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 emission 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 with and without US participation by using the computable general equilibrium model DART.

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

The Kyoto-Protocol marks the first instance in which a multinational and potentially global emission trading system has become part of an international treaty. The introduction of emission 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 has been rejected by the United States government. As a consequence, it is not at all clear what the emission 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 2001; Boehringer and Loeschl 2002; den Elzen and de Moor 2001a). 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 emission trading (IET) according to the Kyoto rules. The three major influences to be considered are

- the participation structure of the emission trading regime, i.e. the role of the USA,

- the institutional details of the permit allocation especially in countries with hot-air, and
- the likely supply of hot-air in the commitment period of the Kyoto-Protocol.

These three aspects are closely linked. The permit allocation within the two major suppliers of hot-air, Russia and the Ukraine, has repercussions on the global permit market, and at the same time it influences the ability of these two countries to strategically control the global permit market. Similarly, the participation or non-participation of the USA in global trading influences the permit market, the climate protection costs of other regions and the benefits from strategic restrictions of hot-air supplies.

The paper is organized as follows. The next section presents a qualitative discussion of these interactions 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 emission trading is done in Section 4. Section 5 presents the results of the simulations with the CGE model DART both with respect to the participation of the USA and with respect to the likely supply of hot-air. The paper ends with some conclusions and an appendix which gives a short description of the DART-Model.

2 Allocation Effects in the International Market for Greenhouse Gas Emissions

2.1 Institutional Details of International Trading

At first sight and according to standard economic theory, the way in which emission permits are allocated in each state - whether through auctioning, grandfathering, or updating (Baron and Bygrave 2002) - should not make a difference in terms of its allocation effect. The only indirect effect would come through different income effects depending on where the ownership of emission rights and the subsequent rents are located. However, at least for the large participants of an international emissions trading regime with a considerable amount of hot-air the institutional design of permit allocation makes an important difference. There are essentially two states which have been allocated most 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 FSU/EEC).

As the FSU/EEC is the largest seller of permits in the case of unrestricted emission 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 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 see both government and firm trading. The modalities for emission trading adopted in Marrakech (UNFCCC

2001) state that to participate in IET Annex B countries have to establish national registries, that transfers and acquisitions between these registries shall be made under the responsibility of the Parties and that if a Party authorizes legal entities to transfer and/or acquire permits it has to supervise that it acts in accordance with the rules and remains responsible for the fulfillment of its obligations (Article 5). This suggests that it will be indeed national registries, that will trade with other national registries and act as a clearing board for national firms, so that market power might indeed be a relevant issue. On the other hand, as the Joint Implementation mechanism (JI) is seen as a chance for private investments in mitigation technologies, private firms are likely to be part of JI projects and this is nothing but some kind of emission trading on firm level.

The question remains though, how the governments will distribute their assigned amount units (AAU). Will they sell them to local firms, or grandfather them for free? Will they distribute all their AAU 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.

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 emission 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. Against the background of JI this scenario can also be interpreted the way that only the government is participating in IET wile the domestic firms are required to hold emission permits and are allowed to take part in JI projects to sell or acquire permits. As noted above, under usual CGE model assumptions it does not matter whether the domestic firms have to buy their rights from the government of receive permits for their business as usual emissions for free.

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, permit prices domestically and world market prices will equalize but at a much lower level.

State trading of excess amounts of permits 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 will remove this strategic ability, but it will also endow firms with an additional source of income. However, some studies (Boehringer 2001; Loeschl 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.

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. But these gains depend not only on the ability to coordinate strategies between the largest hot-air countries. The just mentioned internal institutional settings 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.

2.2 What is to be maximized with restricted supplies of Hot Air?

If the hot-air economies want to act as a cartel, the question arises what kind of objective function they follow in determining the optimal supply of hot-air. Many partial equilibrium studies (Boehringer and Loeschl 2001; Burniaux 1999) simply presume that revenue from selling hot-air is to be maximized, while some sort of welfare maximization is assumed in general equilibrium analysis (Boehringer 2001; Bernstein, Montgomery, Rutherford, and Yang 1999). Though Babiker, Jacoby, Reilly, and Reiner (2002) state that both lead approximately to the same result, this need not be the case since restricting hot-air has not only revenue but also allocation effects, the most important one coming through the impact of hot-air trading on the world market prices for fossil energy net of taxes or permit prices.

An increase in the supply of hot-air on international markets first of all lowers permit prices. Some studies claim that they can drop as low as to a zero price. Yet, at the same time the sale of hot-air increases the demand for fossil energy and thus energy prices net of permit prices will rise. However, in economies restricted by the Kyoto-commitments gross energy prices will fall. This will in turn affect the comparative advantage of energy intensive industries in the different economies and change trade flows and as a consequence affect welfare. Since the region FSU/EEC is a strong net exporter of fossil energy and of energy intensive products rising net energy prices in their export markets would increase the comparative advantage of these sectors. In addition, the fall in gross energy prices will shift demand towards more energy intensive goods in the Annex B countries. This will need to be balanced against the rising energy prices in Non-Annex B countries whose demand for energy and energy intensive products will fall. The net effect of this price effect on demand and on competitiveness in the different economies can only be assessed quantitatively.

2.3 The interaction of national permit regulation 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. This is most likely true for the countries with a significant amount of hot-air, i.e. Russia and the Ukraine. The two options for these governments - 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 region FSU/EEC decides not to charge the local emitters of CO_2 the world market permit price or not to allow these emitters to sell grandfathered emission rights on the global permit market, it 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 emission trading (demand effect).

In hot-air economies, an additional supply of hot-air will - besides raising government revenues - increase exports (resp. 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 have lower gross energy prices thus increasing demand and Non-Annex B countries experience higher prices with a reduction in demand. 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 the 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.

The other option for the FSU/EEC to sell a fixed share of the overall permits to local and international emitters alike 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.

When comparing the scenario ET1 in which local emitters in the region FSU/EEC are not constrained with the scenario ET2 in which the permits are auctioned to local emitters as well, 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.

2.4 The Role of the US Participation in Hot Air Decisions

Equally important for the strategic and institutional designs is the participation of the USA. In 2001 the new Bush adminstration announced that the USA are no longer willing to fulfill their Kyoto commitment, declaring the Kyoto-Protocol as "fatally flawed" (Bush-Administration 2001). As the largest buyer, the participation or non-participation also influences the decisions by the hot-air suppliers. The withdrawal of the USA from IET and from the Kyoto commitments essentially moves the largest economy into the Non-Annex B group. Although the qualitative effects of alternative hot-air trading regimes remain the same, the size of the international allocation effects changes. First of all, the largest economy demanding emission permits would withdraw from the permit market thus drastically lowering permit prices. This would tend to reduce the optimal amount of hot-air supplied.

A second effect comes in through different price reactions on world markets. Whereas an increase in hot-air supplied in the case of an US participation will lower American energy prices it will raise them if the USA does not participate. The withdrawal of the USA would therefore drastically increase the demand for energy which to some extent would be supplied by the FSU/EEC thus benefiting FSU/EEC exporters of fossil fuels. At the same time the withdrawal improves the American comparative advantage in energy intensive products thus hurting the FSU/EEC competitive position. In scenario ET1 it also raises energy prices within FSU/EEC thus accelerating the American comparative advantage effect in energy intensive products. In contrast, energy prices in the FSU/EEC fall in scenario ET2, hence a diminished loss in comparative advantage. Which of these two effects finally dominates can only be assessed quantitatively. It is likely, however, that because of these opposite effects the participation or non-participation of the USA will make little difference between revenue and welfare maximization.

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. For running such models a number of empirical questions need to be resolved. These include the amount of available hot-air, the regional aggregation, complications through other policies such as CDM, JI and Banking, sinks and the way market power is actually exercised.

3.1 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 newest EIA data (IEA 2002) project 2010 emission to be 745 MtC in the FSU and 233 in the EEC, while emission in 1990 were 1036 resp. 301 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). Thus, the amount of hot-air would altogether be around 410 MtC. 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).

Partial equilibrium models use these estimates directly (Boehringer and Loeschl 2001; den Elzen and de Moor 2001b), while most CGE models calibrate their business as usual or 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 the benchmark will not materialize since climate policies will be introduced in some regions thus changing the emission path even in regions with hot-air. As soon as some Annex B countries face binding emission constraints, gross energy prices in these countries increase and the production of energy intensive goods is shifted to the rest of the world, including the hot-air economies that do not face emission restrictions. This is also called "leakage" and leads to an increasing demand for energy in the rest of the world and the hot-air countries. Hence, the amount of *available* hot-air is decreasing. Thus, the withdrawal of the USA from Kyoto has a double effect on the importance of hot-air. First it decreases the demand for emission permits considerably. In addition, compared to the case where the USA fulfills its Kyoto commitment, less energy intensive production is shifted to the FSU/EEC, so that the amount of available hot-air increases.

Due to the leakage effect, available hot-air is also less in the case of emission trading compared to the case of unilateral action. With emission trading, the same reductions can be achieved at a lower abatement cost so that less production is shifted to non abating countries including the FSU/EEC. In our model for example, under unilateral emission reductions in all Annex B countries the amount of hot-air is 6.3% less than in the benchmark. The difference reduces to around 4% without the US participation or under emission trading including the US.

Summarized, the *available* hot-air, defined as the difference between the Kyoto target and the emissions actually demanded by 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.

3.2 CDM, JI and Sinks

Three further issues that influence the amount of hot-air traded are the clean development mechanism (CDM), joint implementation (JI) and sink enhancement. CDM and JI work the same way. Countries can get so called Certified Emission Reductions (CER) for abatement in Non-Annex B countries in the case of CDM and Emission Reduction

Units (ERU) for emission reducing projects by two or more Annex B countries in the case of JI. In addition the the Removal Unit (RMU) was created in Marrakech for sink credits. 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. In the following simulations JI is treated as part of IET while we ignore CDM and sink enhancement as substitutes for permit trading.

3.3 Banking

In Marrakech and Bonn it was agreed that general emission permits resulting from the Kyoto commitment, the assigned amount units (AAU), can be banked without a time constraint. CERs and ERUs can be banked up to a limit of 2.5 resp. 5% of a Party's initial assigned amount. RMUs can not be banked (IETA 2001). Independently of market power, banking provides an incentive for the hot-air countries to defer a part of the hot-air for later use and restrict their permit supply. Compared to a scenario of market power and no banking, banking increases the benefits of restrictions, as the saved permits can be used e.g., when the FSU/EEC emissions reach the Kyoto limit in future. Thus, it can be expected that less hot-air is sold compared to the no banking scenario. Manne and Richels (2001) use intertemporal optimization in the CGE model MERGE and find indeed that if one looks at the period until 2020 the FSU/EEC optimally banks over 80% of hot-air if the USA participate in emission trading and even over 90% if not. This is more then most studies find to be optimal under market power only (see section 3.5). Using a partial equilibrium model based on marginal abatement curves, Steenberghe (2002) considers the period 2008-2017 and concludes that the total amount of banked permits in the first period is even larger than the amount of hot-air. Intertemporal optimization is not uncontroversial though. The emissions, the permit demand and the permit endowment in the post Kyoto period are highly uncertain and it is questionable as to whether government decisions about the intertemporal allocation of permit revenues or of welfare benefits from using permits will be based on a time horizon of more than one decade. As until 2010 the FSU/EEC emissions will stay clearly below the Kyoto limit, it seems legitimate to focus on market power and ignore the additional benefits of banked permit for the future if one considers only the first commitment period.

3.4 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 Loeschl 2001; Loeschl and Zhang 2002). Working with the regional aggregate FSU thus implies that Russia and the Ukraine coordinate their behavior and build a cartel.

3.5 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 maximizing its welfare or revenue a modeler has to make an assumption on how the market power is actually exercised. One possibility for the FSU/EEC is to participate in emission 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, Montgomery, Rutherford, and Yang (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 Loeschl (2001). In all the cases the FSU/EEC participates in the emission market and does even sell more than the hot-air as long as the world market price is above its marginal abatement costs. Boehringer (2001) 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 talk about 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 emission 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 will analyze in this study to see whether the different settings make a difference in the allocative effect.

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

Table 1: Selected studies on hot-air trading and market power

	Model	Scenario +/- USA	Objec- tive	Optimal % hot-air
1)	EPPA (CGE)	Export quota +US	Revenue	??
2)	MS-MRT (CGE)	Markup on domestic price +US	Welfare	(180% markup in 2010 declines to 18% in 2030)
3)	CGE	Export quotas -US	con- sumption	40%
4)	Partial equilib. model (PEM) (POLES*)	supply ceiling -US *a* Cartel FSU&EEC *b* EEC fringe suppl. *c* Duopoly	Revenue	*a* 35%; *b* FSU: 35%, EEC: 100%; *c* FSU: 32%, EEC: 100%
5)	PEM (World- SCAN*)	supply ceiling -US diff. emission scen.	Revenue	30-60%
6)	GREEN (CGE)	export quota (= markup) USA?	Revenue -AC	(170% markup in 2005, 38% in 2010, 0 in 2050)
7)	MERGE (CGE)	supply ceiling -US	GDP	40-54%

*: Provides marginal abatement cost curves

1) Babiker et al. 2002, 2) Bernstein et al. 1999, 3) Boehringer 2001

4) Boehringer/Loeschl 2001, Loeschl/Zhang 2002

5) den Elzen/de Moor 2001a, 2001b, 2002,

6) Burniaux 1999, 7) Manne/Richels 2001

4 Policy Simulations

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

Table 2: 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		

4.1 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 2 and the two production factors labor and capital. The regional aggregation for this study include the FSU/EEC, the USA and other Annex B parties, that are essential for our analysis. 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 3: 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%

Source: (Boehringer 2001; Boehringer and Loeschl 2001)

4.2 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 emission trading. The sink credits are included in the reduction targets (see Table 3), but we do not model sink enhancement. For the implementation of Kyoto 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.

Besides the benchmark where we assume that no emission reductions are undertaken, the analyzed scenarios differ in two dimensions. The first is the participation of the USA:

+US: Each Annex B country including the USA reduce its emissions accordingly to its Kyoto commitment.

-US: Only WEU, ANC and JPN reduce their emissions. The US emissions are not restricted.

The second dimension is the permit allocation in the hot-air economies. As discussed in section 2 three realistic scenarios for international emission trading among the Annex B countries, including the hot-air, should be distinguished:

ET1: The government of the FSU/EEC is selling a fixed number of permits (hot-air) on the international permit market. The FSU/EEC firms are isolated from the emission market and receive their permits from the FSU/EEC government for free[2].

ET2: The FSU/EEC is selling a fixed number of permits to domestic and foreign emitters alike, charging the same price. Thus,

[2] To be precise, our CGE model assumes that 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.

FSU/EEC firms participate in IET and the international permit price also applies domestically.

ET3: The government grandfathers all permits (including the hot-air) to its domestic firms. These participate in the competitive international emission market.

The first two scenarios imply that the FSU/EEC government is able to exercise market power, the third assume competitive behavior. These scenarios are combined with the two US participation scenarios. In addition for the 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)[3]. All scenarios are summarized in Table 4:

Table 4: Policy Scenarios

	+US	-US	
ET1	ET1W+US	ET1W-US	max welfare
	ET1R+US	ET1R-US	max revenue
ET2	ET2W+US	ET2W-US	max welfare
	ET2R+US	ET2R-US	max revenue
ET3	ET3+US	ET3-US	competitive market

To determine the welfare and revenue maxima for scenarios ET1 and ET2 we varied the amount of hot-air supplied by the FSU/EEC from 5% to 100%. Hot air is defined as the difference between the Kyoto

[3]Some studies (Burniaux 1999) also compare the FSU/EEC to a monopolistic firm and maximize permit revenue minus total abatement cost. Market power is only relevant though in the case of government trading and as the government does not have to pay the abatement cost, it is only interested in revenue.

target and the 2010 benchmark emissions and amounts to 465 MtC in our model. 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 sells to local emitters, as it is only a redistribution in the own country.

5 Simulation results

The question is how the different institutional set ups ET1-ET3 that differ in (1) the objective of the FSU/EEC (welfare vs. revenue maximization), (2) the permit allocation in the FSU/EEC, and (3) the participation of the USA influence the outcome of international emission 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) resp. participation (ET2) of the FSU/EEC firms in the permit market influences the outcome of the optimization process. In this context we also investigate the impacts of the USA withdrawal. Finally we take a closer look at scenario ET2R as it shows the largest difference to the other scenarios and on competitive trading (ET3). All following results refer to the year 2010.

5.1 Welfare versus revenue maximization

As discussed in section 2 welfare and revenue maximization do not lead to the same result and it can be expected that the optimal amount of hot-air is larger under welfare maximization. Table 5 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.

Table 5: Welfare versus Revenue maximization

Scenario	hot-air (1)	Permit Price (2)	Permit export (3)	emis (4)	welfare (5)
Welfare Maximization					
ET1+US	65%	32.91	302	1230	103.1
ET1-US	30%	19.55	139	1058	100.7
ET2+US	70%	21.51	397	1237	101.8
ET2-US	35%	7.68	190	1074	100.1
ET3+US		8.64	494	1376	101.1
ET3-US	= bench	0.00	220	1132	100.0
Revenue Maximization					
ET1+US	60%	36.10	278	1208	103.1
ET1-US	25%	25.62	116	1037	100.7
ET2+US	30%	39.67	267	1052	101.0
ET2+US	0%	31.14	105	912	99.1

(1) optimal % hot-air
(hot-air = 2010 benchmark emissions minus Kyoto target = 465 MtC)
(2) in US$ je tC
(3) FSU/EEC permit exports in MtC
(4) domestic + exported emissions from FSU/EEC in MtC
(5) benchmark 2010 = 100

Moving from revenue to welfare maximization in the scenario ET1 where the FSU/EEC firms receive their permits for free the hot-air supply rises by only around 5% points. As the loss in welfare due to revenue maximization is close to zero (0.01%) though, both mechanisms lead in fact approximately to the same results as Babiker, Jacoby, Reilly, and Reiner (2002) claim. If the FSU/EEC firms are participating in emission trading, the difference is - as postulated in section 2 as well - much larger. Now, welfare maximization leads to the provision of 70% of the hot-air with US participation and 35% without US participation while it would be optimal to sell only 30% respectively no hot-air to maximize revenue. The reason for this large difference was already explained in section 2. In scenario ET1 the provision of more hot-air increases welfare through higher energy exports and decreases it by a lose in the comparative advantage in the production of energy intensive goods. In contrast, the comparative advantage is increased through a larger hot-air supply in scenario ET2, as the domestic FSU/EEC firms gain from lower permit prices as well. Here, both effects work in the same direction and increase welfare from the additional supply of hot-air. In ET2, revenue maximization results in a welfare loss of approximately 1%. The welfare and revenue curves of the different restrictions are plotted in Figure 1.

Comparing revenue and welfare maximization from the point of view of the FSU/EEC, the final welfare result in 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 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

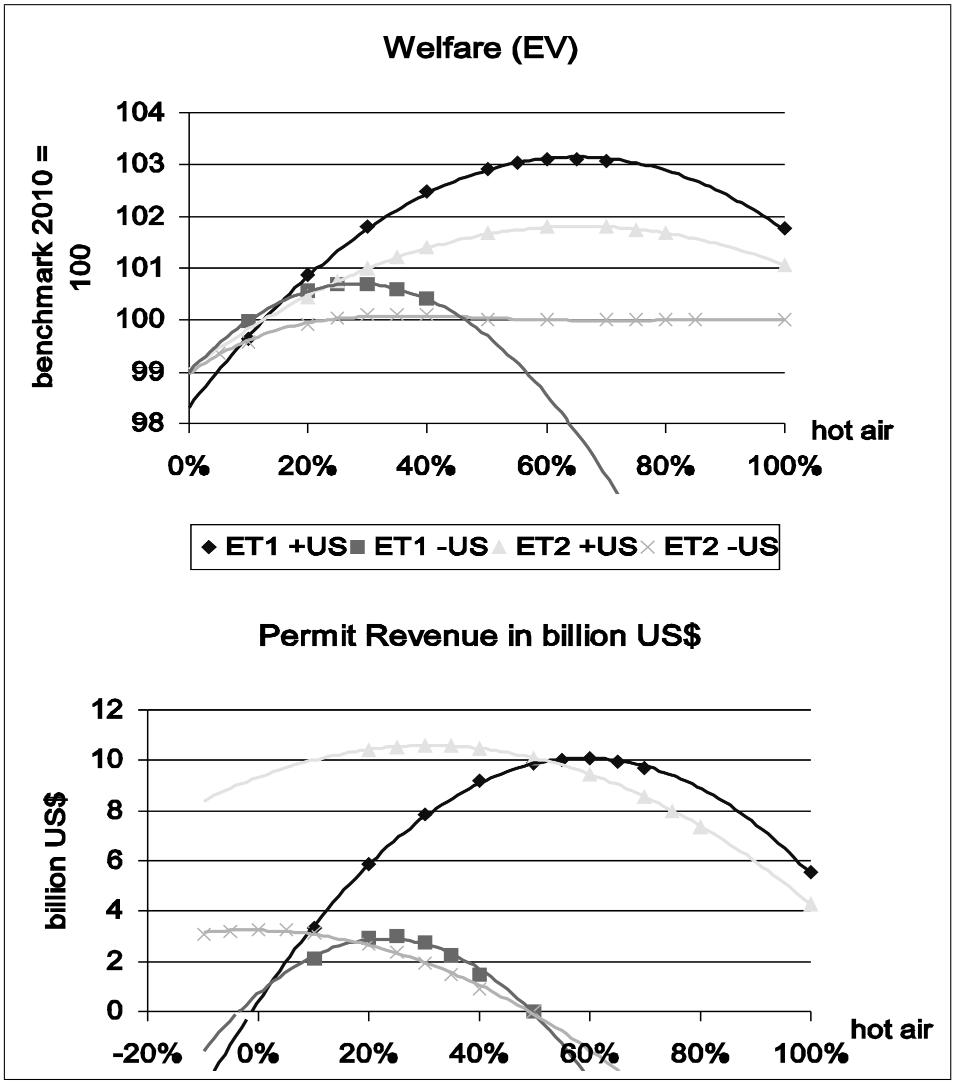

Figure 1: Welfare versus Revenue Maximization

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.

5.2 The two institutional setups under welfare maximization

Under welfare maximization, the deviation between the provided hot-air in the two institutional setups ET1 and ET2 is relatively small and overall FSU/EEC emissions (domestic plus exported) are almost identical. The 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.

If the FSU/EEC firms are participating in trading (ET2W), the permit price is lower. As their abatement costs are relatively small compared to the rest of the world, the FSU/EEC firms sell in scenario ET2W not only the hot-air, but also additional permits stemming from domestic reductions. 20% (+US) resp. 15% (-US) 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 and raises energy demand in the countries participating in emission trading. Thus, with lower permit prices net energy prices go up world wide while gross prices decline in the countries that participate in emission trading. In the energy exporting countries, the FSU/EEC trading scenario ET2W with its higher energy demand and higher world market prices welfare increases. The energy importing countries are better off with the FSU/EEC grandfathering its permits (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 1.3% (+US) resp. 0.6% (-US) 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 ET1 prices of 33 $/tC with US participation and 22 $/tC without the US prevail. They are by more than 10 $/tC lower in ET2. This is due to the fact that in addition to the expected "official" hot-air - i.e. benchmark emissions in 2010 minus Kyoto target - at the world market price domestic permits will be sold since the FSU/EEC has sufficiently low marginal abatement costs. As a consequence regions like WEU get cheaper permits in ET2 than in ET1 and thus experience higher welfare effects in ET2.

Finally we compare the scenarios of hot-air trading with and without the USA. All things said so far also apply here. What is striking though, is the significant drop in permit prices without the USA. Even though the FSU/EEC react to the decreased permit demand by cutting the supply of hot-air by half, the permit prices fall by 13 $/tC which is 40% in ET1 and over 60% in ET2. The reason is that in both scenarios ET1+US and ET2+US the USA are responsible for around 60% of world permit demand. Under emission trading the US withdrawal thus not only induces a shift of the marginal abatement cost curves but also a downward move along the curves itself. Taken together the sharp drop in permit prices dominates the increase in fossil fuel prices in all abating Annex B countries, so that all gross prices for fossil energy - including the oil price which was rising in the NOTR-US scenario - decline. We can see in Table 6 that without the US welfare increases in all abating Annex B countries. From the point of view of the FSU/EEC the US withdrawal implies a loss in welfare as the permit revenue declines by around 70% in both scenarios ET1 and ET2. The welfare loss is higher in ET1 (2.3%) than in ET2 (1.7%) as in ET2 the FSU/EEC firms benefit from the lower permit prices as well which compensates for part of the revenue loss.

Table 6: The scenarios under optimal FSU/EEC behavior

	bench	ET1W		ET2W		ET2R		ET3
		+US	-US	+US	-US	+US	-US	+US
	Welfare (Equivalent Variation)							
US	100	99.7	100.0	99.8	100.0	99.7	100.0	99.9
WEU	100	98.9	99.2	99.4	99.7	98.8	98.9	99.7
ANC	100	98.5	99.2	98.9	99.7	98.1	98.7	99.5
JPN	100	99.6	99.7	99.8	99.9	99.6	99.5	99.0
FSU	100	103.1	100.7	101.8	100.1	101.0	99.1	101.1
MEA	100	98.5	99.4	98.9	99.7	98.0	98.9	99.6
CPA	100	100.1	100.1	100.1	100.0	100.2	100.1	100.0
	Emissions in GtC							
US	1.72	1.59	1.73	1.63	1.73	1.56	1.74	1.69
WEU	1.05	0.97	1.00	1.00	1.03	0.97	0.98	1.03
ANC	0.26	0.24	0.25	0.25	0.26	0.24	0.24	0.26
JPN	0.40	0.38	0.39	0.39	0.40	0.38	0.38	0.40
FSU	0.91	0.93	0.92	0.84	0.88	0.79	0.81	0.88
MEA	0.55	0.56	0.56	0.56	0.56	0.56	0.56	0.56
CPA	1.33	1.35	1.33	1.34	1.33	1.36	1.35	1.33
World	8.20	8.02	8.16	8.02	8.16	7.88	8.06	8.13
	Gross Oil Price (1997 = 1)							
US	1.59	1.68	1.58	1.64	1.58	1.69	1.57	1.61
WEU	1.71	1.83	1.79	1.78	1.74	1.85	1.84	1.74
ANC	1.69	1.79	1.76	1.75	1.72	1.80	1.80	1.72
JPN	1.49	1.57	1.54	1.54	1.51	1.58	1.58	1.51
FSU	1.65	1.62	1.64	1.72	1.68	1.78	1.76	1.68
MEA	1.81	1.77	1.79	1.78	1.80	1.75	1.78	1.80
CPA	1.78	1.74	1.76	1.75	1.77	1.72	1.75	1.77

bench = ET3-US

5.3 Revenue maximization in scenario ET2

The scenario ET2 in which the FSU/EEC auctions off permits to the domestic emitters 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 word 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 - 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 accordingly 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 including the private supplies would result only in a small share of hot-air supplied. In fact, without the USA participation 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[4].

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

[4]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.

energy sectors in the FSU/EEC as discussed above. The additional hot-air also lowers permit prices. With the USA in the Kyoto-process from 40 $/tC to 22 $/tC and without the USA 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, i.e. from 30% to 70% in ET2+US and from 0% to 35% in ET2-US. Finally it is interesting to note in the case without the US demand (ET2-US) almost any hot-air supply is close to the welfare maximum, 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 substitute each other.

5.4 Competitive Trading

Our third institutional set up in the FSU/EEC (ET3) assumed that the government grandfathers all its emission rights, including the hot-air to the local firms that participate in international emission trading. This leads to a competitive market. As a result the supply of hot-air is not restricted and the permit price falls in IET from 33 $/tC in ET1+US and 22 $/tC in ET2+US to 8 $/tC in ET3+US. The withdrawal of the USA now leads to an excess supply of hot-air, so that the prize drops to zero and scenario ET3-US reduces to the benchmark. The exported 220 MtC reported in Table 6 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 (3%). 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 gains from further permit revenue through a restriction of hot-air are compensated by the higher domestic permit prices.

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 emission 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 isolates 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 - either directly or indirectly through JI projects - 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% in a trading system without the USA and between 30% and 7% with the USA participating. 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 of revenues from the export of permits, it matters simply because - in the case of US participation and free permits to local producers - revenues can be increased from roughly 6 billion US$ to 10 billion if hot-air exports are restricted to 60%. Similarly strong effects occur in the other scenarios. It does not matter much if welfare maximization is the objective. A variation in the share of hot-air supplied has almost no effect on welfare. This happens because restricting hot-air raises revenues but it also hurts the domestic industry regardless whether local producers pay for emissions or not. Again the competitiveness effects of the energy price changes which accompany the variation in hot-air are at work. There is on exception, though, in scenario ET1-US (no participation of the USA, free non-tradable permits in the FSU/EEC) the permit market is so thin such that the negative permit price effect always dominates the competitiveness effect.

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A The DART Model

Basic structure

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 covering 12 regions and 11 sectors that are summarized in section 3.1 and the two production factors labor and capital. The sectoral aggregation covers among others the main energy sectors. The economic structure is fully specified for each region and covers production and final consumption. Each market is perfectly competitive. Output and factor prices are fully flexible. For each region the model incorporates two types of agents: producers, distinguished by production sector and the final consumer which comprises an representative household and the government.

Producer behavior is derived from cost minimization for a given output. Each industry is characterized by a multi-level nested separable constant elasticity of substitution (CES) function that describes the technological substitution possibilities between a value added composite of capital and labor, energy and non-energy intermediate inputs in domestic production. The distinction between energy and non-energy intermediate products is useful in the context of climate policies.

The **final consumer** receives all income generated by providing primary factors to the production process. A fixed share of income is saved in each time period. These saving are invested in the production sectors. The disposable income (net of savings and taxes) is then used for maximizing utility by purchasing goods. The expenditure function is modelled as a CES composite which combines consumption of an energy aggregate and a non-energy-bundle. Within the non-energy consumption composite, substitution possibilities are characterized by a Cobb-Douglas function of Armington goods.

To analyze climate policies **CO_2 emissions** are calculated for final and intermediate energy consumption.

All regions are linked by bilateral **trade** flows and all goods, except the investment good, are traded among regions. Following the proposition of Armington 1969 (1969), domestic and foreign goods are imperfect substitutes distinguished by country of origin. Import demand is a three stage, nested separable CES cost resp. expenditure function. On the first level domestic and imported goods are substitutes. Imports are itself a composite of the sum of exports and transportation costs form each other. On the export side, the Armington assumption applies to final output of the industry sectors destined for domestic and international markets.

Factor markets are perfectly competitive and full employment of all factors is assumed. Labor is assumed to be a homogenous good, mobile across industries within regions but internationally immobile. In the basic version of the DART model capital is inter-sectorally but not internationally mobile. Capital stock is given at the beginning of each time period and results from the capital accumulation equation.

Dynamics

The DART model is recursive-dynamic, meaning that it solves for a sequence of static one-period equilibria for future time periods connected through capital accumulation. The major driving exogenous factors of the model dynamics are population change, the rate of labor productivity growth, the change in human capital, the savings rate, the gross rate of return on capital, and thus the endogenous rate of capital accumulation. The savings behavior of regional households is characterized by a constant savings rate over time.

Labor supply considers human capital accumulation and is, therefore, measured in efficiency units, $L_{r,t}$. It evolves exogenously over time. Hence, labor supply for each region r at the beginning of time period t+1 is given by:

$$\bar{L}_{r,t+1} = \bar{L}_{r,t} * (1 + gp_{r,t} + ga_{r,t} + gh_r)$$

where the bar denotes exogenous variables. An increase of effective labor implies either growth of the human capital accumulated per physical unit of labor, gh_r, population growth gp_r or total factor productivity ga_r or the sum of all.

The version of the DART model used for this paper assumes constant, but regionally different labor productivity improvement rates, ga_r, constant but regionally different growth rates of human capital, gh_r, which stem from Hall and Jones (1999), and declining population growth rates over time,$gp_{r,t}$, according to the World Bank population growth projections. Because of the lack of data for the evolution of the labor participation rate in the future the growth rate of population instead of the labor force is used implying that the labor participation rate is constant over time.

Current period's investment augments the capital stock in the next period. The aggregated regional capital stock, Kst at period t is updated by an accumulation function equating the next-period capital stock, Kst_{t+1}, to the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment, $Iq_{r,t}$. The equation of motion for capital stock $Kst_{r,t+1}$ in region r is given by:

$$Kst_{r,t+1} = (1 - \delta_t)Kst_{r,t} + Iq_{r,t}$$

where δ_t denotes the exogenously given constant depreciation rate. The allocation of capital among sectors follows from the intra-period optimization of the firms.

For a detailed description of the DART-Model see (Springer 2002; Klepper, Peterson, and Springer 2002) .

Calibration

The static part of the DART-Model is currently calibrated to the GTAP version 5 database that represents global production and trade data for countries and regions, commodities and primary factors for the year 1997. As the model is solved as a mixed complementary problem (MCP) using the Mathematical Programming Subsystem for General Equilibrium (MPSGE) described by Rutherford (1999), the GTAP data are transformed using the GTAPtoGAMS algorithm provided by Rutherford and Paltsev (2000). In addition the elasticities of substitution ϵ for the energy intermediate goods coal ($\epsilon = 0.6$), gas ($\epsilon = 1.5$) and crude oil ($\epsilon = 0.33$) are chosen to reproduce the emission IPCC projections for the year 2030[5].

Implementation of the Kyoto Protocol

To model the implementation of the Kyoto protocol, we assume that Annex B countries start abatement in 2005. In the following years emissions are reduced by the same absolute amount each year, until the target is reached in 2010.

[5]We choose the "middle" scenario B2 from (IPCC 2001) and calculate the average prognosis from all model used

To calculate the appropriate emission targets for our model, we run our model for the year 1997 with the base data. The resulting 1997 emissions are compared to the actual EIA data (IEA 2002). As DART overestimates emission for some countries and underestimates it for other, we use the differences to adjust the official 1990 emission data from IEA (2002). These adjusted 1990 data are finally multiplied with the reduction requirement implied by the Marrakech agreement. Table 3 in section 4.2 lists these new Marrakech targets as they are reported by Boehringer (2001). To calculate the rates for our regional aggregation these data are combined with the EIA emission estimates for 1990.