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US Rejection of the Kyoto Protocol: The Impact on Compliance Costs and CO_2 emissions

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Executive Summary

Despite the US rejection of the Kyoto Protocol, the meeting of the parties to the UN Framework Convention on Climate Change in July 2001 has increased the likelihood that the Protocol will be ratified. This raises a number of issues concerning mitigation costs, particularly for the buyers and sellers of emission permits. In this paper, we examine how the US decision is likely to affect compliance costs for other Annex B countries during the first commitment period. We also explore the implications for US emissions. Key findings include:

1. Participating OECD countries may experience a decline in mitigation costs, but because of the banking provision contained in the Protocol, the decline may not be as great as some would suggest.

2. If the majority of "hot air" is concentrated in a small number of countries in Eastern Europe and the former Soviet Union, these countries may be able to organize a sellers' cartel and extract sizable economic rents; and

3. Even in the absence of mandatory emission reduction requirements, US emissions in 2010 may be lower than their business-as-usual baseline because of expectations regarding future regulatory requirements.

US Rejection of the Kyoto Protocol: The Impact on Compliance Costs and CO_2 Emissions

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1. Summary

Despite the US rejection, the meeting of the Conference of the Parties to the UN Framework Convention on Climate Change in July 2001[1] has increased the likelihood that the Kyoto Protocol[2] will be ratified by a sufficient number of Annex B countries to enter into force. This raises a number of issues concerning mitigation costs, particularly for the buyers and sellers of emission permits. In this paper, we examine how US non-ratification is likely to affect compliance costs for other Annex B countries. We also explore the implications for US emissions. The results are summarized below. As with any such analysis, it is easy to quibble over the exact numbers. The real value lies more in the insights, rather than precise numerical values.

- **Banking and hot air**. In the absence of US ratification of the Kyoto Protocol, the overall costs of mitigation may decline for other OECD countries during the first commitment period (2008-12). However, based on the results of the present analysis, the reduction in mitigation costs may not be as great as some would suggest. This is because the "banking" provision of the Protocol permits countries to defer the use of some portion of their emission rights in one period for use at a later time. Such flexibility is particularly important for some of the countries of Eastern Europe and the former Soviet Union. With the economic difficulties encountered during restructuring, their business-as-usual emissions in the first commitment period are apt to fall below 1990 levels.

  With banking, it appears to be in the interest of the owners of "hot air" to defer a substantial portion of their excess emission rights for later use. As a result, mitigation costs during the first commitment period for those OECD countries that adopt the Kyoto Protocol appear to be slightly lower than they would be with US ratification, but not nearly as low as they would be in the absence of banking.

US nonparticipation may be particularly costly to the owners of hot air since the decline in demand may result in a huge decline in permit prices.

- **No banking and market power.** In the above, we assume that the owners of hot air are price takers. That is, they are willing to sell all of their hot air during the first commitment period if banking is disallowed. However, if the majority of hot air is concentrated in a small number of countries, they may be able to organize a sellers' cartel and extract sizable economic rents. As a result, they may be able to reduce substantially the negative impacts to their economies from US nonparticipation. This, of course, would be at the expense of participating OECD countries.

- **Anticipatory behavior.** Even in the absence of mandatory emission reduction requirements, US emissions in 2010 may be lower than expected. This is because energy-sector investments are typically long-lived. If investors believe that there may be mandatory reductions in the future, they will factor this consideration into near-term decision-making. Hence, although US emissions are projected to increase during the first decade of the 21st century, they are expected to be below their business-as-usual baseline. Clearly, the scale of the near-term reductions will be sensitive to one's expectations about the magnitude and nature of future requirements.

We stress the preliminary nature of the present study. Sensitivity analysis is needed with regard to a number of potentially important parameters. These include GDP growth, the price and availability of new technologies, the potential for price and non-price induced conservation, additional requirements for subsequent commitment periods, which countries would be involved, and so on.

Finally, these calculations are based upon the assumption that policies will be efficient. That is, market mechanisms will be chosen over "command and control" approaches to accomplishing environmental objectives. This is the assumption both domestically and internationally. To the extent that policies depart from market mechanisms (for example, the adoption of CAFE standards in the transport sector)[3], mitigation costs could be considerably higher than those reported in this paper. Still, we believe that the qualitative insights will hold with regard to the value of banking, hot air, market power and anticipatory behavior.

2. The MERGE Model

The analysis is based on MERGE (a **m**odel for **e**valuating the **r**egional and **g**lobal **e**ffects of greenhouse gas reduction policies). MERGE is an intertemporal general equilibrium model. The model assumes that investors correctly anticipate future targets and timetables. Uncertainty is treated through sensitivity analysis. Like its predecessors, the current version (MERGE 4.4) is designed to be sufficiently transparent so that one can explore the implications of alternative viewpoints in the greenhouse debate. It integrates submodels that provide a reduced-form description of the energy sector, the economy, emissions, concentrations, temperature change, and damage assessment.

MERGE combines a bottom-up representation of the energy supply sector together with a top-down perspective on the remainder of the economy. For a particular scenario, a choice is made among specific activities for the generation of electricity and for the production of non-electric energy. Oil, gas, and coal are viewed as exhaustible resources. There are introduction constraints on new technologies and decline constraints on old ones. MERGE also provides for endogenous technology diffusion. That is, the near-term adoption of high-cost carbon-free technologies leads to accelerated future introduction of lower cost versions of these technologies.

Outside the energy sector, the economy is modeled through nested constant elasticity production functions. The production functions determine how aggregate economic output depends upon the inputs of capital, labor, electric and non-electric energy. In this way, the model allows for both price-induced and autonomous (non-price) energy conservation and for interfuel substitution. Since there is a “putty-clay” formulation, short-run elasticities are smaller than long-run elasticities. This increases the costs of rapid short-run adjustments. The model also allows for macroeconomic feedbacks. Higher energy and/or environmental costs will lead to fewer resources available for current consumption and for investment in the accumulation of capital stocks.

MERGE is calibrated to the year 2000. Future periods are modeled in 10-year intervals. Hence, the first commitment period is represented as 2010 in the model. Economic values are reported in US dollars of constant 1998 purchasing power.

The model divides the world into nine geopolitical regions: 1) the USA, 2) OECDE (Western Europe), 3) Japan, 4) CANZ (Canada, Australia and New Zealand), 5) EEFSU (Eastern Europe and the Former Soviet Union), 6) China, 7) India, 8) MOPEC (Mexico and OPEC) and, 9) ROW (the rest of world). Figure 1 shows baseline emissions for each of the nine regions. Based on the assumptions underlying the analysis, it projects how emissions would grow *in the absence of policies and measures to reduce* CO_2 *emissions.* Note that the countries belonging to the Organisation for Economic Co-operation and Development (OECD) (Regions 1 through 4) together with the economies in transition (Region 5) constitute Annex B of the Kyoto Protocol.[a]

Each of the model's regions maximizes the discounted utility of its consumption subject to an intertemporal budget constraint. Each region's wealth includes not only capital, labor, and exhaustible resources, but also its negotiated international share in emission rights. Particularly relevant for the present calculations, MERGE provides a general equilibrium formulation of the global economy. We model international trade in emission rights, allowing regions with high marginal abatement costs to purchase emission rights from regions with low marginal abatement costs. There is also trade in oil, gas, and energy-intensive goods. International capital flows are endogenous, but the model is calibrated so that these flows will be small.

For more on the model, see our web site: http://www.stanford.edu/group/MERGE/

3. Focus of the Analysis

With an intertemporal general equilibrium model, it is necessary to make assumptions not only about the first commitment period, but also about subsequent periods. For illustrative purposes, we assume that Kyoto will be followed with a subsequent protocol in which all Annex B countries agree to reduce emissions by an additional 10% per decade starting in 2020. For the US, the constraint in 2020 is assumed to be the same as if it had

[a] Figure 1 highlights the importance of international cooperation in reducing CO_2 emissions. Even if Annex B countries were to reduce emissions to zero, global emissions would continue to grow in the absence of emission reductions on the part of developing countries.

adopted the Kyoto Protocol. Clearly, the nature and timing of future constraints are highly speculative and need to be subjected to extensive sensitivity analysis.

Table 1 describes the distinguishing characteristics of our initial set of cases. In Case 1, we make the counterfactual assumption that all Annex B countries (including the US) ratify the Kyoto Protocol. We further assume full trade in emission rights both within and across Annex B countries. In Case 2, the US does not adopt mandatory targets and timetables until 2020. Accordingly, we assume that it does not participate in international trade in emission rights until that year. The final distinguishing characteristic of Case 2 is that the banking of emission rights is prohibited. That is, countries are not allowed to defer the use of some portion of their emission rights in one period for use at a later time. Case 3 differs from Case 2 in that the banking of emission rights is permitted.

Table 1. Distinguishing Characteristics of Three Cases

	Ratify Kyoto Protocol	**Ratify Subsequent Protocol**	**International Trade in Emission Rights**	**Banking**
Case 1	All Annex B countries	All Annex B countries	Beginning in 1st commitment period for all Annex B countries.	Permitted
Case 2	All Annex B countries with the exception of the US	All Annex B countries	Beginning in 1st commitment period for Annex B countries ratifying the Kyoto Protocol. Beginning in 2020 for the US.	Not permitted*
Case 3	All Annex B countries with the exception of the US	All Annex B countries	Beginning in 1st commitment period for Annex B countries ratifying the Kyoto Protocol. Beginning in 2020 for the US.	Permitted

* Banking is permitted under the Kyoto Protocol. Cases 2 and 3 are designed to assess the value of this provision to various regions.

Although CO_2 is the most important of the manmade greenhouse gases[4], the Kyoto Protocol includes a number of other trace gases. The focus of the present analysis is exclusively on CO_2. Although inclusion of the other gases may raise or lower absolute costs, depending upon the shape of their marginal abatement cost curves, we do not believe that it would alter the general insights from the analysis.

We do, however, include carbon sink enhancement. Table 2 shows the values adopted for each of the five Annex B regions. To provide some perspective, in order for the US to reduce carbon emissions by 7% below 1990 levels in 2010, it would have to reduce emissions by approximately 600 million tons below its baseline trajectory. Sink enhancement would satisfy less than 10% of this obligation. For purposes of the present analysis, we assume sink enhancement is costless. Clearly, an important next step would be to incorporate supply curves for sink enhancement.

Table 2. Sink Enhancement (million metric tons of carbon annually)[5]

USA	50
OECDE	6
Japan	13
CANZ	19
EEFSU	27

We also allow for emission credits through the Clean Development Mechanism (CDM). In calculating the potential size of the contribution from the CDM, we first calculate the magnitude of the imports from non-Annex B countries if there were full global trading and if these countries were limited to their baseline carbon emissions. However, because of the difficulties in implementation, we assume that only 15% of the potential would be available for purchase during the first commitment period and 30% thereafter.

4. The Importance of Banking and Hot Air

The Kyoto Protocol sets limits on aggregate greenhouse gas emissions for Annex B countries for the first commitment period. For several countries, these limits are projected to exceed their actual emissions. In particular, the decline in economic activity in Eastern Europe and the former Soviet Union (EEFSU) during the 1990's has led to a decrease in their carbon dioxide emissions. As a result, this region is projected to have excess emission rights. In the parlance of the climate debate this is commonly described as "hot air" or "Russian hot air" to denote the country expected to receive the largest number of excess credits. The Protocol permits these rights to be sold to countries in search of low-cost options for meeting their own targets or to be "banked" for use at a later date. In this section, we examine the implications of banking and hot air.

Figure 2 shows baseline emissions and the emissions constraint for EEFSU. In 2010, domestic emissions are beneath the cap. EEFSU's excess credits exceed 300 million tons. However, with economic growth and a further tightening of the emissions constraint, the cap becomes binding by 2020. It is debatable how the excess permits generated during the first commitment period might be distributed over time. The answer will vary across the three cases described in Table 1.

Figure 3 shows how the hot air is allocated based upon the assumptions underlying the present analysis. Perhaps most important is the assumption that EEFSU will behave as a price taker.[b] In Case 1, most of the hot air is sold during the first commitment period. If all Annex B countries were to ratify the Kyoto Protocol, the demand for emission rights would be high, and only a small amount of the hot air is banked for subsequent use. In Cases 2 and 3, the US chooses not to adopt mandatory targets and timetables until 2020. With banking disallowed, EEFSU will have no alternative but to sell all of its hot air during the first commitment period. Conversely, if EEFSU is able to defer the sale of its excess permits until 2020, most of its hot air is carried forward for use at that time.

Figure 4 shows the international price of permits. In Cases 1 and 3 where banking is allowed, the permit price rises at approximately the marginal product of capital, 5% per year, between 2010 and 2020. The intertemporal allocation of the hot air ensures that this is the case.

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[b]In Section 7, we explore a scenario in which EEFSU is able to exert market power with regard to the sale of hot air.

Case 2 shows the international price of emission rights when banking is prohibited. The demand for emission rights in 2010 is reduced because of US nonparticipation in the Protocol. On the supply side, all of the hot air is available since its use cannot be deferred to a subsequent period. As a result, the value of the hot air is quite small. The situation is reversed in 2020. Demand for permits increases dramatically with the US adopting mandatory targets and timetables in 2020. There is a tightening of the Annex B constraints and there is also the absence of hot air. Hence, the price of permits rises sharply.

5. GDP Losses

We next turn to the issue of GDP losses. Here, we feel it is important to restate the earlier caveat. *The analysis is based on the assumption that policies will be efficient.* That is, we assume that market mechanisms will be chosen over "command and control" approaches to accomplishing environmental objectives. To the extent that we depart from market mechanisms, mitigation costs could easily be much higher

Figure 5 shows percentage GDP losses in 2010 for each region. We begin with OECD Europe (OECDE). Notice that their losses decline when the US does not participate in the first commitment period. Moreover, their losses decline dramatically when banking is prohibited. This is consistent with a very low price for permits.

When banking is permitted, as it is in the Kyoto Protocol, the decline is less steep. With much of the hot air deferred for later use, permit prices are only slightly lower than in Case 1. Note that the same is true for Japan and CANZ. Hence, it seems that contrary to conventional wisdom, US nonparticipation in the first commitment period does not substantially lower mitigation costs for the remaining OECD countries.

In terms of mitigation costs, EEFSU is negatively affected by US nonparticipation in the first commitment period. In Case 2, the price of permits plummets. There is a decline in demand coupled with a large supply of hot air available for sale in that period. In Case 3, most of the hot air is banked for use in subsequent periods. Again, this negatively impacts EEFSU in 2010.

If the US were to adopt the Kyoto Protocol, its losses are estimated to be of the order of three-quarters of one percent of GDP in 2010. We stress that this assumes full Annex B trading both *among* and *within* countries. These numerical results are consistent with a number of studies conducted over the last several years.[6] Interestingly, the US also incurs GDP losses in 2010 even when it faces no mandatory constraints in that year (Cases 2 and 3). This brings us to the issue of anticipatory behavior.

6. Anticipatory Behavior[c]

MERGE incorporates the effect of anticipatory behavior on the part of investors. Given the long-lived nature of many energy-sector investments, e.g., transport, buildings and power plants, the anticipation of significant emission constraints in the future will affect near-term decision-making—*even if no mandatory constraints are in place for that period*. For example, in Cases 2 and 3 we assume that mandatory constraints will be placed on US emissions beginning in 2020. The positive US losses reported for 2010 reflect the fact that, in preparation for a less carbon-intensive infrastructure in the future, energy-sector investors are making more costly investments than would be made in the absence of concerns about future constraints on CO_2 emissions.

If the US were to adopt the Kyoto Protocol, it would have to reduce emissions by 600 million tons in 2010. We calculate that roughly half of this requirement would result from reductions in domestic CO_2 emissions. Carbon sinks and the import of emission rights would account for the remainder. Figure 6 compares domestic emission reductions if the US were to ratify the Kyoto Protocol with reductions due solely to anticipatory behavior. With regard to the latter, we examine two cases. In Case 2, EEFSU is prohibited from banking its excess emission rights. In Case 3 it is not. Notice that the anticipation of mandatory targets in 2020 result in domestic reductions in 2010.

Also notice that anticipatory reductions are higher when banking is prohibited. This is due to the absence of hot air in 2020. In that year, the US will be able to offset less of its obligation through the purchase of emission rights. As a result, it must rely more heavily on domestic emission reductions in 2020. Anticipating this in 2010, investors will begin adapting to the tighter future constraints. Clearly, the scale of the

[c] We note that the issue of anticipatory behavior does not apply solely to the US, but to any country facing the prospects of emission reductions in the future. Indeed, the prospect of economic growth coupled with an increasingly tighter emissions constraint, contributes to the magnitude of the losses to EFFSU in 2010 in Cases 2 and 3.

near-term reductions will be sensitive to one's expectations about the magnitude and nature of future requirements.

7. Market Power

Thus far, we have assumed that, in the absence of banking, the sellers of emission rights will be price takers. That is, they will be willing to sell all of their hot air during the first commitment period. However, if the majority of the hot air is concentrated in a small number of countries, these countries may be able to organize a sellers' cartel and extract sizable economic rents.

To explore this possibility, we assume that EEFSU is a price maker, and is able to limit the amount of hot air available for sale to other Annex B countries during the first commitment period. Figure 7 illustrates how percentage GDP losses to EEFSU might change if it were able to control the amount of hot air sold. Notice that losses are minimized when the sale of hot air is limited to somewhere between 120 and 160 million tons. Figure 8 shows the impact, in terms of percentage GDP losses, when EEFSU limits sales of hot air to 140 million tons in 2010 (Case 2a). The participating OECD countries experience losses comparable to those of Case 1. Conversely, relative to Case 2, the losses to EEFSU decline significantly.

8. Some Concluding Remarks

In this paper, we examined how the US decision to reject the Kyoto Protocol is likely to affect compliance costs for the remaining Annex B countries during the first commitment period. In the case of other OECD countries, compliance costs may decline, but perhaps not as much as some have suggested. In the case of the economies in transition, compliance costs are likely to increase. Although we believe that the basic insights are likely to hold, more analysis is required to explore the sensitivity of the results to changes in key assumptions. The following issues, not explored in the present analysis, also need to be examined:

- Suppose that in order to entice other countries into joining a future Protocol, they too are accorded hot air. What would be the impact on the value of emission permits in subsequent periods? How would this affect the willingness of the current owners of hot air to defer the sale of their excess emission rights?

- We assume that the US will not partake in international trade in emission rights until it adopts mandatory targets. How realistic is this assumption? What would be the implications if the US were to act otherwise?

- We assume that countries will correctly anticipate future constraints. Clearly, there is a strong likelihood of future constraints on CO_2 emissions. But what constraints do we assume? One way to handle this uncertainty is through sensitivity analyses. A better way would be to employ the techniques of decision analysis and identify the optimal near-term hedging strategy in the face of the many long-term uncertainties.[7]

- Finally, with regard to near-term emission reductions, how well does the current proposal fit into the ultimate goal of the Framework Convention, "the stabilization of greenhouse concentrations at a level that will prevent dangerous anthropogenic interference with the climate system"[8]? A great deal of effort has been devoted to identifying the least-cost emission pathways for stabilizing concentrations at various levels. This work suggests that the pathway to stabilization can be as important as the stabilization level itself in determining mitigation costs. Are the reductions mandated under the Kyoto Protocol consistent with the long-term goals of the Framework Convention?

Notes

[1] Conference of the Parties (2001). “Review of the Implementation of Commitments and of Other Provisions of the Convention,” Report of the Conference of the Parties, Sixth Session, part two, Bonn, 16-27 July.

[2] Conference of the Parties (1997). “Kyoto Protocol to the United Nations Framework Convention on Climate Change,” Report of the Conference of the Parties, Third Session Kyoto, 1-10 December. FCCC/CP/1997/L.7/Add.1 http:/www.unfccc.de.

[3] See Hahn, Robert W. and Robert N. Stavins (1999). *What Has the Kyoto Protocol Wrought? The Real Architecture of International Tradable Permit Markets*. AEI Press, Washington, D.C.

[4] Schimel, D. *et al.* (1996). In *Climate Change 1995: The Science of Climate Change—Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change* (eds. Houghton, J.T. *et al.*), Cambridge University Press, Cambridge.

[5] Missfeldt, F. and E. Haites. “The Potential Contribution of Sinks to Meeting Kyoto Protocol Commitments,” *Environmental Science and Policy*, in press.

[6] EMF-16 (1999). *The Costs of the Kyoto Protocol: a Multi-Model Evaluation*. Special Issue of the *Energy Journal*, (eds. Weyant, J. *et al*.).

[7] Manne, A. and R. Richels (1995). “The Greenhouse Debate: Economic Efficiency, Burden Sharing and Hedging Strategies,” *The Energy Journal*, vol. 16, no. 4, pp. 1-37.

[8] Climate Change Secretariat (1992). *United Nations Framework Convention on Climate Change*, Geneva, Switzerland.

Figure 1. Reference Case (baseline) Emissions

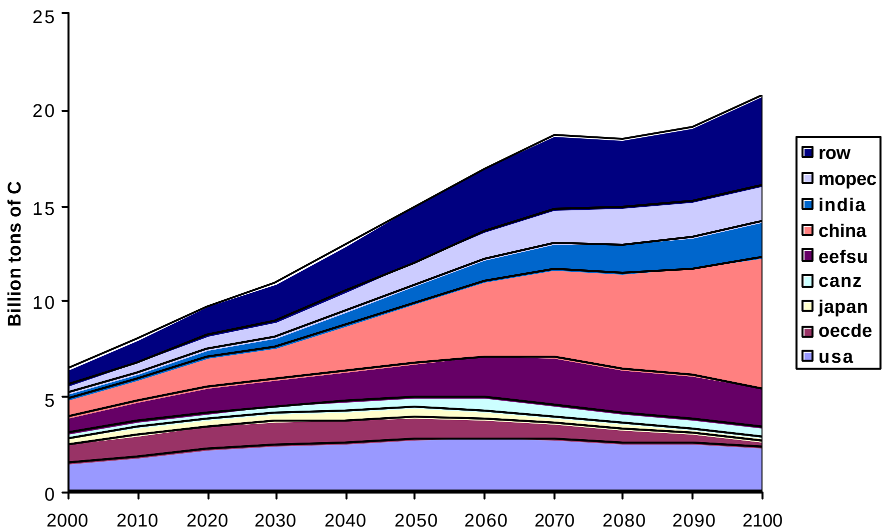

Figure 2. Excess Emission Rights ("Hot Air") in Eastern Europe and the Former Soviet Union

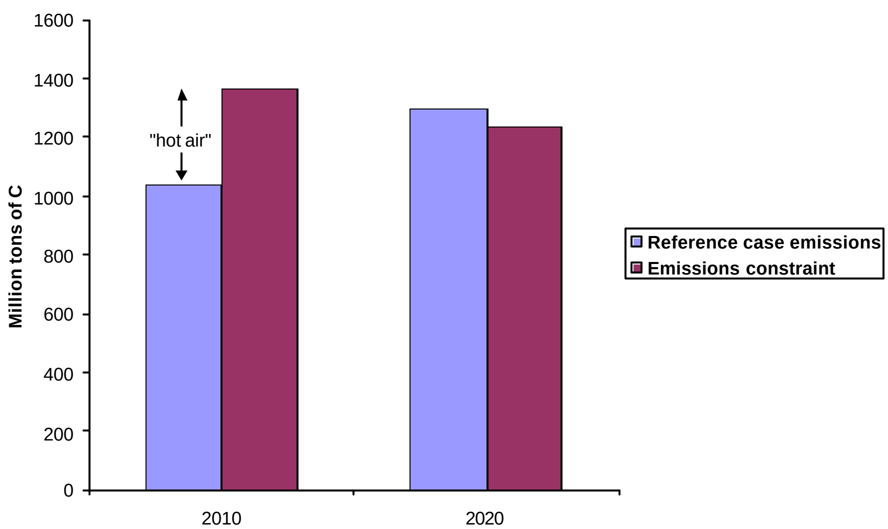

Figure 3. Exports of “Hot Air” in 2010 from Eastern Europe and the Former Soviet Union (EEFSU)

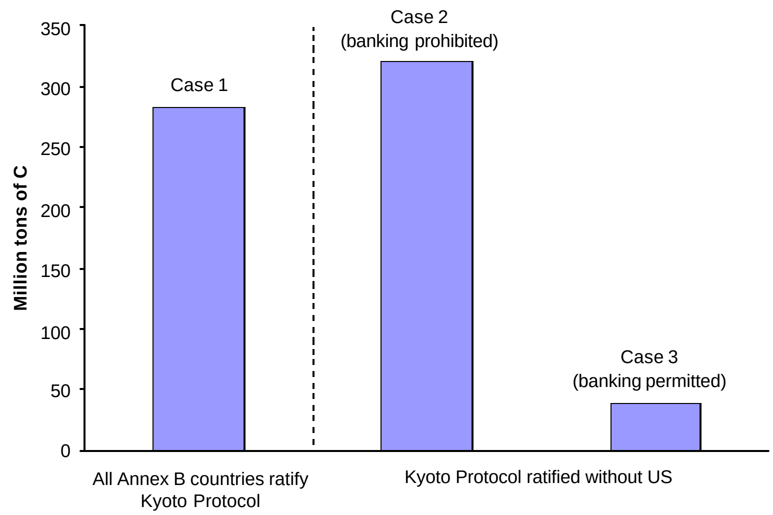

Figure 4. Incremental Value of Carbon Emission Rights

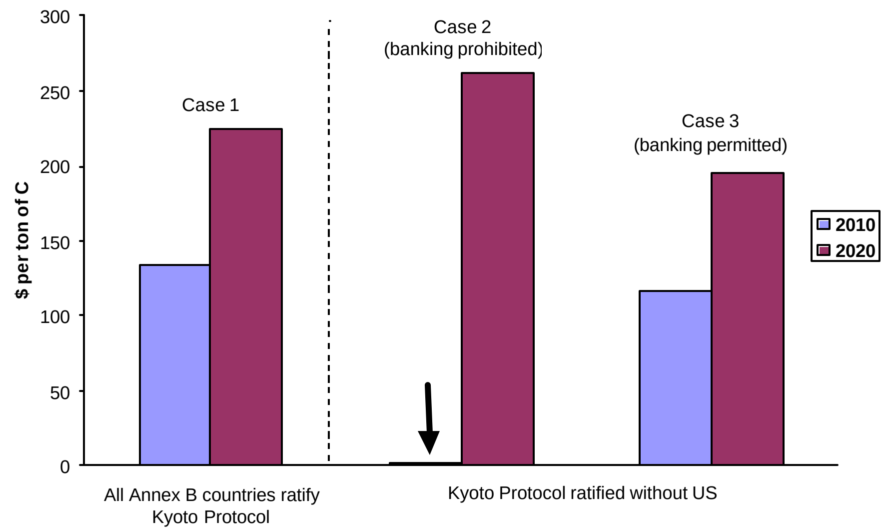

Figure 5. Percentage GDP Loss in 2010

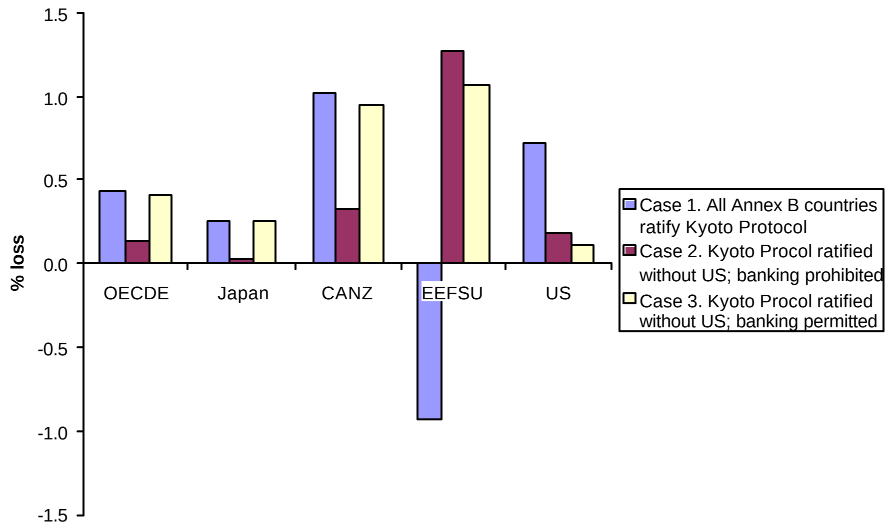

Figure 6. US Domestic Emission Reductions in 2010 -- the impact of anticipation of future constraints

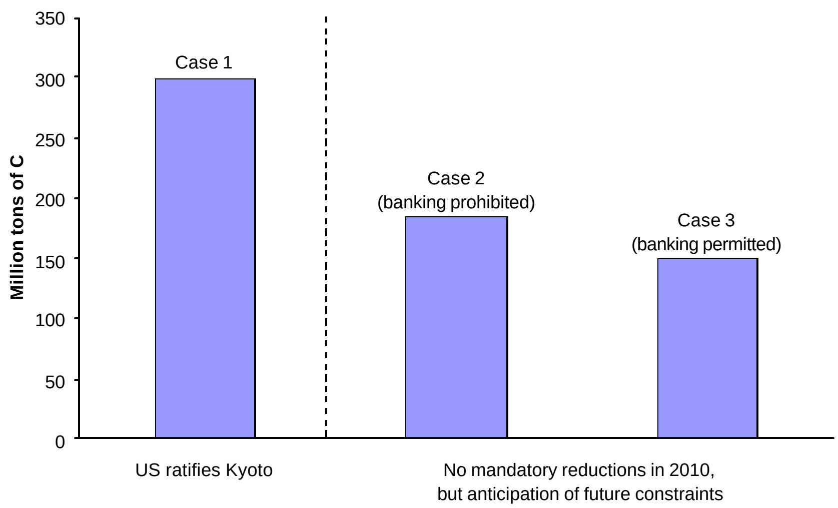

Figure 7. Percentage GDP Losses for EEFSU -- assuming alternative levels of emission rights sold in 2010

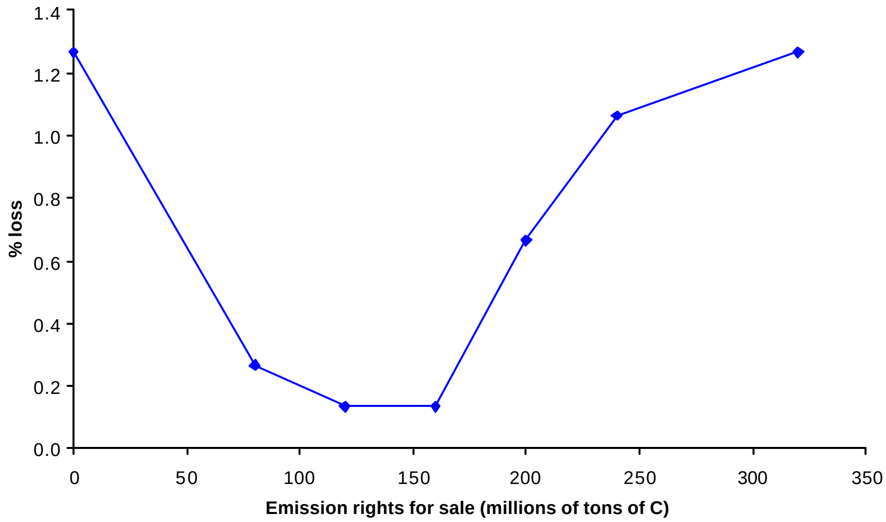

Figure 8. Percentage GDP Losses in 2010 -- with EEFSU as price taker (Cases 1 and 2) and price maker (Case 2a)