"Hot Air" and market power in carbon emission trading

F. Pratlong 1
ERASME and EUREQua, Université Paris I Panthéon-Sorbonne

D. Van Regemorter
CES, Katholieke Universiteit Leuven

P. Zagamé
ERASME and EUREQua, Université Paris I Panthéon-Sorbonne

Abstract: In respect to carbon emission targets set in the Kyoto protocol in 1997, emission quotas trading will be implemented among the Annex-1 participating countries to lower the mitigation costs of the international cooperation on climate change issue. Nonetheless, in the way the market was designed, the states of the Former Soviet Union and Eastern Europe are likely to become large sellers of carbon as a result of the drop in emissions level due to economic downturn, referring to "Hot Air". Indeed, these countries may exert substantially market power in the international permits market since the US had decided to withdraw from the Kyoto protocol. This paper aims to develop a better understanding of the consequences of "Hot Air" in the international carbon emission trading using some policy variants simulated with the GEM-E3 world model. The present analyze focuses particularly on "Hot Air" and the implications of potential market power in the emission trading market. Under various scenario options, the exercise of market power leads to a misallocation of abatement efforts across the remaining Annex-1 countries as a consequence of the welfare effects and the permits price increase.

Keywords: Emission Trading, International Climate Change, Market Power, Computable General Equilibrium Model.

JEL Classification: D43, D58, Q48.

1Correspondance: Laboratoire d’Economie, Ecole Centrale Paris, Grande Voie des Vignes, 92295 Châtenay-Malabry cedex, France, E-mail: fpratlong@ecp.fr
1 Introduction

In December 1997, the Kyoto protocol set limits to the greenhouse gases emissions and defined reduction objectives for the OECD industrialized countries, Central Europe and the states of the Former Soviet Union (FSU), as listed in the Annex-1 of the protocol. On average, in the period 2008-2012, the Annex-B parties are entitled a reduction of their emissions by 5.2% relative to their 1990 emissions. To lower the mitigation costs, international trading of Assigned Amounts Units (AAUs), provided by the article 17 of the protocol, will be implemented among participating countries committed to emission limits. Nonetheless the evolution in the design of the market, from the Kyoto protocol [1997] to the Johannesburg [2002] conference, raises the issues of imperfection in emission trading through strategic behaviours, if the Kyoto protocol is finally ratified. Indeed, some signatory countries may exert substantial market power in the carbon permits market, i.e. the FSU and Eastern Europe, accounting for approximately two-third of total emission objectives commitments in Kyoto, are likely to turn out large sellers of carbon units. In addition, since the USA, a potential large buyer, has decided to withdraw from the international cooperation on climate change before the Bonn Conference [2001], they get even more bargaining power and may turn out as dominant countries acting as oligopolists. Russia and Ukraine will therefore play a central role in the international emission trading, reinforced by their potential "Hot Air".

Indeed, the Kyoto protocol commits the states of the FSU to stabilize their carbon emissions up to the reference year of 1990 level for the period 2008-2012. Nonetheless, as a consequence of the economic downturn with the collapse of the Soviet Union, carbon emissions declined sharply in the early 1990s and were 32% lower than their 1990 level in 1995. The actual emissions still lie far below the 1990 level target established under the protocol. The excess between the anticipated emissions in 2008 and the low 1990 emissions limits are called "Hot Air", also being referred to as "base mitigation credits". This potential may greatly undermine the efficiency of the Kyoto protocol as trading "Hot Air" represents a large supply of emission, which weakens the incentive for abatement efforts but can be used for strategic considerations. It must be mentioned however that a major concern of the Kyoto protocol since the withdrawal of the USA, is its ratification by at least 55 Annex-1 countries representing at least 55% of the 1990 carbon dioxide emissions level.

This paper aims to develop a better understanding of the implications of the participation structure and potential market power in the international carbon emission trading using some policy variants simulated with the GEM-E3 world model. We try to assess the implications of imperfections in the international tradable emission permits system related to the potential "Hot Air" of the FSU, taking into account the US withdrawal from the Kyoto protocol. Indeed, the present analyze focuses particularly on the measures of market power in the context of the emission trading market relative to environmental effectiveness (i.e. how far does emission
trading achieve the required emission reduction) and economic efficiency (i.e. which allocation in achieving cost-efficient abatement efforts). The starting point of this paper investigates an overview of definitions and implementation of market power (oligopolistic stances of Cournot-Nash type) in the GEM-E3 world model, as proposed by Zagamé [2001]. In the following, we turn to various scenarios options to determine the implications of these alternatives on the permits price and the social welfare to meet the Kyoto objectives in the Annex-1 countries. So far, we identify the distribution of emission abatement efforts and the potential efficiency loss resulting from imperfection in trading.

2 Formalisation of market power in emission trading

2.1 Definitions and measures of market power

How important is market power in the context of international emission trading when permits market are dominated by a few? Formally, a major concern arises related to price manipulations in marketable permit systems. The simple cost-price manipulation is a market power strategy, so called "Cost minimizing (or profit maximizing) manipulation" studied by Hahn [1984]. It identifies the ability of a dominant participant to influence the price of traded emission quotas. In particular, it follows that when each emission source seeks to minimize its compliance costs to achieve emissions reduction acting as oligopolist, it induces an additional cost to meet emissions reduction targets. Indeed, under simple manipulation, dominant participants lower their volume of Assigned Amounts Units traded, inducing an increase in the price of permits actually traded. Therefore, compared with the competitive outcome market, this would result in an efficiency loss, which is particularly relevant if the allocation of quotas to these dominant sources deviates from its cost-effective level.

In the following, we will only consider this concern of simple cost-price manipulation exerted by dominant countries in an international carbon emission quotas market. To determine the size of possible market power in the Kyoto carbon emission market, Baron [1999] shows that much attention has to be paid to the share of Assigned Amounts Units allocated to a dominant country. As there exists no historical data for carbon emission reduction cost, it is difficult to induce a cost-effective allocation of the initial quotas to participating countries. Hence large holding of carbon units, as well as the number of Cournot countries, enhance the potential of substantial market power and can lead to efficiency loss in the allocation of abatement efforts between countries. In the face of these considerations about strategic behaviour, the way the international market is designed (specially the initial distribution of quotas to countries) is crucial for the expected efficiency of emission trading in presence of oligopolistic market power. So, let us have a look at the theoretical consideration of these issues.
2.2 The theoretical model

2.2.1 The basic competitive model

The basic framework, which is also implemented in GEM-E3, remains simple. We consider a perfect international competitive market for carbon emission, which represents under this assumption a cost-effective means for reducing pollution. The level of actual emissions of a country $i$ results from the difference between the given "Business As Usual emissions" $E_{i}^{BAU}$ and the emissions abatement $R_i$. Each country has a different abatement cost curve representing the cost change associated with a reduction of carbon emissions. Let $C_i(R_i)$ be the cost associated with abating $R_i$ tons, strictly increasing $C_i'(R_i) > 0$, strictly convex $C_i''(R_i) > 0$ and with $C(0) = 0$ and $C'(0) = 0$. This means that the marginal cost of abatement is increasing with emissions reduction. It’s equivalent to the assumption that all countries have a downward sloping demand function for emission permits. Each country $i$ receives an emission objective or an amount of permits $AAU_i$ ("the Assigned Amount Units) from the international agreement, defined in Kyoto with reference the 1990 emission levels. Given the initial distribution, country $i$’s net demand for permits is $(E_{i}^{BAU} - R_i) - AAU_i$. When the expression $(E_{i}^{BAU} - R_i) - AAU_i$ is negative, then, the country $i$ chooses to reduce its emissions more than its emission target and sells its additional permits on the international market.

In the case of perfect competition, a typical price taking country chooses its abatement level solving the following problem, which minimises its overall compliance costs equal to the sum of abatement costs and the costs of buying permits (in the case of permits purchase) or minus the profit of selling permits (in the case of permits sales).

$$
Min \sum_{i} C_i(R_i) + P \left[ (E_{i}^{BAU} - R_i) - AAU_i \right]
$$

where $P$ is the equilibrium price of permits under perfect competition. It implies from the first order condition that:

$$
P = C_i'(R_i)
$$

with the constraint that permits market clears:

$$
\sum_{i} (E_{i}^{BAU} - R_i) - AAU_i = 0
$$

This relation points out the usual optimality rules in environmental economics: with perfect competition, the permits price equals the marginal cost of abatement. The competitive permit price, determined by the aggregate emissions ceiling and by the abatement cost function, is independent of the initial permit distribution.

Each country will buy (or sell) the number of permits until the marginal cost (or benefit) of an additional permit, measured by the permits price $P$, equals its
marginal cost of abatement $C'_i(R_i)$. Under this condition, the permits price provides the correct incentive for countries to fix their emission levels. The number of permits demanded (or supplied) by country $i$ is determined by the optimal emissions abatement choice as a function of the permit price, $R^*_i = R_i(P)$. In short for a country $i$, its marginal abatement cost curve is a proxy for its demand (or supply) of permits.

2.2.2 The model with market power

The preceding discussion has explicitly consider the international permit market under competitive behaviour, where no market power exists for any participant or group of participants. In this section, market power in the permit market is assumed, where countries are able to influence the market price and the resulting emission reduction effort. This focus differs from Westskog [1996], as it considers market power with oligopolistic stances of Cournot-Nash type and provides some insights for market power and "Hot Air" in emissions trading.

Assume an international emission permit market in which $m$ countries are price takers ($i = 1, ..., f, ..., m$) while $k$ dominant countries exert oligopolistic market power ($j = 1, ..., c, ..., k$), in the sense that they can affect the market price of traded quotas. This arises when dominant countries recognize the sensitivity of the permit price to their permits sales/purchases. Such countries can use their influence on the market price, when seeking to minimize their compliance costs to achieve the predetermined emission ceiling. To analyze the imperfect competitive equilibrium in the permits market, we consider a leader-follower class game where dominant countries are leaders. They act as Cournot rivals, taking into account the reaction of their Cournot rivals and of the fringe countries.

Following the same reasoning as in the case of the competitive equilibrium, a representative country in the competitive fringe will choose its sales/purchases of quotas, regardless of its initial permit allocation, such as to minimize its compliance costs. As established above, the first order condition for a typical fringe country $f$ is:

$$P = C'_f(R_f)$$

This expression means that the countries of the fringe reduce their emissions up to the level at which their marginal abatement costs equal the permit price.

Each country with market power decides its abatement effort given the other market power countries’ emission reduction and the behaviour of the fringe countries. The oligopolistic country $c$ choose the amount of quotas which minimizes its costs, subject to the constraint that the permits price is a function of the abatement effort
and with the permit market clearing at world level:

\[
\begin{cases}
\min_{R_c} C_c(R_c) + P \left[ (E_c^{BAU} - R_c) - AAU_c \right] \\
Sc \quad P = P(R_1, \ldots, R_m, \ldots, R_c, \ldots, R_k)
\end{cases}
\]

with \( R_F + \sum_{j=1}^{k} R_j = E_F^{BAU} + \sum_{j=1}^{k} E_j^{BAU} - \sum_{i=1}^{m} AAU_i - \sum_{j=1}^{k} AAU_j \) \( (5) \)

The first order necessary condition for a Cournot-Nash equilibrium choice of quotas can be written as:

\[ P + \frac{dP}{dR_c} [AAU_c - (E_c^{BAU} - R_c)] = C'_c(R_c) \] \( (6) \)

as \[ \frac{dP}{dR_c} + \sum_{j=1}^{k} \left[ \frac{dP}{dR_c} \frac{dR_j}{dR_c} \right] = \frac{dP}{dR_c} \] \( (7) \)

where \( \frac{dR}{dR_c} = v_c \) is country c’s conjectural variation\(^2\). Upon substitution, and after rewriting the preceding condition (eq. 6) for country \( c \), we get:

\[ P = \frac{C'_c(R_c)}{1 + \frac{1}{\eta} \frac{AAU_c - (E_c^{BAU} - R_c)}{R_F}} \] \( (8) \)

where \( \eta \) is the demand elasticity for permits. Thus, the greater the price sensitivity of permits demand the greater the difference between the Cournot price relative to its competitive level. Moreover, as already shown by Hahn [1984]: if the dominant participants in permits market do not receive an amount of permits equal to its net emission in equilibrium (after trade), then the total expenditures on abatement will exceed the cost minimizing solution. Therefore, the extent to which a dominant country exerting market power has an impact, depends not only on its relative size, but also on its initial permit holding and the price sensitivity of permit demand.

### 2.2.3 Interpretation and comments

The condition (eq. 6) implies that, for a dominant country, its marginal cost of abatement differs from the competitive permits price and deviates across countries, which gives rise to a dead weight loss under the Cournot-Nash equilibrium relative to the perfect competitive equilibrium. The efficiency loss in the Cournot market is influenced by the discrepancy between the endowment of AAUs initially allocated to the countries with market power and the amount chosen to be used. The marginal abatement costs of price-setting countries only coincide with the equilibrium permits price, when the number of quotas \( AAU_c \) initially allocated to the Cournot countries is equal to the number of quotas \( (E_c^{BAU} - R_c) \) they will hold after trading. When

\(^2v_c = 1\) corresponds to country c’s Cournot-Nash conjecture. If \( v_c \) becomes larger, the dominant country behaves more collusively.
the level of net emissions is less than its permits allocation, \((E^{B\text{AU}}_c - R_c) < AAU_c\), a particular Cournot country has a negative net demand for permits, and hence, the permit price exceeds its marginal abatement cost \(C'_c(R_c)\), while for the fringe countries the marginal abatement cost will be higher than in the perfect competition case. In this context the initial allocation of permits for the states of the Former Soviet Union and for Eastern Europe, as a consequence of their potential dominant position in emission trading due to potential "Hot Air", appears to be one of the major loopholes of the Kyoto protocol.

3 Implementation of "Hot Air" and market power in the GEM-E3 model

3.1 Scenario options in the GEM-E3 World model

GEM-E3\(^3\) is a multi-country applied general equilibrium model, consisting of 18 inter-linked world country/region-modules, which has been used to evaluate the implications of the global climate change issues, as developed by Eyckmans et alii [2002]. Supporting policy analysis, this model can provide a consistent evaluation of the distributional effects of emissions trading across countries. We give here a brief overview of the key changes in GEM-E3 for this study.

The model already allows the modelling of perfect competitive domestic/international permit markets. The implementation of market power for dominant countries into GEM-E3 imposes two steps:

1. Ensuring that for each country exerting market power, the marginal abatement cost is equal to the permit price plus the correction for the price elasticity; this is equivalent to computing a mark-up in the model.

2. Computing the permit price elasticity: as it is analytically not possible in a CGE model to compute the price elasticity it has been done numerically through simulation of GEM-E3 around the emission target, evaluating the change in permits price due to a change in the overall emission reductions target; no iteration were done for the computation of the price elasticity (the change in price from a change in the reduction target is computed once) but a re-evaluation is done for each period.

The mark-up is computed through the formula given by eq 8 and the price transmitted to each branch in the country to determine their reduction efforts, is computed as the sum of the international price plus the mark-up, imposing thus that the marginal abatement cost of a dominant country is equal the price with mark-up.

With the US withdrawal from the Kyoto protocol and the latest decisions in Bonn and Marrakech, the potential for market power exerted by the Former Soviet Union and Eastern Europe remains very high and it can have a large impact on the cost

\(^3\)General Equilibrium Model for Energy-Economy-Environment Interactions
of reaching the Kyoto targets for the countries participating in the protocol. This is illustrated with the simulations with GEM-E3 World, in which the countries are aggregated in 18 regions. To provide insights for the international emission trading, we compare two scenarios under different emission strategies. The main focus lies on the potential market power exerting by dominant countries. We develop:

Scenario 1: "Hot Air" and the Kyoto commitment targets with a perfect competitive permit market.

Scenario 2: "Hot Air" and the Kyoto commitment targets with the FSU and Eastern Europe exerting market power.

3.2 Numerical results

In all scenarios the US are not participating in the international permits market and there is no limit imposed on the use of "Hot Air". The emission endowments per region are given by the reduction target for each region derived from the Kyoto protocol. The revenue from "Hot Air" are distributed for half to the household and for half to the public sector.

In the first scenario with perfect competition in emission trading, the equilibrium carbon price would be US$ 2.6 per ton CO2 equivalent in 2010. This is rather low price due to the lower demand for emission quotas as a result of the US withdrawal and a high supply induced by "Hot Air". As a comparison, Böhringer [2001] estimates the international permit price to only US $1.9 with the US defection from the Kyoto Protocol. With this low permit price, the Annex-B countries face a low cost to comply with the Kyoto objective. When the Former Soviet Union sells its emission quotas corresponding to the virtual emissions reduction from "Hot Air", it implies zero abatement efforts. Therefore, the environmental effectiveness of the Kyoto protocol is loosened because the remaining Annex-B countries have less incentive to abate their own domestic emissions.

In the second scenario we explore the implications of the price-setting behaviour by the FSU and Eastern Europe. A substantial concern is the oligopolistic power exerted, which leads to social welfare loss. When the dominant country uses its market power, the supply of permits to the market is reduced and this increases the international permit price from 2.6 to 2.9 US$ / t CO2 which is an increase of 12% compared the perfect competition case.

Since the FSU and Eastern Europe abate less than under perfect competition, their supply of permits decreases and it increases the permit price. The other Annex-B countries reduce their emissions by more than it would be cost-efficient because this increase in price. Thus this increase in domestic reduction efforts, except in the oligopolistic countries, implies an overall efficiency loss. The total welfare loss is therefore also slightly increased. For FSU and Eastern Europe there is a slight increase in terms of welfare, as they benefit from the higher international permit price. Thus the market power by the FSU and Eastern Europe prevents the other Annex-1 countries to face low abatement costs for meeting their Kyoto objectives.
4 Final comments

These first results with the extended GEM-E3 World model show that the impact of market power can be important and there is a possibility of strategic behaviour by the regions of the Former Soviet Union. This potential "Hot Air" may be used by the Former Soviet Union Countries in order to acquire a dominant position in the carbon emission trading. In this context, Russia and Ukraine have a strong incentive to withhold their emission quotas so as to increase emission permits and raise gains from the international trading. These results are still rather preliminary and need to be further examined taking account of possibilities for banking and cheating in the remaining Annex-B countries.

5 References


6 Acknoledgements

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7 Annex 1

Table 1: Impact of "Hot Air" and market power on regions’ reduction effort (% difference from baseline) in 2010.

Table 2: Impact of "Hot Air" and market power on regions’ social welfare (% difference from baseline) in 2010.
8 Annex 2: The GEM-E3 model

The standard GEM-E3 model is a full scale general equilibrium model, simultaneously representing the world regions and the EU countries, linked through bilateral trade. It provides details on the macro-economy of the world regions and its interactions with the environment and the energy system. This model considers explicitly market clearing mechanisms and computes the optimum balance for energy demand/supply and emission/abatement. The GTAP version 4 have been employed as the major data source for constructing the social accounting matrix. The GEM-E3 model allows to calculate the welfare effects of alternative environmental policies.

Figure 1 gives the basic scheme of the standard version of the GEM-E3 model: