEC has the potential to influence the trading price of permits to maximize its profits from selling hot-air or to maximize welfare. As monopoly power implies a small number of sellers the studies that analyze market power implicitly assume that trading would take place in a centralized fashion and not through a large number of domestic entities that could act as independent agents (Baron 1999). The Kyoto Protocol and its related decisions do not explicitly state who is actually supposed to be trading. Probably we will observe both government and firm trading. Under the former, market power might indeed become a relevant issue.

The other question is, how the governments will distribute their assigned amount units (AAUs). Will they sell them to local firms, or grandfather them? Will they distribute all their AAUs to domestic firms or keep some to trade with international firms or registries themselves? The economic effects of these alternative permit allocation schemes are likely to be small in economies without hot-air. Grandfathering, i.e. free allowances to local emitters, creates an income effect for those receiving the permits and it leaves the government without revenues from permit sales. The size of this income effect is confined to the question whether different demand structures and different propensities to consume exist between the groups that might receive the rents from allocating emission permits. In fact, in a world with perfect competition, a constant government budget surplus or deficit, and with representative consumers and producers - as it is usually assumed in CGE-models - there is no difference in the allocation. Of course, the rents to specific groups in the case of grandfathering or additional government revenues in the case of an auctioning of permits change the internal distribution of incomes. Such distributional issues are not subject of this paper. For a detailed discussion of different allocation modes see Harrison and Radov (2002).

In economies with a considerable amount of hot-air the allocation scheme does matter. Essentially three institutional settings with differing repercussions on international permit markets can be considered. First, governments of economies with hot-air can insulate their domestic industries and consumers emitting greenhouse gases from the international permit market by relying on state trading on the international permit market and by issuing free permits to local emitters which are not tradable internationally. Hence, the governments can maintain a zero domestic price for emissions and they can choose the amount of hot-air that is sold internationally at the then prevailing world market prices (Scenario ET1).

The second option is to include the domestic firms in emissions trading and charge the same price to all emitters - domestic and foreign. In this case, state trading - i.e. only the government can in the first place sell permits - allows a government to strategically restrict the total supply of emission permits at its disposal (ET2). In this setting no price wedge is driven between national and foreign permit prices. As noted above, under usual CGE model assumptions it does not matter whether the domestic firms have to buy their rights from the government or receive permits for free. Thus, this scenario can also be interpreted in such a way that the government decides on the overall amount of permits to be grandfathered to firms which then participate in IET. The government can, for example, only grandfathers business-as-usual emissions and directly sell some hot-air on the international market to generate revenue. Such a scenario is indeed very likely.

The third option of grandfathering all permits to local emitters or citizens according to some rule would most likely preclude any strategic behavior because it would effectively produce perfect competition on the supply side of the permit market. The governments registry would only administer the bookkeeping of all permit sales with foreigners (ET3). In such a case all permits including all hot-air would be used either domestically or sold on international markets. As in the second option, domestic permit prices and world market prices will equalize but at a much lower level.

The allocation effects of the three scenarios differ significantly. State trading of excess amounts of permits (ET1) not used inside the country will give local emitters a free endowment of permits which results in an improvement of comparative advantage of the energy intensive producers on world markets. It also gives the government the ability to strategically manipulate the supply of hot-air, i.e. of additional emission permits, on world markets.

To the contrary, a grandfathering of all permits to local emitters (ET3) will remove this strategic ability, but it will also endow firms with an additional source of income. However, some studies (Boehringer 2002; Loeschel and Zhang 2002;

den Elzen and de Moor 2001b) claim that this income can not be generated since the permit price might drop to zero. This depends essentially on the hypothesis that grandfathered permits will lead to a competitive supply behavior, hence revenue maximization with hot-air on international markets by restricting supply is not possible. In addition, these studies ignore the possibility of banking.

If there is state trading and the economies with hot-air are able to coordinate their supply behavior they can reap considerable rents from restricting supplies (ET1 and ET2). But these gains depend not only on the ability to coordinate strategies between the largest hot-air countries. The local allocation rules are important as well. Hence, a careful treatment of the institutional details of permit allocation and permit trading in the economies with hot-air is necessary in order to correctly simulate the likely allocation effects.

Market Power and Hot-Air Trading

Studying the impact of the different internal allocation regimes of hot-air on the global permit market is necessary if the regions involved are large enough to influence world market prices through their actions. The two options for governments with a significant amount of hot air-air - participating in global trading without having local trading and global trading with local emitters facing the same permit prices - will have different allocative effects.

If the FSU/EEC governments - provided they build a cartel - decide not to charge the local greenhouse gas emitters the world market permit price or not to allow these emitters to sell grandfathered emission rights on the global permit market, they can sell a restricted amount of hot-air on world markets in such a way as to maximize government revenue or welfare. At the same time local fossil energy users do not face an emission constraint nor do they have an incentive to reduce emissions. Selling hot-air then has several effects:

- It raises government revenue in economies with hot-air (revenue effect),
- By lowering the global emissions constraint it reduces gross energy prices in the other Annex B countries (marginal abatement cost effect)
- These lower gross energy prices raise world demand for fossil fuels - compared to a situation without hot-air trading - thus leading to higher energy prices even in the countries not participating in emissions trading (demand effect).

These three effects differ between the two scenarios ET1 and ET2. Also they imply that revenue maximization, which is assumed in many partial equilibrium studies (Boehringer and Loeschel 2001; Burniaux 1999), does not necessarily lead to the same results as welfare maximization, which is assumed in most general equilibrium analyses (Boehringer 2002, Bernstein et al. 1999), even though Babiker et al. (2002) only find a minor difference between the two.

This can be illustrated by considering the marginal effects of an increase of the amount of hot-air supplied on world markets. Looking first at scenario ET1, where private firms in the hot-air economies do not participate in emissions trading and face no emission restrictions, an additional supply of hot-air will - besides raising government revenues - increase exports (respectively reduce imports) of fossil fuels through the demand effect. At the same time local producers of energy intensive goods face higher energy prices whereas foreign producers may or may not experience an increase in energy costs. In particular, the other Annex B countries experience lower gross energy prices through the abatement cost effect and the Non-Annex B countries higher prices again through the demand effect. Hence, a shift of energy intensive production away from hot-air countries and Non-Annex B countries towards the abating countries will take place resulting in a change in comparative advantage and possible welfare losses to the hot-air suppliers. As a consequence, maximizing permit revenues and maximizing welfare will not yield identical optimal hot-air amounts to be sold by the FSU/EEC. If the welfare effects from direct fuel exports dominate the indirect effect through the energy intensive goods then a fuel exporting country like FSU/EEC would sell more hot-air in the welfare maximization case than in the revenue maximization case.

In scenario ET2 where the FSU/EEC sell a fixed share of the overall permits to local and international emitters alike, an additional supply of hot-air has the same three effects, but now the marginal abatement cost effect also applies for the domestic economy that benefits from lower permit prices, too. Hence, energy use increases in all Annex B countries. In addition, the relative price of energy intensive goods to the other goods falls thus leading to an expansion of these sectors. For the hot-air region FSU/EEC this means that an additional amount of hot-air promotes higher exports of energy and increased production of energy intensive goods. Compared to revenue maximization, welfare maximization would tend to lead to a higher supply of hot-air in order to reap the benefits from the increased competitiveness of energy sectors *and* energy intensive industries.

Summarized, the positive welfare effect of additional supplies of hot-air is larger in ET2 than in ET1. This is so because in ET1 additional hot-air reduces the comparative advantage of energy intensive industries in the FSU/EEC whereas it improves it in ET2. Therefore one can expect that a move from revenue maximization to welfare maximization in the determination of the optimal supply of hot-air will result in a larger difference in the scenario ET2. The issue of maximizing welfare or revenue is therefore most important if the FSU/EEC also use the permit system inside their own economies. In our simulation studies in section 5 we will analyze the welfare and revenue effects of the different scenarios empirically.

The Role of the US Participation in Hot-Air Decisions

Finally, the behavior of the US is also important for the strategic and institutional designs in hot-air economies. The US withdrawal from the Kyoto Protocol essentially moved the largest economy into the Non-Annex B group. If the US rejoin the Protocol, the qualitative effects of alternative hot-air trading regimes remain the same, but the size of the international allocation effects will change.

If the US join the international emissions trading with their Kyoto target this has basically three effects for the hot-air economies compared to the case of emissions trading without the US. First, as the US will be a permit importer, the permit price increases which, at the same time, increases the benefits from selling hot-air and thus the optimal amount of hot-air supply. Second, US demand for energy and energy intensive goods drops, which lowers world energy prices and hurts the FSU/EEC energy exporters. Third, the gross energy prices in the FSU/EEC are affected. In scenario ET1 where emissions are free for FSU/EEC firms, gross energy prices fall in the FSU/EEC due to the falling world market prices and the FSU/EEC firms gain compared to a scenario without US participation in international emissions trading. In contrast, in scenario ET2 where FSU/EEC firms participate in international emissions trading as well, they suffer from the now higher permit price.

3 Issues in Modelling Hot-Air Trading

The qualitative aspects of the interactions of different participation structures, institutional details, and strategic supply behavior already give some important insights. However, the net effects can only be assessed in a quantitative study by using a simulation model. Existing studies on hot-air and market power differ mainly in the way they model the strategic behavior of the hot-air economies. In addition, there are a number of other empirical questions that need to be resolved and are also treated differently in the existing studies. These include the regional aggregation, the amount of available hot-air, complications through other policies such as the Clean Development Mechanism (CDM), Joint Implementation (JI) and sinks and finally the important issue of banking. Table 1 summarizes the different modelling approaches and results of selected studies on hot-air trading and market power. Columns 3 and 4 are concerned with the assumptions on the strategic behavior of the hot-air economies. Column 5 reports the different estimates for the amount of available hot-air. Column 6, finally, gives the optimal behavior of the hot-air economies. The different issues are discussed in the following paragraphs.

[Table 1]

Strategic Behavior

As discussed in section 2, it is likely that - under certain institutional setups - the hot-air countries will act strategically. To analyze the outcome of the FSU/EEC exercising market power, a modeler has first to make an assumption on the variable the FSU/EEC wishes to maximize. This could be, as Table 1 shows, welfare, revenue or other measures such as GDP or consumption. Second, the modeler has to make an assumption on how the market power is actually exercised. One possibility for the FSU/EEC is to participate in emissions trading but to put a markup much like an export tariff on the FSU/EEC export price of permits. As a result, the FSU/EEC pays a lower permit price than the rest of the Annex B countries. This scenario, which is economically the same as an export quota, is modelled by Bernstein et al. (1999) and also by Burniaux (1999) who assumes that the FSU/EEC is directly setting the international permit price, and presumably also in Boehringer and Loeschel (2001). In all the cases the FSU/EEC participates in the emission market and even does not only sell hot-air, but also permits resulting from true emission reductions.

Boehringer (2002) proceeds differently and assumes that the FSU/EEC exports a fixed amount of emission rights, while inside the FSU/EEC permits are given away for free.[1] Other CGE studies just state that the FSU/EEC act as price makers and are able to limit the amount of hot-air available for sale (Manne and Richels 2001), that they do not supply all their permits on the market (Babiker et al. 2002) or mention a ceiling on the supply side (Paltsev 2000) without explaining what is meant by this.

In summary, the models differ with respect to the assumptions about the participation of the FSU/EEC firms in emissions trading, the quantitative emission restrictions for domestic FSU/EEC emissions and exports and the price of FSU/EEC emissions compared to the world market price. As discussed in section 2, there are basically three realistic setups that we analyze in this study to see whether they make a difference in the allocative effect.

Regional Aggregation

Another issue is, that there are several countries that can sell hot-air. Due to the lack of data most studies work with the aggregated regions FSU and EEC or even one region FSU/EEC, which also includes Former Soviet Republics that are not Annex B countries. The studies then assume that the FSU/EEC behaves as a monopoly/cartel or that the FSU does so, while the EEC as a competitive fringe will follow the price leadership of the domination region FSU or that both do not cooperate at all (Boehringer and Loeschel 2001; Loeschel and Zhang 2002). Working with the regional aggregate FSU thus implies that Russia and the Ukraine coordinate their behavior and build a cartel. In this study we will also aggregate all hot-air countries to one region FSU/EEC.

What is the Available Amount of Hot-Air?

Hot-air is defined as the difference between projected baseline emissions and the Kyoto target, in the case where the former turn out to be smaller then the latter. Thus every estimate of hot-air depends on the projected baseline emissions which depend among others on the expected economic development of the FSU/EEC. Estimates for the overall amount of hot-air available in 2010 range from 100 to 500 million metric tons of carbon (MtC). The EIA (2002) projects 2010 emission to be 978 MtC in the FSU and EEC, while emissions in 1990 were 1347 MtC. In addition, the FSU is allowed to credit another 46 MtC for sinks and the EEC 7.5 MtC (den Elzen and de Moor 2001a). This, implies an overall amount of 410 MtC hot-air. The largest suppliers are Russia and the Ukraine who account for about one third of total hot-air each, followed by Romania who provides around 15% (Missfeldt and Villavicenco 2002). Table 1 reports the different amounts of hot-air used in the different studies.

Partial equilibrium models use these estimates directly (Boehringer and Loeschel 2001; den Elzen and de Moor 2001b), while most CGE models calibrate their benchmark scenario where no abatement action is taken to such emission projections. Once a certain emission path is chosen, the amount of hot-air is seen as fixed. This is misleading though, as climate policies in some regions will change the emission path even in regions with hot-air. As soon as some countries face binding emission constraints, their gross energy prices increase. This, on one hand, shifts the production of energy intensive goods to the countries without emission restrictions (including the hot-air countries) increasing their demand for energy. This effect is called "leakage". On the other hand, the loss of income in the abating countries reduces import demand and thus energy demand in the non-abating countries. In our model, for example, a scenario where the Annex B countries except the US unilaterally reduce their emissions to reach their Kyoto target, leads to an overall increase of energy demand and thus of emissions in the FSU/EEC, so that the available hot-air is 6.3% less than in the benchmark. Other scenarios, such as emissions trading, that change gross energy prices and thus energy demand in the FSU/EEC have comparable effects.

Summarized, the *available* hot-air, defined as the difference between the Kyoto target and the actual emissions of the FSU/EEC depends on the economic development in the FSU/EEC as well as on the level and cost of abatement in the rest of the world.

CDM, JI and Sinks

Three further issues that influence the amount of hot-air traded are CDM, JI and sink enhancement. All mechanisms provide alternative sources of supply of emission reduction permits for economies with high marginal abatement costs. Hence, they lower the incentive of the Annex B countries to buy hot-air from the FSU/EEC. The studies listed in Table 1 ignore all three mechanisms, though JI can be seen as being part of international emissions trading. In the following simulations we do exactly the same. We assume that JI is part of IET while we ignore CDM and sink enhancement as substitutes for permit trading.

Banking

In Marrakech and Bonn it was agreed that assigned amount units (AAUs) resulting from the Kyoto commitment can be banked without a time constraint. Credits from JI or CDM can be banked up to a limit of 2.5 respectively 5% of a Party's initial assigned amount. Sink credits can not be banked (IETA 2001).

On the supply side, banking provides an incentive to reduce the supply of permits in order to save emission rights while prices are low, as they might become more valuable in future commitment periods. On the demand side, provided that rising permit prices are expected, there is an incentive to buy more permits than presently needed. Both effects, lower supplies and increased demand, tend to raise permit prices above the level obtained in a short-term market without banking. These effects are - with the exception of study (5) - not incorporated in the studies listed in Table I and will also not be incorporated in the simulation exercises in this paper.[2]

The simulation results presented below therefore produce lower bounds for the permit prices as hot-air suppliers might restrict their supply even further than shown here for banking purposes.[3] In the competitive scenario ET3 in which there is an excess supply of permits, hence a zero price (see section 4), demand will also make sure that a low but positive price will prevail since banking of permits would constitute an almost costly insurance against a future scarcity of permits. Hence, the extreme model result of ET3 with zero prices is extremely unlikely to materialize in reality.

4 Policy Simulations

In order to assess the economic implications of different participation structures, institutional details and the treatment of hot-air on international emissions trading, we use the DART model for running different policy scenarios that will be defined below.

The DART Model

The DART (**D**ynamic **A**pplied **R**egional **T**rade) Model is a multi-region, multi-sector recursive dynamic CGE model of the world economy developed by the Kiel Institute for World Economics to analyze climate policies. It covers 11 sectors and 12 regions that are summarized in Table II and the two production factors labor and capital. The economic structure of the DART model is fully specified for each region and covers production, final consumption and investment. A more detailed model description can be found in the appendix.

[Table II]

Formulation of Policy Scenarios

In order to focus on the allocative effects of the different scenarios on prices, trade and production structure, and also for practical modelling reasons we have to make a number of simplifying assumptions. First, we do not include banking and CDM in our study. JI is only implicitly modelled through Annex B emissions trading. The sink credits are included in the reduction targets (see Table III), but we do not model sink enhancement. For the implementation of the Kyoto Protocol we assume that the regions start emission reductions in 2005 and then reduce their emission by a fixed amount each year, until the target is reached in 2010. For the hot-air modelling we focus on the cartel case and aggregate all hot-air countries to the region FSU/EEC.

[Table III]

Besides the benchmark where we assume that no emission reductions are undertaken, the analyzed scenarios differ in two dimensions. The first is permit allocation in the hot-air economies. As discussed in section 2 three realistic scenarios for international emissions trading among the Annex B countries, including the hot-air, should be distinguished:

ET1: The FSU/EEC government is selling a fixed number of permits (hot-air) internationally. The FSU/EEC firms are isolated from the emission market and receive their permits from the FSU/EEC government for free.[4]

ET2: The FSU/EEC government is restricting the amount of available permits but the FSU/EEC firms participate in IET and the international permit price also applies domestically.

ET3: The FSU/EEC government grandfathers all permits (including the hot-air) to its domestic firms that participate in competitive IET.

For the two scenarios ET1 and ET2 where the FSU/EEC is able to exercise market power, we differentiate between welfare maximization (ET1W/ET2W) and revenue maximization (ET1R/ET2R).

To determine the welfare and revenue maxima for scenarios ET1 and ET2 we vary the amount of hot-air supplied by the FSU/EEC from 5% to 100%. Hot-air is defined as the difference between the Kyoto target and the 2010 benchmark emissions and amounts to 465 MtC in our model.[5] The revenue is in both scenarios the revenue for *exported* permits. Thus, in scenario ET2 the FSU/EEC government does not consider the revenue from its permit sales to local emitters, as it only amounts to a redistribution within the country.

In all scenarios the US are not participating in emissions trading, as this is currently the most likely scenario. At the end of section 5 we will shortly comment on the results we get by assuming that the US rejoin the Kyoto commitment and engage in emissions trading

5 Simulation Results

The question is how the different institutional set ups ET1-ET3 that differ in the objective of the FSU/EEC (welfare vs. revenue maximization) and the permit allocation in the FSU/EEC, influence the outcome of international emissions trading. First, we compare welfare and revenue maximization in the two scenarios with market power (ET1 and ET2). Next, we assess how the non-participation (ET1) respectively participation (ET2) of the FSU/EEC firms in the permit market influences the outcome of the optimization process. In addition, we take a closer look at scenario ET2R as it shows the largest difference to the other scenarios and on competitive trading (ET3). Finally we comment on the role of the US participation. All following results refer to the year 2010 which marks the midpoint of the first Kyoto commitment period and is frequently chosen as the year of reference.

Welfare versus Revenue Maximization

As discussed in section 2 welfare and revenue maximization do not lead to the same supply behavior and it can be expected that the optimal amount of hot-air is larger under welfare maximization. Table IV shows that this is indeed the case. Note that the provision of a certain percentage of hot-air does not lead to the same overall FSU/EEC emissions in the two scenarios. While in scenario ET1 the domestic FSU/EEC emissions change relative to the benchmark due to the increase in international fossil fuel prices, such a leakage can not occur in scenario ET2 where the FSU/EEC government restricts the total amounts of permits used by foreign *and* domestic firms. Furthermore, in scenario ET3W which is equivalent to the benchmark, not all available hot-air is used, since only 220 MtC are required to meet the emission targets of the countries participating in IET. Also, when firms are participating in IET (ET2), not only hot-air is sold, but also permits resulting from real emission reductions (see discussion of scenario ET2W below).

[Table IV]

When we compare revenue to welfare maximization in the scenario ET1 where the FSU/EEC firms receive their permits for free we find the supply of hot-air under revenue maximization to be 5% points below that under welfare maximization. As the loss in welfare due to revenue maximization is close to zero though, both mechanisms lead in fact approximately to the same welfare effect.[6] If the FSU/EEC firms are participating in emissions trading (ET2), the difference is - as postulated in section 2 - much larger. Now, welfare maximization leads to the provision of 35% of the hot-air while under revenue maximization it would be optimal to sell no hot-air at all. The reason is that in scenario ET1W the provision of more hot-air increases welfare through higher energy exports and decreases it by a loss in the comparative advantage in the production of energy intensive goods. In scenario ET2W, however, the comparative advantage is increased through a larger hot-air supply, as the domestic FSU/EEC firms that participate in emissions trading benefit from the fall in permit prices. Here, both effects work in the same direction such that an additional supply of hot-air will increase welfare. In ET2W, revenue maximization results in a welfare loss of approximately 1%. The welfare and revenue curves of the different restrictions are plotted in Figure 1.

[Figure 1]

Comparing revenue and welfare maximization from the point of view of the FSU/EEC, the final welfare result is practically identical in the scenarios ET1 with unconstrained emissions in the FSU/EEC. This is mainly due to the fact that the revenue effect dominates and that energy price effects of increased energy exports through an increase in hot-air are compensated by the loss in comparative advantage of energy-intensive industries thus leaving a very small net effect. This is quite different in ET2 where both competitive effects go into the same direction, such that increasing hot-air supplies beyond the revenue maximizing level effectively raises welfare. The curvature of the welfare and revenue curves (Figure 1) also indicate that from a welfare point of view the exact amount of hot-air supplied does not matter much since the curves turn out quite flat. Only if the governments look for revenue maximization in ET2 the determination of the share of hot-air brought to international markets makes an important difference. Note also, that the results of optimal hot-air supply in scenario ET1R are in line with the results of studies reported in Table 1 where these are comparable. The studies by den Elzen und de Moor (2001a, 2001b, 2002) and Boehringer and Loeschel (2001), Loeschel und Zhang (2002) find that under revenue maximization a supply of 30 - 60% of hot-air is optimal. Our study is at the lower end of this range.[7]

The two Institutional Setups under Welfare Maximization

Under welfare maximization, the difference between the hot-air supplies in the two institutional setups ET1 and ET2 is relatively small and overall FSU/EEC emissions (domestic plus exported) are almost identical. A significant difference between the two scenarios can only be seen in the variation in the world permit price and the resulting world prices for fossil fuels (see table V[8]).

[Table V]

If FSU/EEC firms need to buy permits for emitting CO_2 as assumed in scenario ET2W, they will decrease their emissions relative to the benchmark as this is cheaper than to buy permits at the world market price. This essentially happens because FSU/EEC firms have much lower abatement costs than the rest of the Annex B countries. 15% of the FSU/EEC permits sold on the international permit market are not hot-air but are associated with emission reductions in the FSU/EEC. The resulting increase in permit supply cuts down the permit price compared to scenario ET1W and raises energy demand in the countries participating in emissions trading. As a result net energy prices world wide are slightly higher in ET2W than in ET1W while gross prices in the countries that participate in emissions trading decline noticeable by 2.5 - 3%. For the non-Annex B countries welfare effects are ambiguous. In the energy exporting countries the FSU/EEC trading scenario ET2W with its higher energy demand and higher world market prices implies a slightly higher welfare than scenario ET1W. The energy importing countries are slightly better off with the FSU/EEC excluding domestic firms from IET (ET1W) and the resulting higher permit price and lower net energy price. This is also the case for the FSU/EEC itself. It faces lower gross energy prices in scenario ET1W resulting in a slight welfare increase compared to scenario ET2W. This is so because the FSU/EEC under welfare maximization can by selecting the optimal hot-air supply introduce the equivalent of an optimal tariff on fossil energy.

The impact of the two institutional regimes on the welfare in the abating Annex B countries is predominantly determined by the permit price effect. In ET1W the permit price is 19.5 \$/tC and drops by more than 50% to 7.7\$/tC in ET2W. This is due to the fact that in addition to the hot-air - i.e. benchmark emissions in 2010 minus Kyoto target - domestic permits from real emission reductions are sold since the FSU/EEC firms have sufficiently low marginal abatement costs. As a consequence, regions like WEU get cheaper permits in ET2W than in ET1W and thus experience higher welfare effects in ET2W.

Revenue Maximization in Scenario ET2

The scenario ET2 in which the FSU/EEC firms participate in IET is of particular interest. The difference between revenue and welfare maximization under the optimal hot-air supply is largest, and under revenue maximization the lowest emissions world wide as well as the lowest emissions from the FSU/EEC (including the exported hot-air) will be achieved.

The emission effect is, of course due to the positive price on emissions imposed on local emitters in the FSU/EEC. But the hot-air available at the government level - defined as the difference between the Kyoto commitment and benchmark emissions - will also not be supplied on world markets. The reason is the high price for permits. At high prices only few permits will be sold internally, hence the effective amount of permits that can be brought to the international market increases. One could also explain this effect in a different setting, where local emitters receive permits according to benchmark emissions which then are tradable on the international market. At the world market prices and the low abatement costs more than 100 MtC would be supplied by the private sector of the FSU/EEC. Maximizing revenues of permit sales exports would result only in a small share of hot-air supplied. In fact, it would be optimal to keep all hot-air because the private supplies would already suffice to reach the revenue maximum for the FSU/EEC.[9]

These internal incentives to supply hot-air also in part explain the drastic rise in hot-air supplies in the case of welfare maximization. Increasing hot-air supplies improve the competitive situation of the energy sectors in the FSU/EEC as discussed above. The additional hot-air also lowers permit prices from 31 $/tC to less than 8 $/tC. Such a drop in permit prices drastically reduces the permit supply of local emitters, hence the government can increase its supplies strongly from 0% to 35%. Finally it is interesting to note that scenario ET2 is close to the welfare maximum at almost every hot-air supply, probably because the revenue effect from the international permit market and the competitiveness effect together with the abatement cost effect inside the FSU/EEC seem to compensate each other.

Competitive Trading

Our third institutional set up leads to a competitive market. As a result the supply of hot-air is not restricted and the permit price drops to zero and scenario ET3 reduces to the benchmark. The exported permits of 220 MtC reported in Table IV is the amount of hot-air supply at which the price reaches zero. Thus, in the benchmark WEU, JPN and ANC emit together 220 MtC more then their common Kyoto target. In any case, ET3 is associated with the lowest permit prices and the highest world market prices for fossil fuels with the well known implications for energy exporting and importing countries and the abating Annex B regions. Finally, if we compare the FSU/EEC welfare under strategic behavior to the welfare under a competitive market, we can see that only under ET1 the FSU/EEC can significantly gain welfare. Under scenario

ET2 the increase in welfare compared to ET3 is almost negligible. The reason is that ET3 is the same scenario as ET2 with 100% hot-air supply. As already explained, the welfare curve in Figure 1 is quite flat and the benefits from further permit revenue through a restriction of hot-air are compensated by the higher domestic permit prices.

The Effects of the US Rejoining the Kyoto Protocol

Table VI reports optimal hot-air supply and resulting permit price, permit export, emissions and welfare in FSU/EEC for scenarios ET1W, ET2W (welfare maximization in the hot-air economies) and ET3 (competitive trading) if the US rejoin the Kyoto Protocol and engage in international emissions trading compared to the original scenarios without US emission reductions. To alleviate comparisons, the table repeats some of the results shown already in table IV.

[Table VI]

Comparing the (+US) to the (-US) scenario shows that indeed the qualitative results remain the same, while the size of the effects changes. As expected, permit prices and permit exports in the optimal scenarios increase substantially even though the FSU/EEC react in ET1 and ET2 by more than doubling their hot-air supply. As a results, permit revenues under market power are three to five times larger with the US participation and welfare in the FSU/EEC increases as well. The increase in welfare is higher in ET1 as in ET2 because in scenario ET2 the firms in the FSU/EEC suffer from the higher permit prices. Summarized, the curves in figure 1 are shifted to the north-east. In the case of competitive trading the US demand for permits leads to a positive permit price of 8.64 $/tC and the FSU/EEC gain in welfare as well.

6 Conclusions

In this paper we analyzed the impacts of the interaction between different participation structures, institutional set ups and strategic supply of hot-air in international emissions trading. Many studies have found a wide range of optimal hot-air supplies. We have shown that the permit allocation within the hot-air countries is an important determinant of hot-air supplies. Three institutional scenarios appear to be most realistic:

- the FSU/EEC governments give emission permits to the domestic firms for free and isolate them from the international permit market while the governments themselves trade a certain percentage of the hot-air on the world market,
- domestic firms participate in IET but the FSU/EEC government controls the amount of permits that are available for both domestic firms and international entities,
- the FSU/EEC government grandfathers all emission permits to local firms that participate in IET

Within these three settings optimal hot-air supplies vary between 0% and 35%. This variation is also influenced by the objective function used by the governments of the hot-air countries provided they cooperate in order to strategically restrict the supply of hot-air. Under welfare maximization always more hot-air is sold than under revenue maximization, mainly because under welfare maximization hot-air supplies can be used as trade policies for energy sectors and for energy-intensive industries.

The question as to whether the optimal degree of hot-air really is an important one for the hot-air economies depends mainly on the objective they are pursuing. In the case of a simple revenue maximization from the export of permits, it matters simply because - in the case of no US participation and free permits to local producers - revenues can be increased by roughly 7 billion US$ to 10 billion US$ if hot-air exports are restricted to 30%. Similarly strong effects occur in the other scenarios. If welfare maximization is the objective, it matters only if the firms in the hot-air economies are not restricted in their emissions and excluded from the permit market. In the case where firms participate in emissions trading, a variation in the share of hot-air supplied has almost no effect on welfare. This happens because the increased revenue from restricting hot-air is offset by the negative impacts on the domestic industry. Again the competitiveness effects of the energy price changes which accompany the variation in hot-air are at work.

The issue of hot-air might be of importance though from a different perspective. The simulation results show that the welfare gains the hot-air economies can realize by moving from one scenario to another are smaller than the negative welfare externalities in the other Annex B countries. These countries are especially affected by the varying permit and energy prices. Thus it turns out, that strategic behavior of the hot-air economies might not have significant welfare effects on the hot-air economies themselves, but that the welfare effects in the other Annex B regions can be used as a strategic opportunity in international climate negotiations.

Notes

[1]Unfortunately it is not stated clearly how the FSU/EEC permit system works, but as marginal abatement cost are reported for all Annex B countries except the FSU/EEC this is what was most likely modelled.

[2]If banking is analyzed, this is mostly done using partial equilibrium models as e.g. in Steenberghe (2003).

[3]This result is reported in Manne and Richels (2001) with the help of an

intertemporal optimization model.

[4]To be precise, the permits not designated for the world market are *sold* on a domestic market. In all relevant scenarios though these domestic permits exceed the domestic demand, so that the price is zero.

[5]We thus define hot-air as a fixed number. The difference to the EIA estimate of 410 MtC mentioned in section 3, results from the calibration of the DART model, which is described in the appendix, and also from the fact that we account for sink credits.

[6]This is also found by Babiker et al. (2002).

[7]The scenarios of the other studies listed in Table 1 are either not comparable to our scenarios or do not report their results in a way to allow for meaningful comparisons. Note also that these studies assume that only 220 - 375 MtC hot-air is available compared to 465 MtC in this study.

[8]We only report the results for the Annex B regions and China and Middle East in order to keep the presentation of results clear. The latter two regions exemplify the effects for non-abating, energy importing in contrast to non-abating, energy exporting regions. Detailed results are available from the authors upon request.

[9]The result of an optimal supply of 0% of hot-air is accidental. In fact, the optimal supply is slightly below 0%, i.e. the FSU/EEC would bank even more than the predicted amount of hot-air.

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Table I: in landscape format - extra file

Table II: Dimensions of the DART-Model

Countries and regions		Production sectors	
Annex B		Energy	
USA	USA	COL	Coal
WEU	West European Union	CRU	Crude Oil
ANC	Canada, Australia,	GAS	Natural Gas
	New Zealand	OIL	Refined Oil Products
JPN	Japan	EGW	Electricity
FSU/	Former Soviet Union,		
EEC	Eastern Europe	Non energy	
		AGR	Agricultural production
Non-Annex B		IMS	Iron Metal Steal
LAM	Latin America	CPP	Chemicals, rubber, paper
IND	India		and plastic products
PAS	Pacific Asia	Y	Other manufactures
CPA	China, Hong Kong		and services
MEA	Middle East, North Africa	TRN	Transport
AFR	Sub-Saharan Africa	CGD	Investment good
ROW	Rest of the World		

Table III: Emission Targets after Marrakech (including sinks)

Country	Original target	Marrakech target
	as percentage of 1990 emissions	
USA	94%	96.8 %
WEU	92%	94.8%
ANC	97%	109 % (*)
JPN	94%	99.2%
FSU/EEC	98.5%	103%

(*) As emissions have grown by more than 9 % since 1990, this target does not imply that hot-air is available in ANC.

Source: (Boehringer 2002; Boehringer and Loeschel 2001)

Table IV: Results for Welfare and Revenue Maximization

Scenario	Hot-air (1)	Permit price (2)	Permit export (3)	Emissions (4)	Welfare (5)
Welfare Maximization					
ET1W	30%	19.55	139	1058	100.7
ET2W	35%	7.68	190	1074	100.1
ET3W	= bench	0.00	220	1132	100.0
Revenue Maximization					
ET1R	25%	25.62	116	1037	100.7
ET2R	0%	31.14	105	912	99.1

(1) Optimal % hot-air supplied

(Hot-air = 2010 benchmark emissions minus Kyoto target = 465 MtC)

(2) In US$ per tC

(3) FSU/EEC permit exports in MtC

(4) Domestic + exported emissions from FSU/EEC in MtC

(5) Benchmark 2010 = 100

Table V: The Scenarios under Optimal FSU/EEC Behavior

	ET3*	ET1W	ET2W	ET1R	ET2R
	Welfare (Equivalent Variation)				
USA	100.0	100.0	100.0	100.0	100.0
WEU	100.0	99.2	99.7	99.0	98.9
ANC	100.0	99.2	99.7	99.0	98.7
JPN	100.0	99.7	99.9	99.6	99.5
FSU/EEC	100.0	100.7	100.1	100.7	99.1
MEA	100.0	99.4	99.7	99.3	98.9
CPA	100.0	100.1	100.0	100.1	100.1
	Gross Oil Price (1997 = 1)				
USA	1.59	1.58	1.58	1.57	1.57
WEU	1.71	1.79	1.74	0.82	1.84
ANC	1.69	1.76	1.72	1.78	1.80
JPN	1.49	1.54	1.51	1.56	1.58
FSU/EEC	1.65	1.64	1.68	1.64	1.76
MEA	1.81	1.79	1.80	1.79	1.78
CPA	1.78	1.76	1.77	1.76	1.75
	Emissions in GtC				
USA	1.72	1.73	1.73	1.74	1.74
WEU	1.05	1.00	1.03	0.98	0.98
ANC	0.26	0.25	0.26	0.24	0.24
JPN	0.40	0.39	0.40	0.38	0.38
FSU/EEC	0.91	0.92	0.88	0.92	0.81
MEA	0.55	0.56	0.56	0.56	0.56
CPA	1.33	1.33	1.33	1.34	1.35
Total**	8.20	8.16	8.16	8.15	8.06

* ET3 = benchmark, as excess supply of hot-air leads to a permit price of zero.

** Emissions of all regions taken together

Table VI: Welfare Maximization with (+US) and without (-US) the US Participating in the Kyoto Protocol and International Emissions Trading

Scenario	Hot-air (1)	Permit price (2)	Permit export (3)	Emissions (4)	Welfare (5)
US not participating in Kyoto and international emissions trading					
ET1W-US	30%	19.55	139	1058	100.7
ET2W-US	35%	7.68	190	1074	100.1
ET3-US	= bench	0.00	220	1132	100.0
US participating in Kyoto and international emissions trading					
ET1W+US	65%	32.91	302	1230	103.7
ET2W+US	70%	21.51	397	1237	101.8
ET3+US	100%	8.64	494	1376	101.1

(1) Optimal % hot-air supply

(hot-air = 2010 benchmark emissions minus Kyoto target = 465 MtC)

(2) In US$ per tC

(3) FSU/EEC permit exports in MtC

(4) Domestic + exported emissions from FSU/EEC in MtC

(5) Benchmark 2010 = 100