# How important is market power in achieving Kyoto ?: An assessment based on the GREEN model.

by

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## Introduction

The protocol agreed in Kyoto in December 1997 imposed restrictions on GHG emissions by Annex I countries. The protocol also specified that these restrictions have to be respected "individually or jointly", with emissions reductions acquired through trading, joint implementation with Annex I countries and the Clean Development Mechanism counting towards these commitments.

According with the projections made by using the OECD GREEN model, Russia and Ukraine are likely to meet the Kyoto commitment without further efforts. In fact, reforms of energy markets, together with the slump in economic activity, have already brought emissions in these countries below the target levels specified in the Kyoto protocol. If their unconstrained emissions remain significantly below the target decided in Kyoto, the implication is that permit trade among Annex I countries would be likely to have an oligopolistic structure with Russia and Ukraine being main sellers of emission rights to other Annex I countries. Scenarios of the Kyoto agreement simulated by global models confirm the expectation that the countries of the Former Soviet Union (CIS) will act as dominant suppliers of emission rights if permit trading were to be implemented (van der Mensbrugghe, 1998; Gielen and Koopmans, 1998). However, these scenarios do not take into account the consequences of imperfect market conditions on overall efficiency and on the distribution of costs and benefits among Annex I countries.

This note provides a preliminary estimate of the possible effects of monopolistic behaviour by the Russian Federation and Ukraine (referred to as CIS in the remaining of this paper[2].) in permits trade under the provisions agreed in the Kyoto protocol It uses a reduced form model calibrated on the simulations and parameters of the GREEN model. The main outcome is that if, under stylised assumptions, the CIS takes advantage of its market power in permit trading, the expected efficiency gains from establishing a permits market among Annex I countries could be reduced by about a third. The results are preliminary, however, as they need validation from incorporating the reduced form model into the full GE specification of GREEN.

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1. The author is Administrator in the Economic Department of the OECD.

2. In the rest of this note, the region CIS is treated as a single entity which corresponds to the region FSU in the GREEN model (Former Soviet Union = CIS + Baltic Republics). In economic terms, this corresponds more or less to the assumption that the Russian Federation and Ukraine can agree on behaving like a single monopolist in the permit market.

**Survey of the literature**

There are two aspects of imperfect competition in permits trading. The first is the capacity of a firm/country to influence the transaction price of traded permits (referred to as a "cost minimising manipulation"). Hahn (1984) has developed a model which describes how a monopolistic/monopsonistic firm might behave in such a context. The second aspect occurs when a firm uses market power in the permits market to gain market power in the product market. Models which deal with this aspect make the assumption that the firm has market power on both markets and that it uses its market power on the permits market in order to exclude—or to raise a barrier to entry of—firms on the products market (referred to as "exclusionary manipulation") (see Misiolek and Elder, 1989). Only the first aspect is analysed in this note. Moreover, a purely static approach is taken, abstracting from different forms of strategic behaviour.

Authors have generalised these models to the case of oligopolistic competition (Fershtman and de Zeeuw, 1998). So far (and as far as I am aware), these models have never been applied to the issue of trading carbon emissions rights among countries nor have they been integrated and tested in the context of a general equilibrium model.

**Basic assumptions**

The model used here applies the specification formulated by Hahn (1984). Hahn's model is specified at the firm level. It assumes that one dominant firm has the ability to influence the price of permits. In the case of monopoly, the firm sets this price at the level which corresponds to the maximisation of the difference between revenues from permits sales and its abatement costs[3]. All other firms behave as price takers, i.e. they minimise their abatement/trading costs given the permit price set by the dominant firm. There is one single transaction price for permits (thus, permits are traded as if they were homogenous goods). The firm with market power is identified as the one which sells or purchases the largest share of permits in a corresponding competitive scenario (where all firms are price takers).

Hahn's main results are the following :

i) a monopolistic firm will set the permit price higher compared with the competitive scenario and abate less (sell fewer permits) than under competitive conditions. A monopsonistic firm will set the permit price lower compared with the competitive scenario and abate too much (buy too few permits) relative to competitive conditions.

ii) in both situations, the total abatement cost is larger than under the competitive scenario.

iii) the price set by the dominant firm—and the resulting loss of efficiency (relative to the competitive case)—depends on the amount of permits initially allocated to this firm. Thus, imperfect competition establishes a link between distributional aspects and overall efficiency. In other words, one initial allocation of emission rights may prove more or less costly than another. This contrasts with the competitive case where the total abatement cost is the same whatever the initial allocation of emission rights[4].

3. Thus a monopolistic firm maximises the difference between the proceeds of permits sales and its abatement cost. A monopsonistic firm manipulates the permit price in order to minimise the sum of expenditures from permits purchases and its abatement cost.

4. Another case where the efficiency of a market is dependent on the assignment of property rights is when the traded property right relates to a good which is public in nature, i.e. consumed by all agents in the same

In the following, Hahn's model is applied to the behaviour of the CIS in the context of emissions trading under the provisions made in the Kyoto protocol. It implies three important -- and possibly questionable -- assumptions: first, that permits trading in the CIS is centralised rather than being pursued by individual countries and firms; second, that trade in other Annex 1 countries is performed by individual firms which have no market power; and, third, that the CIS does not take into account the effects of its monopolistic behaviour in the permits market on energy prices and thereby its terms of trade[5]. In addition, it is assumed that firms have no market power on the goods market. It is impossible to know at this stage whether permits trading under the Kyoto protocol will correspond to this particular structure. However, the following results provide an order of magnitude of the inefficiency which could be generated by price manipulation if the CIS were to exert monopolistic power in permits trading.

## Main results

### *Marginal costs and trade shares with perfect competition.*

The Figure 1 shows the marginal cost profiles if parties of Kyoto were to meet their target individually, for instance, by imposing domestic carbon taxes. The reference scenario which is used here assumes that all energy subsidies are removed by 2010 in all Annex 1 countries, with the noticeable exception of the Former Soviet Union where subsidies are cut by half in 2010 and remains unchanged hereafter[6]. Reforms of energy market that have occured in the CIS since 1990 kept emissions from rising and explain that the CIS is able to meet its commitment by 2010 by imposing no carbon tax[7]. From 2010 to 2045, the marginal cost of keeping emissions constant in level in the CIS, although rising, remains well below the marginal cost in other Annex 1 countries.

Differences in marginal costs across Annex 1 parties explain the pattern of emission trading that would occur assuming perfect competion (reported on Figures 2a-b). Up to 2030, the CIS is projected to act as a single seller of emission rights[8]. By the first commitment period in 2010, the CIS would sell 400 million tons of carbon to other Annex 1 countries at a transaction price equal to 48 1985 $ per ton of carbon. Starting from 2030, the United States would emerge as an important permit seller and the market share of the CIS would decline gradually.

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amount (such like defence, security, ..). Carbon is a "public bad" as we all "consume" the same amount of carbon (depending on its concentration in the atmosphere), irrespective of who has emitted this carbon into the atmosphere (see Chichilnisky and Heal, 1995; Oliveira and Sturm, 1998).

5. In the simulations, overall emission cuts are given. However, the price of permits will affect the fuel mix in individual countries and thereby the relative prices of different types of energy. This again may affect the terms of trade of the CIS which exports mainly oil and gas. This feedback effect can be assessed by introducing the model of imperfect competition in GREEN.

6 The version of the GREEN model used here is calibrated on 1985 data. The reduction of energy subsidy rates in the CIS which is simulated in the reference scenario approximate the substantial reforms that have affected the energy markets since the collapse of the communist system.

7 Since the Kyoto protocol makes provision for a gradual phasing-out of energy subsidies, it is assumed that its implementation yields a further reduction by half of energy subsidies in the CIS by 2010. Thus, compared with the reference scenario, subsidy rates in the CIS are cut by 75 per cent by 2010 and remain constant hereafter.

8 Permit trading is calculated by assuming that Annex 1 Parties are assigned an amount of permits which corresponds to their reduction commitment decided in Kyoto.

### *Transaction price with imperfect competition.*

The Figure 3 describes a scenario in which the CIS exerts it market power. It shows the evolution of the transaction price - i.e. the permit price set by the CIS - (the bold line) compared with the permit price in the competitive scenario. In 2010, the permit price set by the CIS is 38 per cent higher than the corresponding competitive price (67 1985 $ per ton of carbon compared with 48 1985 $).

At this higher price, the CIS would sell less permits and therefore abate less than in the competitive scenario. Thus, its marginal abatement cost - represented by the dotted line in Figure 3 - lies below both the marginal cost with perfect competition and the price at which permits are sold with imperfect competion. The wedge between the transaction price set by the CIS (in bold) and its marginal abatement cost (the dotted line) is the mark-up on permit sales; it reflects the market power of the CIS in permit trading. It also corresponds to the difference between marginal abatement costs in the CIS and in other Annex 1 countries (as other Annex1 countries act as price takers and equalise their marginal costs with the permit price set by the CIS).

The mark-up reaches a maximum in 2005 with a rate of 170 per cent (i.e. the permit price set by the CIS is almost three times its marginal abatement cost) and declines steadily hereafter. It turns to be negligible in 2050. Two factors explain the decline of CIS market power over the longer run: i) the emergence of the United States as an important seller of permits; and, ii) the growing availability of new carbon-free energy sources (back-stop) which makes the substitution away from traditional energy sources easier and thus increases the demand elasticity of permits.

### *Abatement costs.*

The segmentation of the permit market assuming imperfect competition implies that the total emission reduction is achieved at a higher cost than in the perfectly competitive case. This results from the fact that the CIS (the low cost country) abates too little while the other Annex1 countries (the high cost countries) abate too much compared with the competitive scenario.

The total abatement cost in OECD countries (including Eastern European Countries, see Figure 4), although much lower than in the no-trade situation, remain higher than in the competitive trade scenario. Price manipulation by the CIS may reduce significantly the gains expected from permit trading. For instance, in 2010, competitive permit trading would allow to cut OECD cost by half (from 361 to 183 billions 1985 $). But, due to monopolistic price setting, this cost gain is reduced by a third. Form 2030 to 2040, the gains from trading are fading away[9] and market power by the CIS could reduce them further by 40 to 50 per cent (see the right hand scale in Figure 3).

Interestingly, setting permit price makes the CIS able to minimize its total abatement cost over time, as shown by the Figure 5. Under perfect competition, emission trading mainly benefits OECD countries but it increases the burden to be supported by the CIS during the period from 2000 to 2020, a fact which casts some doubt about the political feasibility to implement a trading sheme in practice.

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9 In 2050, although the amount of permit trading is still important (more than 300 million tons of carbon per year), there is virtually no gain from trade. See the note 1 for an explanation.

On contrary, market power reduces the CIS abatement cost to close its level in the no-trade scenario. Monopolistic strategy turns also to be less costly for the CIS by 2030 and after (as for the competitive trade).

***Alternative permit allocation.***

Figures 6a-b illustrate the relation between permit distribution and global cost. It is assumed that CIS emissions are allowed to grow by 1 per cent annually (instead of remaining constant at their 1990 level, as required by the Kyoto protocol). However, total emissions of Annex 1 countries are bound to the same levels than agreed in Kyoto. Thus, emissions targets for Annex 1 countries others than the CIS are reduced proportionately. These modified commitments serve as a basis to allocate permits when a trading system is simulated.

Under this hypothetical allocation of permits, the CIS has potentially much more market power. Assuming that it exerts its market power leads to a higher transaction price for permits. This can be seen from Figure 6a: in 2010, permits would be sold at 81 1985 $ per ton of carbon (67 per cent higher than the competitive price) under this alternative allocation instead of 67 1985 $ per ton of carbon (37 per cent higher than the competitive price) with the allocation decided at Kyoto. Moreover, the price gap (relative to the competitive price) persists over the longer term with this alternative allocation of permits.

Not surprisingly, this alternative distribution of permits proves to be much more costly than the one decided in Kyoto. The Figure 6b reports the total abatement costs for Annex 1 countries if they had to meet the two alternative sets of commitments individually (with no trade) and compares them with the costs under competitive trade (which is independent from the permit allocation and well below the costs with no trade, except in 2050 (see the note 1)). Thus the gain from permit trading is much larger with the second commitments set than with the one decided in Kyoto. However, under this alternative allocation rule, monopolistic trade yields total cost in excess of the one obtained with the allocation rule derived from the Kyoto protocol (see the bold lines on Figure 6b). This illustrates that, with a non-competitive permits trading, there is a link between the initial permits allocation and the total abatement costs, contrary to what happens with perfectly competitive markets.

The above results imply that a larger proportion of the expected gains from trading are lost with this alternative permits allocation than with the one consistent with the Kyoto commitments, reflecting the higher market power of the CIS. For OECD countries, half of the gains from trading are lost in 2030, compared with 38 per cent with the allocation decided in Kyoto. On the other hand, this alternative allocation benefits the CIS much more: its aggregate cost over the entire simulation period remain close to zero.

## Conclusion

These calculations are based on the assumption that the constraints agreed in Kyoto give the CIS a potential monopoly on permits trading. If the CIS were to exploit its market power, about a third or more of the expected gains from trading permits might vanish. Reducing the potential influence of monopoly power could either be achieved through a more stringent initial allocation of emission rights (though that is too late by now) or by imposing an upper bound on the deviation between the transaction price set by the CIS and its marginal abatement cost (though it is difficult to see why the CIS should agree to that now that it has been given generous emission rights). The existence of market power may also be used as an argument for encouraging legal entities as opposed to nations to trade.

## Further work

The above estimates have been obtained by using a reduced-form model estimated and calibrated on the full version of GREEN. It is a partial equilibrium approach in the sense that it does not take into account all the spill-over effects of monopolistic pricing of emission permits on other markets. For instance, that the CIS sells less permits will affect world energy prices which, in turn, would modify revenues obtained by the CIS from exporting natural gas. To take full account of these second-order effects require to implement this model in the full GREEN specification. Another extension would be to assess the impact of a more realistic assumption about the market structure of permits: i.e. a non-cooperative behaviour of the Russian Federation and Ukraine leading to oligopolistic competition instead of a monopolistic one.

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## ANNEX

The Hahn's specification (Hahn,1984) considers m firms with firm 1 being assumed to have market power. All other firms (i=2,m) are price takers. L is the total amount of distributed permits which corresponds to the total amount of pollutant that firms are allowed to emit. Trade takes place at a single transaction price P which is set by the market power firm 1.

***Problem of the price-taking firm.***

All price-taking firms are assumed to have a downward sloping inverse demand function for permits (i.e. their demand for permits declines as the permit price increases). This assumption is equivalent to the assumption that their marginal abatement cost is increasing when emissions are reduced.

Let $C_i(E_i)$ be the cost of firm $i$ associated with emitting $E_i$. The marginal abatement cost (i.e. the cost change associated with a marginal reduction of $E_i$ : $\frac{dC_i}{-dE_i} = -C_i'$) is, by definition, positive and increases with abatement (increases when emissions decrease). This implies that $C'_i$ is negative and $C''_i$ is positive.

The problem of the price-taking firm is to minimize the sum of abatement costs and permit costs (sales or purchases). They choose their emission levels, given the permit price $P$ set by the market power firm 1, by solving the following optimisation problem :

[1] $$\min_{E_2 \ldots E_m} C_i(E_i) + P(E_i - E_i^0)$$
$$\text{for } i = 2,\ldots,m$$

The first-order conditions $(C_i' + P = 0)$ imply that price takers will adjust their emissions until their marginal abatement cost equals the price set by the firm 1.

***Problem of the price-setting firm.***

The problem of the firm 1 with market power is to set the transaction price such as to minimize the sum of abatement costs and revenues (expenses) of permits sales (purchases), subject to the constraint that the permits market clear.

[2]

$$\min_P C_1(E_1)+P(E_1-E_1^0)$$
$$\text{st.}\quad E_1=L-\sum_{i=2}^{m}E_i(P)$$

The first-order condition yields the following solution for the transaction price $P$, given that the emissions of firm 1 are calculated as a residue between the total constraint $L$ and the total emissions from the price-taking firms :

[3]

$$P=\frac{\left(L-\sum_{i=2}^{m}E_i(P)-E_1^0\right)}{\sum_{i=2}^{m}E_i^{'}(P)}-C_1^{'}(E_1)$$

with $E'_i$ being the first derivatives of the inverse demand functions for permits of the price-taking firms ($\frac{dE_i(P)}{dP}<0$). These demand functions are derived from the cost curves $C'_i(E_i)$, given the first-order conditions of the price-taking firms which state that their marginal cost $C'_i(E_i)$ equals the transaction price $P$ at the equilibrium.

Equations [3] tells that the price set by firm 1 ($P$) will deviate from its marginal cost $C'_i(E_i)$ by an amount which corresponds to the first right-hand ratio. Only when the initial permit endowment of firm 1 $E_1^0$ coincides with the cost-minimizing level of its emissions $L-\sum_{i=2}^{m}E_i(P)$ is the price set by firm 1 equals to its marginal cost. In all other cases,the higher the difference between firm 1 permits use and its initial endowment, the higher the deviation between the transaction price $P$ and firm 1 marginal cost. The denominator of the first right-hand term of [3] also indicates that lower values of demand elasticities for permits of price-taking firms will increase the transaction price of permits, all other things being equal.

***Parametrisation***

In practice, several scenarios imposing different levels of abatements in each Annex 1 country/region have been simulated by using the OECD model GREEN. These scenarios yielded series of carbon taxes corresponding to different level of emissions which, in turn, served as a basis to estimate econometrically marginal cost curves for each country/region and period. Once the parameters of the cost curves in each country/region are known, it is possible to calculate the value of the transaction price $P$ set by the CIS (by inverting the cost curve functions for each price-taking country and summing their first derivatives in equation [3]) and the emission levels in price-taking countries (corresponding to the first order conditon $C'_i = P$).

The scenarios have been simulated in a context which reproduces the Kyoto Protocol and implies some reduction of existing energy subsidies. In the baseline scenario (BaU), energy subsidies in Eastern European Countries and the Former Soviet Union are cut by half by 2010 and kept constant hereafter. The achievement of the Kyoto Protocol has been simulated by imposing the specific commitments decided in Kyoto for each Party together with a further reduction of energy subsidies in Eastern Europe and the CIS[10] As a result of these assumptions, the commitment decided for the CIS is not binding before 2030. Thus the aggregate emissions for the Annex 1 area are higher when emission trading is allowed than when Parties have to meet their commitments individually.

The marginal cost curves are shown on figures A1-A6. They report the carbon taxes needed to achieve the reductions at each period and for each country/region. Typically, these cost curves are downward sloping and concave in origin. Over time, they tend to shift upward and their slope tend to flatten, implying that given emission reductions required smaller tax increases. As alternative carbon-free energy sources (backstops) are phased-in, the elasticity of permit demand relative to price is increasing. These changes imply that, in OECD countries, i) keeping emissions constant at relatively high levels needs taxes which increase over time (because backstops are not competitive at this price level and further reductions are more and more costly) and ii) keeping emissions constant at relatively low levels needs taxes which decline over time, as backstops energy sources become available in larger quantities.

10 The remaining energy subsidies are completely phased-out by 2010 in Eastern European Countries and are further cut by half relative to the baseline by 2010 in the CIS. These reductions aim to take account of the provision made in the Protocol that Parties should implement, in achieving their emission limitation, any "progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemption and subsidies in all greenhouse gas emitting sectors" (Article 2).

Note 1

Under certain circumstances, scenarios implying permit trading, as they are simulated with GREEN, prove to be more costly overall than the corresponding equilibrium with no trade. This is the case in the scenario with emission trading under the Kyoto Protocol in 2050 where, despite that 350 million tons of carbon are traded, the total abatement cost of Annex 1 countries with permit trading is slightly higher than with no trading (825 billion 1985 $ instead of 821 billion 1985 $). A similar situation arises in 2050 with the alternative allocation of permits : although trade between the CIS and the other Annex 1 countries would amount to 1126 million tons of carbon, the equilibrium with trade is globally more costly than the equilibrium with no trade (825 billion 1985 $ against 765 billion 1985 $). These results seem to contradict the widespread view that emission trading reduce the total abatement costs.

This note analyses the conditions under which trade reduces total abatement costs. It shows that gains from trade are subject to the condition that the marginal cost curve for the world be concave to the origin (thus its second derivative must be positive). If this condition is not satisfied, a situation involving large amount of trading may prove as or even more costly than the corresponding situation with no trading. In practice, in GREEN, convexities of the world marginal cost curve may occur when backstop technologies become profitable in some countries while other countries still use conventional energy sources.

Let us consider *n* countries. Their emissions are constrained not to exceed $E_i^{NT}$ for $i$ = 1...*n* respectively and this is achieved by raising the carbon price to $P_i^{NT}$ in each country *i*. Altnernatively, if countries are allowed to trade emission rights, they set their emissions $E_i^T$ at the level at which their marginal abatement cost is equal to the common equilibrium carbon price $P$. Trade yields gain if the total abatement cost with emission trading is lower than the total cost with no trade :

[1] $$P^T \sum_i E_i^T - \sum_i P_i^{NT} \cdot E_i^{NT} < 0 \qquad \text{for } i = 1,...n$$

Expression [1] can be rewritten in terms of changes of carbon prices between trade and non-trade cases ($\Delta P_i = P_i^T - P_i^{NT}$) and changes in emission levels between trade and non-trade cases ($\Delta E_i = E_i^T - E_i^{NT}$) :

[2] $$\sum_i \Delta P_i \cdot E_i^T + \sum_i P_i^{NT} \cdot \Delta E_i < 0 \qquad \text{for } i = 1,...,n$$

Expression [2] can be developed for a two-country case with a country where the marginal abatement cost is high (high-cost country HC) and a country where the marginal abatement cost is low (low-cost country LC). The following table summarises how the cost change due to trade can be decomposed.

| Terms | Impact from trade | Sign |
|---|---|---|
| [2.1] $\Delta P_{HC} \cdot E_{HC}^{T}$ | marginal cost reduction in the high-cost country. | negative |
| [2.2] $P_{HC}^{NT} \cdot \Delta E_{HC}$ | increase of emissions in the high-cost country (which corresponds to the purchase of rights by the high-cost country). | positive |
| [2.3] $\Delta P_{LC} \cdot E_{LC}^{T}$ | marginal cost increase in the low-cost country. | positive |
| [2.4] $P_{LC}^{NT} \cdot \Delta E_{LC}$ | decrease of emissions in the low cost country (which corresponds to the sale of rights of the low-cost country). | negative |

The expected outcome that trade reduce the overall abatement cost is verified when terms [2.1] and [2.4] are large (and negative). This happens when the slope of the marginal cost curve in the high-country is larger than in the low-cost country. As illustrated by the Diagram 1.1, this corresponds to a situation where the world cost curve is concave to the origin. On contrary, trade may, in principle, yields a larger overall cost if the slope of the marginal cost curve in the high-cost country is smaller than in the low-cost country, as in the Diagram 1.2 (in this case, terms [2.2] and [2.3] are large and positive). In this case, the cost increase in the low-cost country exceeds the cost reduction in the high-cost country and the right-hand term of expression [2] becomes positive. In GREEN, this occurs when backstop technologies are used in OECD countries while they are still not yet competitive in the CIS (due to the existence of energy subsidies and a different fuel mix). The marginal cost curves reported in Figures A1-A6 show that this situation may imply that the cost curve in the OECD area becomes less steeper than in the CIS.

**Diagram 1.1 : world marginal cost curve is concave to origin**

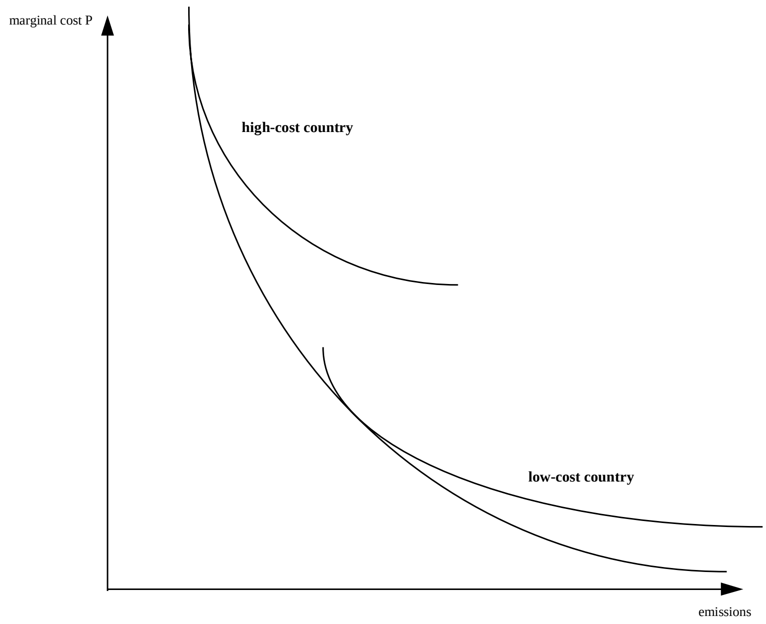



**Diagram 1.2 : world marginal cost curve is convex to origin**

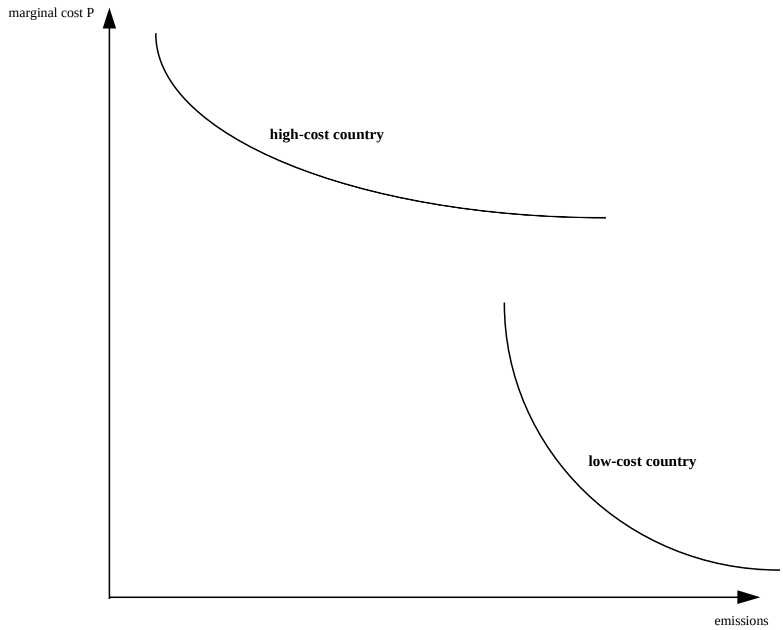
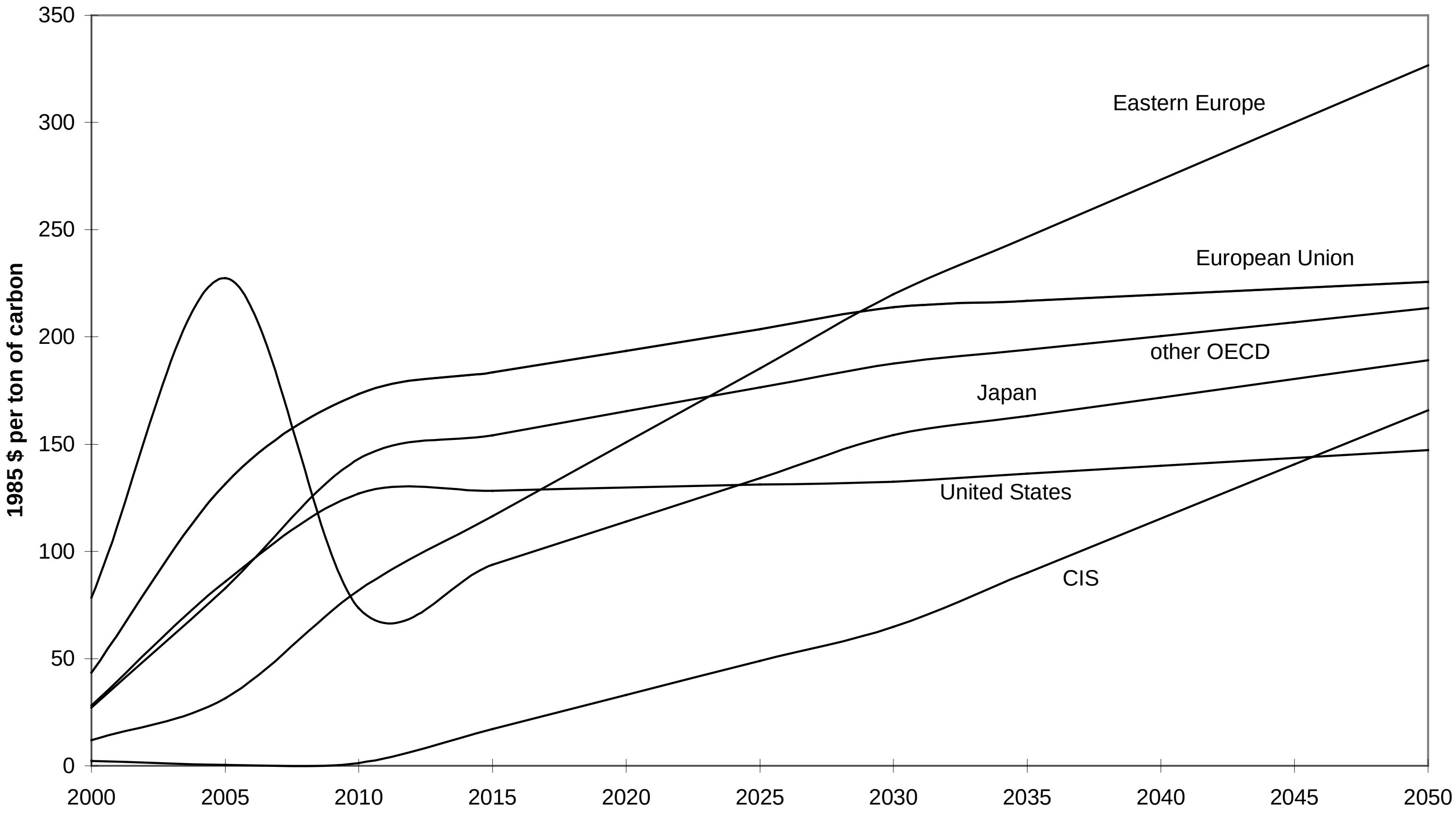


**Figure 1 : Marginal costs of meeting the Kyoto targets by individual country/region**




Source : OECD GREEN model

**Figure 2a : permit purchases by country/region under the Kyoto protocol**

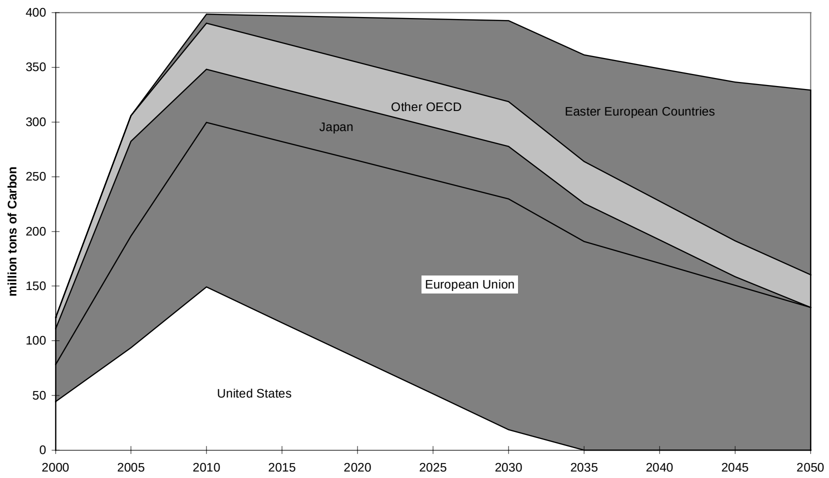



**Figure 2b : permit sales by country/region under the Kyoto protocol**

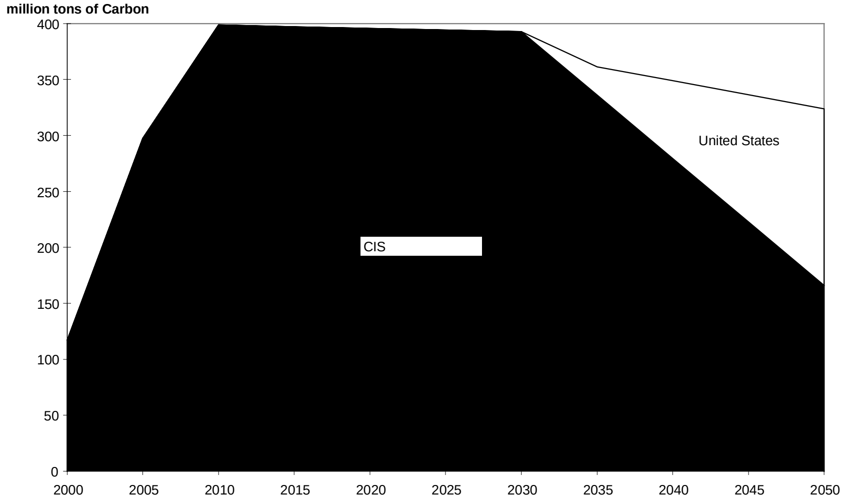


**Figure 3 : Permit price in the Kyoto Protocol under alternative market structure**

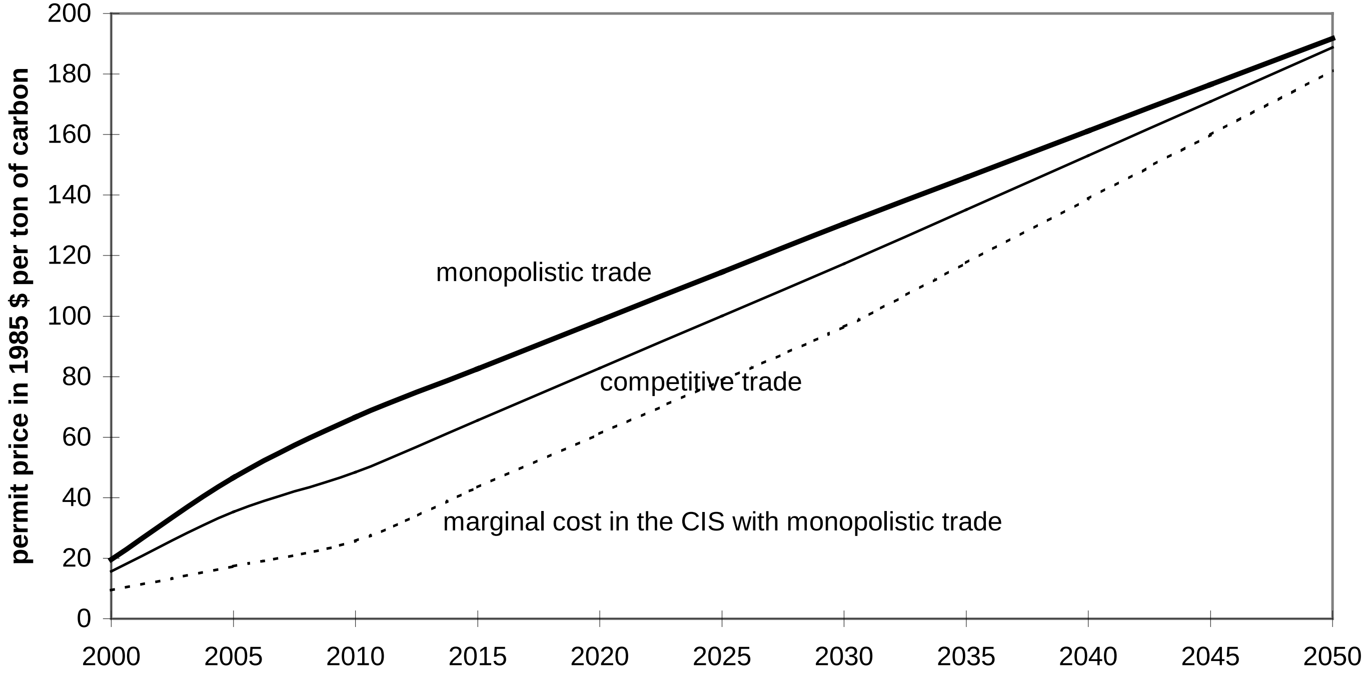
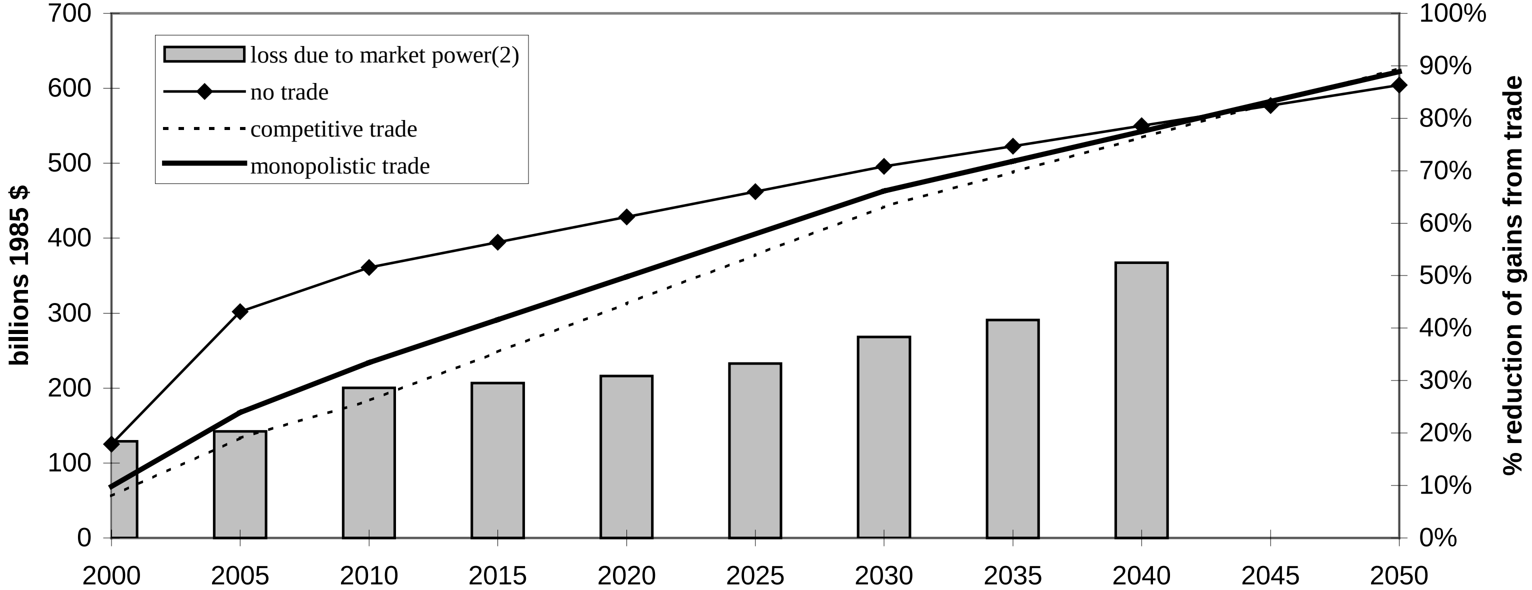


**Figure 4: Abatement costs of OECD countries[1] under alternative market structure**




(1) including Eastern European Countries
(2) expressed as the percentage reduction of the gains from trade under monopolistic competition (relative to the no-trade scenario) compared with the reduction achieved with perfectly competitive trade.

**Figure 5 : Abatement costs of the CIS under alternative market structure**

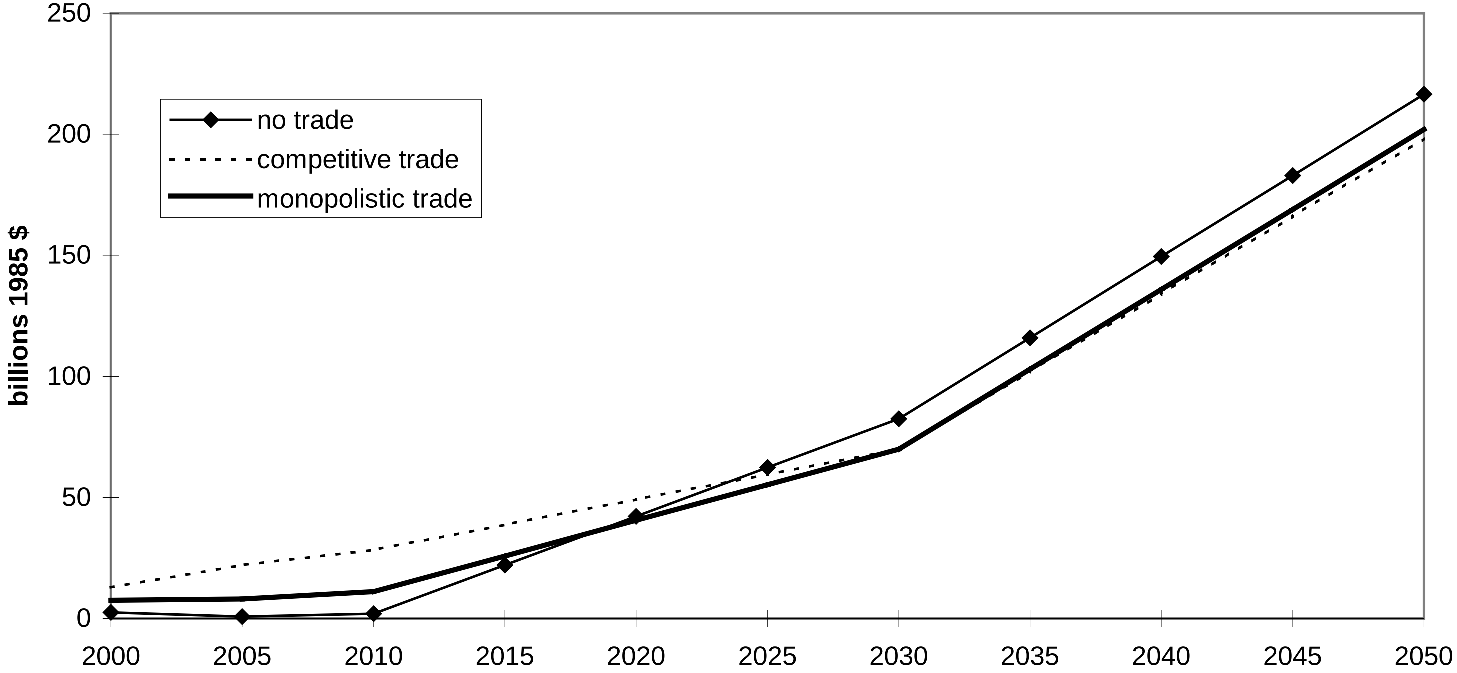
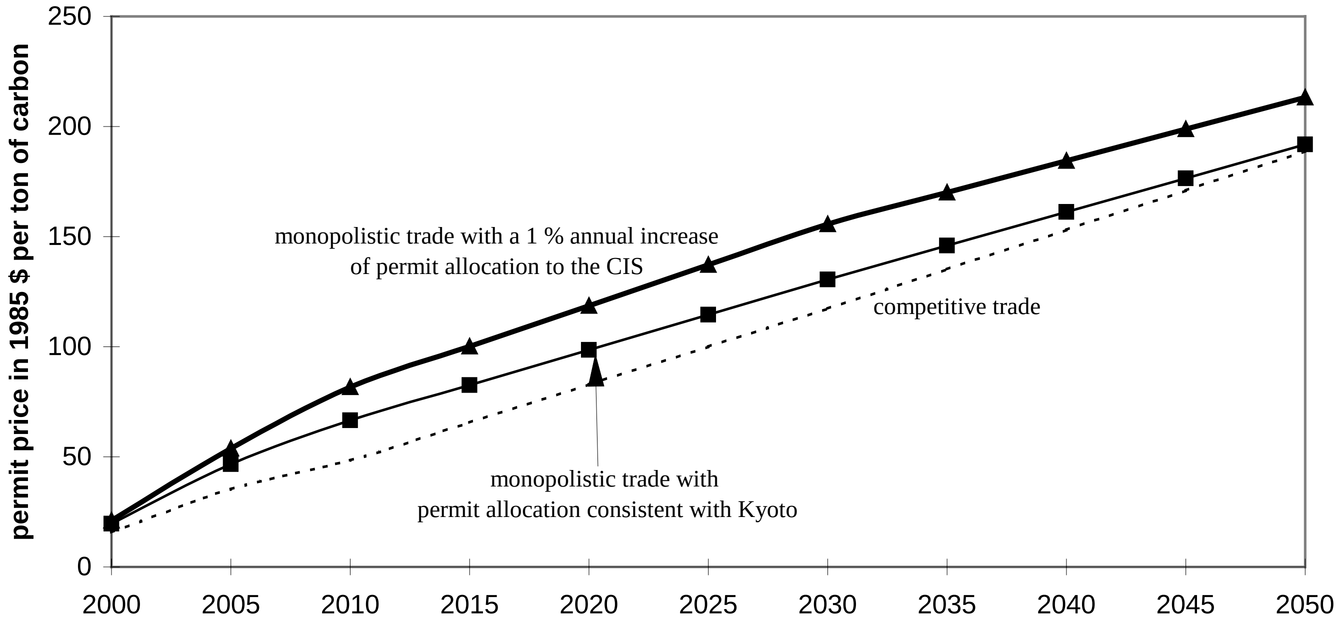
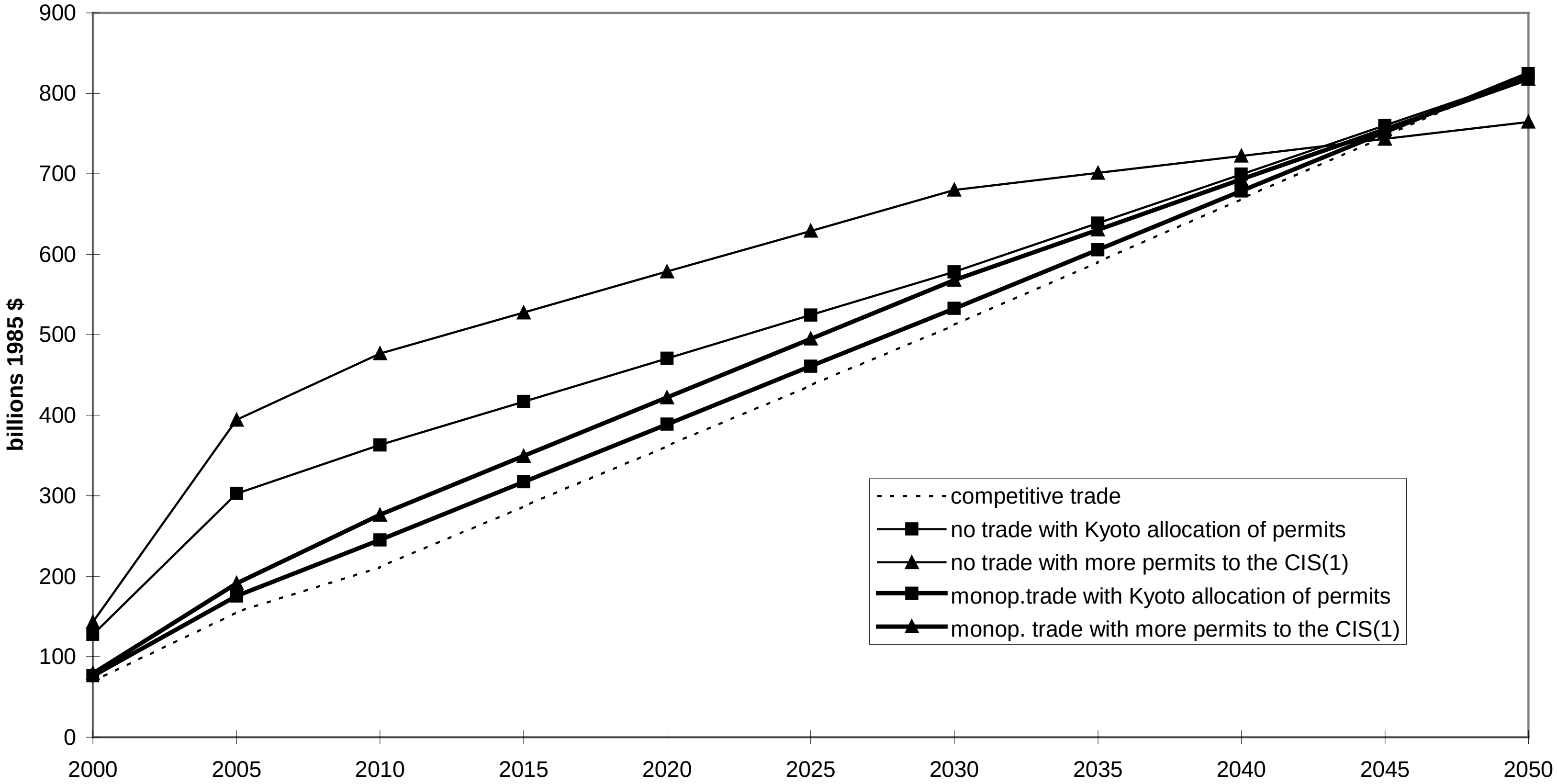


**Figure 6a : Impact on permit price of a larger permit endowment to the CIS[(1)]**




(1) the amount of permits allocated to the CIS grows by 1 per cent annually
in excess to the commitments decided in Kyoto.

**Figure 6b: Abatement costs of Annex 1 countries under alternative permits allocation.**




(1) the amount of permits allocated to the CIS grows by 1 per cent annually in excess to the commitments decided in Kyoto.

**Figure A1 : Cost curves for the EC.**

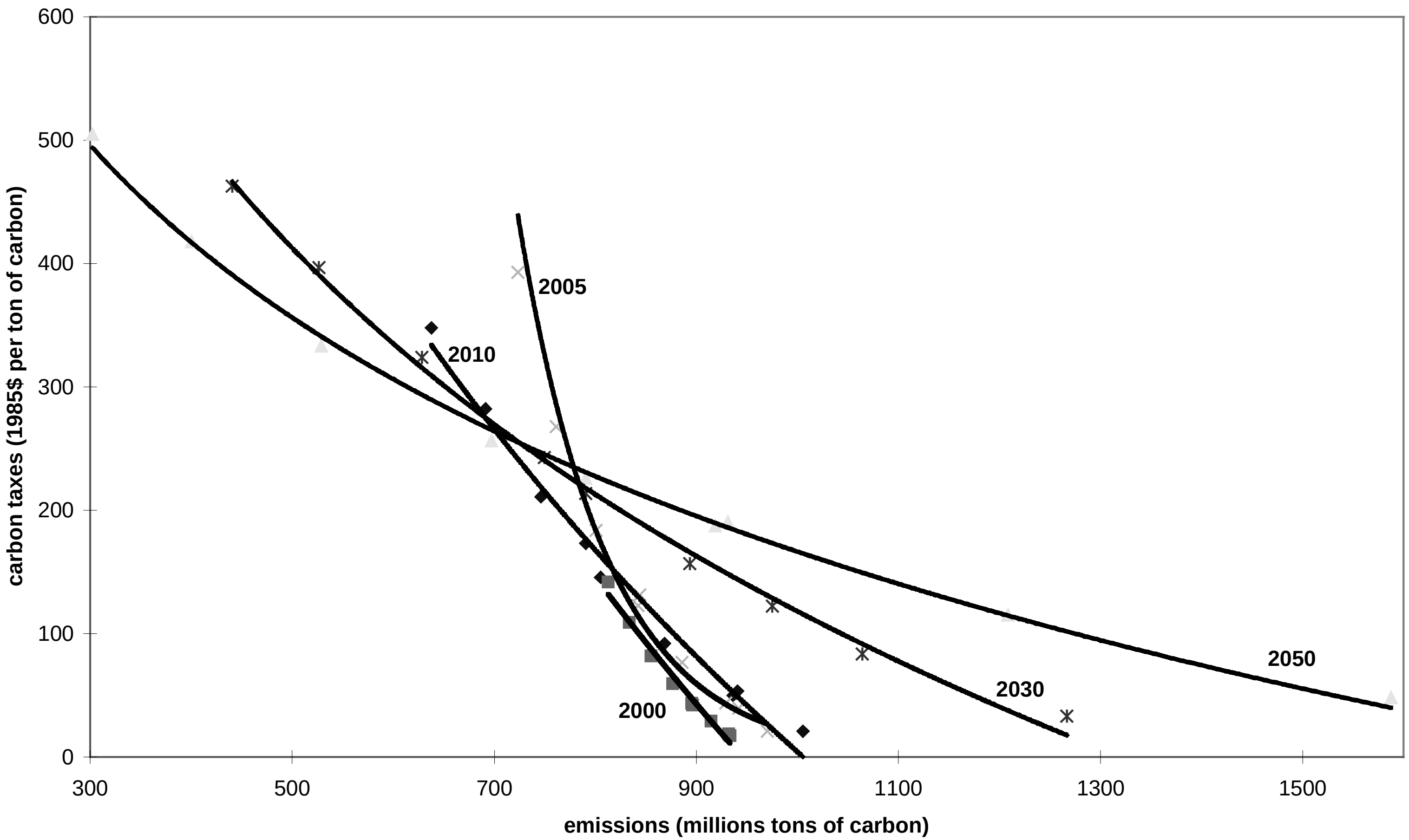


**Figure A2 : Cost curves for the USA.**

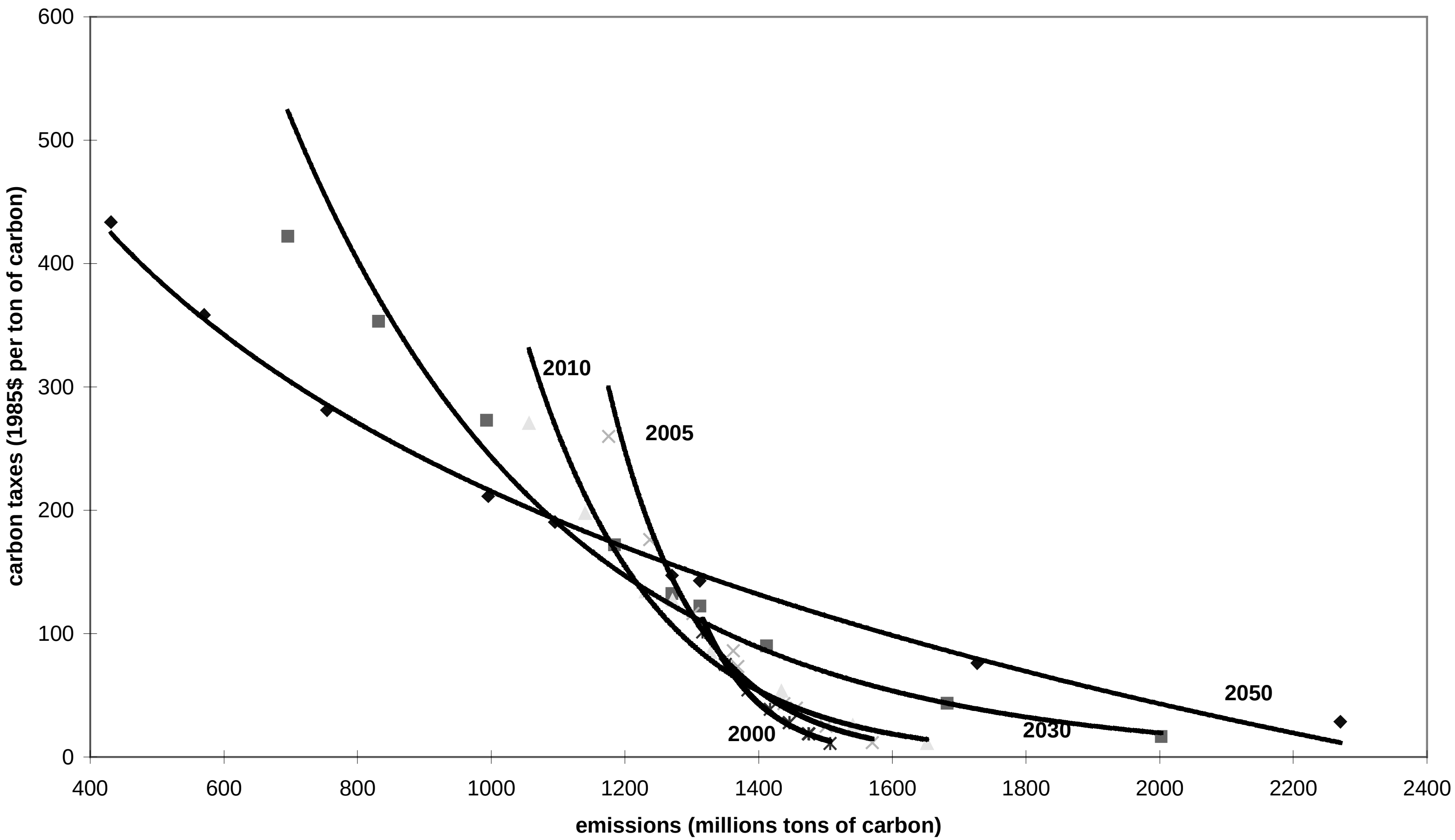


**Figure A3 : Cost curves for Japan.**

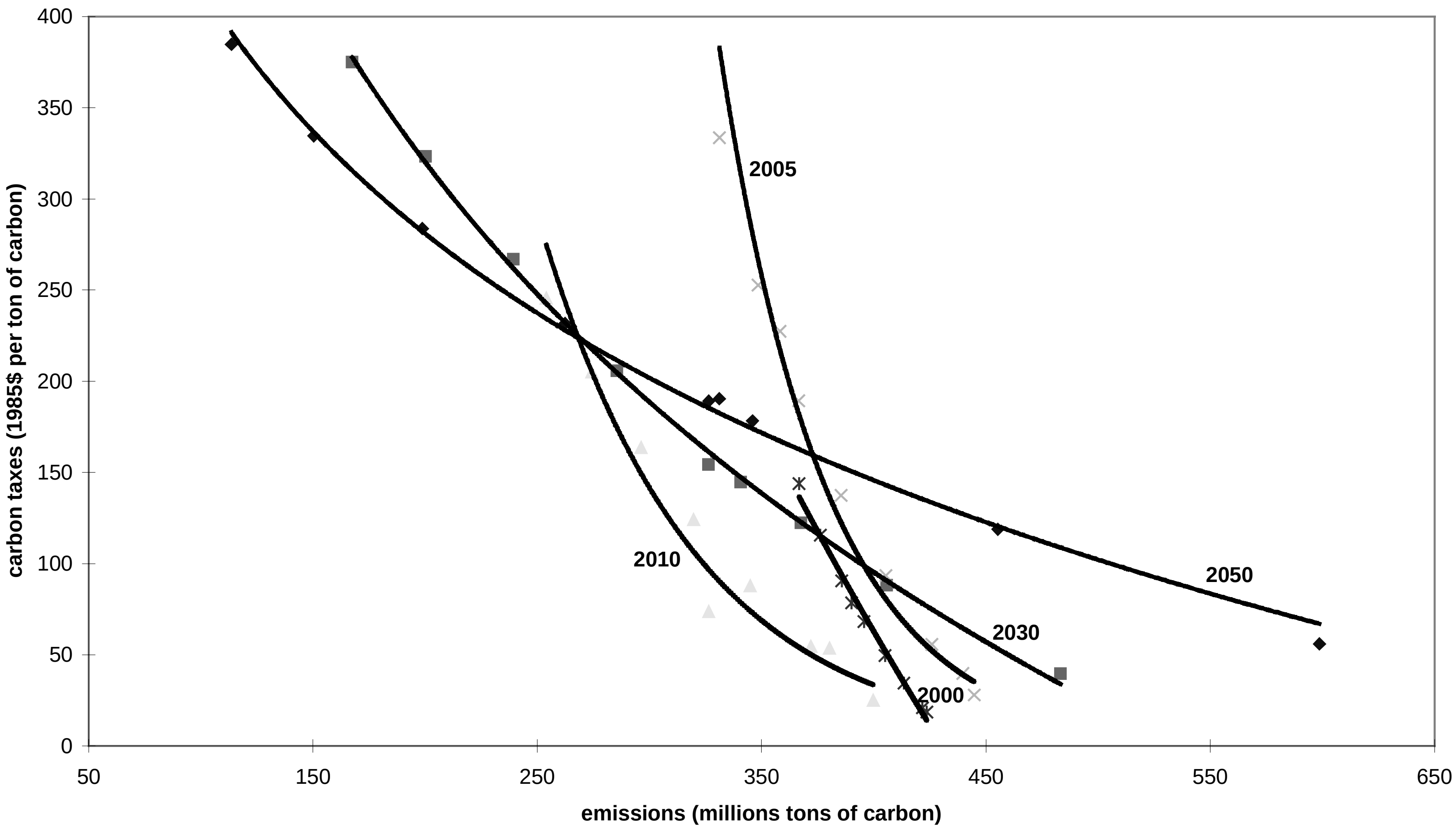


**Figure A4 : Cost curves for Other OECD Countries**

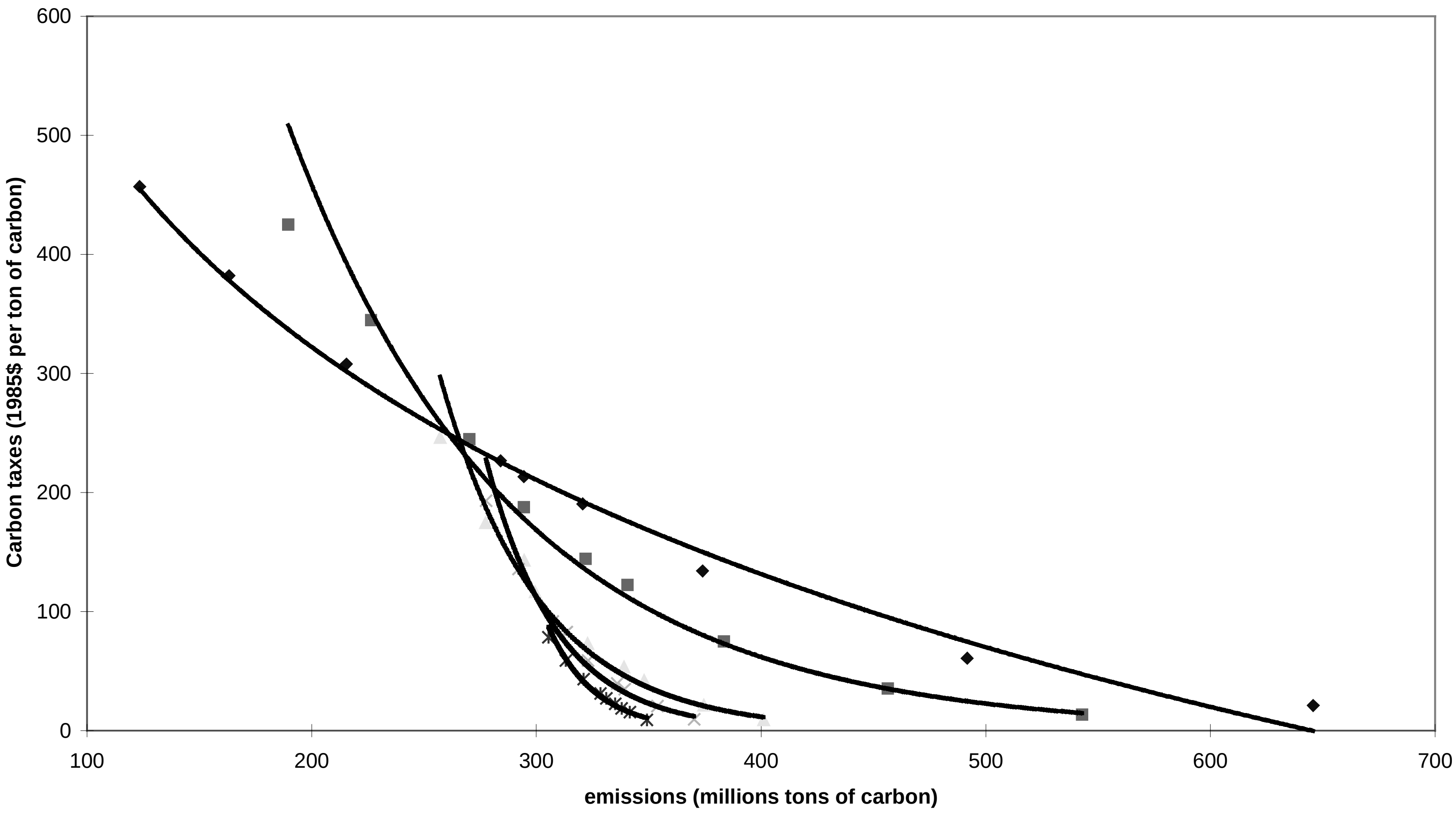


**Figure A5 : Cost curves for Eastern European Countries**

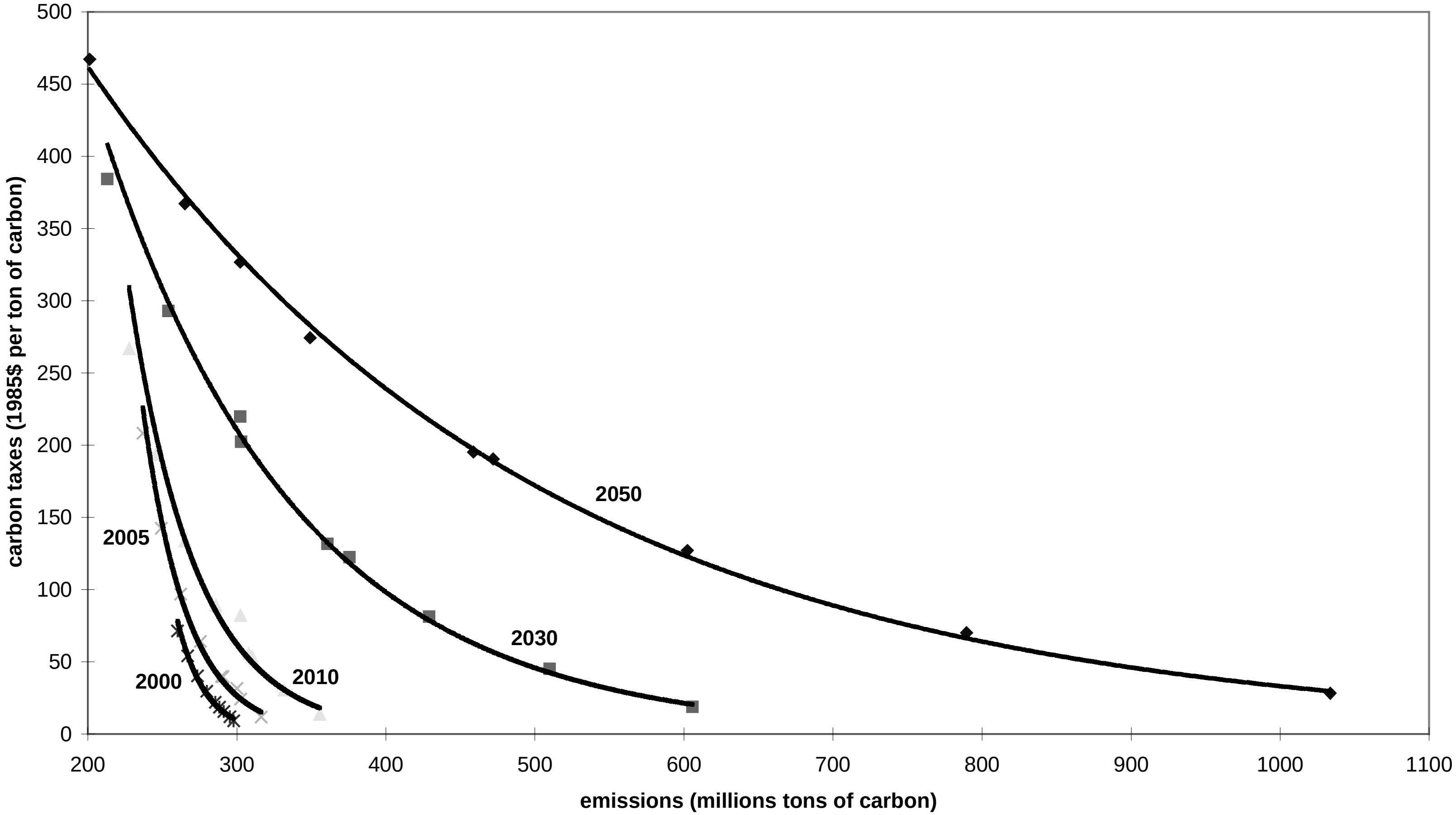


**Figure A6 : Cost curves for the CIS.**