Some Implications of Increased Cooperation in World Oil Conservation

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by Stephen P. A. Brown and Hillard G. Huntington*

This paper combines recent studies of world oil markets and the nascent literature on damage estimates from CO_2 emissions to derive cost and benefit curves for the reduction of CO_2 emissions through cooperative programs of oil conservation. The analysis shows that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue, rather than a conceptual one. The current evidence suggests that over the next two decades, the OECD will have more than sufficient incentive to reduce oil consumption and the associated CO_2 emissions through unilateral actions. During this period, extending cooperation to the oil-importing developing countries may be unneccesary and undesirable.

1. Introduction

The classic problem of free-ridership among nations characterizes efforts to curtail emissions of carbon dioxide and other potential greenhouse gases. When damages from emissions are global rather than local, countries that do not participate in policies directed at reducing global climate change receive the benefits of other countries' actions without incurring the costs.

Past research and game-theoretic analyses have emphasized the gains from eliciting the cooperation of developing countries in an effort to limit global carbon dioxide emissions (Bohm, 1993; Brown and Huntington, 1994b; Eyckmans, Proost and Schokkaert, 1993; Hoel, 1991b and 1994; Manne and Rutherford, 1994; and Welsch, 1995). Broader participation reduces the costs of achieving any given target of emissions reductions among those nations engaged in the coordinated policies. In essence, the cost curve for countries reducing their emissions shifts downward as participation expands to more countries.

Recent estimates of possible climate change damages allow us to examine the impact of cooperation on the optimal strategy for reducing CO_2 emissions. Because increased participation lowers the costs of coordinated policies to reduce emissions, it is likely to increase the amount of conservation that the participants would see as cost-effective for any given set of estimates of the benefits of reducing emissions and avoiding environmental damage. Whether increased cooperation yields too little or too great a reduction in emissions from a world perspective depends critically upon the level of damage estimates, an empirical issue that at the moment is highly uncertain.

Reduced usage of fossil fuels, through higher-efficiency equipment and changing economic structures and lifestyles, is the principal vehicle for CO_2 emissions abatement. Policies that discourage the use of coal, oil, and to a lesser extent, natural gas contribute to reduced emissions of greenhouse gases, and hence lower potential damages from climate change. Abatement policies affecting the oil market are particularly complex to analyze because actions taken by one country or group of countries are likely to influence oil consumption in other parts of the world through their effect on the world oil price.

In this paper, we evaluate the extent to which increasing cooperation beyond the OECD to limit CO_2 emissions through oil conservation is desirable from a world perspective. To accomplish this task, we derive cost and benefit curves from recent studies of world oil markets and the nascent literature on the damages arising from changes in the world environment. Our analysis shows that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue, rather than a conceptual one. In addition, the current evidence suggests that over the next two decades, the OECD has more than sufficient incentive to reduce oil consumption through unilateral actions--even when taking a precautionary approach to reducing CO_2 emissions. Should joint action with other countries become desirable in the longer term, an immediate extension of cooperation beyond the OECD to reduce world oil consumption may be unnecessary and undesirable.

2. Estimating the Cost of Oil Conservation

Like several previous studies, we use a welfare-theoretic framework built on top of a simulation model of the world oil market to compute cost curves for oil conservation under alternative assumptions about which countries are participating in the policy. The curves indicate how participants' costs change as the level of conservation increases. The cost curves include the direct resource costs associated with shifting inputs from other sectors into energy conservation activities, as well as the increased oil consumption in non-participating countries and the wealth transfers associated with changes in the oil price.

2.1 The World Oil Market

Our analysis divides the world into four regions; the industrialized OECD countries; OPEC members; other less developed countries (non-OPEC LDC); and China, Eastern Europe and the former Soviet Union, (C/EE/former SU). The simulation model is calibrated to reproduce the oil price, production and consumption data shown in Table 1. The data in this table represent one of many possible future oil market outlooks. It is based on the mid-price case in the U.S. Energy Information Administration's (EIA's) *1993 International Energy Outlook.*[1]

The projected oil demand conditions depend on a variety of assumptions about economic growth, prices of competing fuels, and the extent of oil-saving technological change in the absence of price changes. The supply conditions outside of OPEC member countries incorporate assumptions about the resource base, engineering constraints on developing resources, and producer-country taxes and policies. In these projections, OPEC members satisfy the excess demand, but adjust the next period's price in response to market tightness.

Table 1 also summarizes representative estimates of the long-run supply and demand responses to price for the major regional areas in the analysis. They represent mean estimates derived from and Energy Modeling Forum study (1991) comparing ten major world oil market models and are quite similar to those used by the EIA in developing the projections shown in the first column. These estimates were used in construction of the simulation model.[2]

The responses for the C/EE/former SU region are judgmental. Their production and consumption decisions are likely to be influenced greatly by the forces of economic transition, resulting in smaller responses to changes in world oil prices than found in other regions. In fact, if the supply and demand responses for the C/EE/former SU were made comparable to responses for other country groups, the conservation scenarios considered here would push world oil prices sufficiently low that we would estimate these economies would import significant quantities of oil. We consider this result untenable, and therefore assumed a smaller response to price than for other countries. To the extent that these countries yield a greater response to price, the estimated costs of achieving various world conservation targets will be larger than reported here.

The response of oil producers within OPEC is highly uncertain. To date, formal modeling of OPEC decisions has been far from reliable. OPEC appears to operate like an imperfect cartel during some times, but not at others.[3] The OPEC countries appear to be about as uncomfortable with a rapidly increasing market share (as accompanied the relatively low prices in the 1960s) as they are with a rapidly decreasing market share (as occurred in the aftermath of the price hikes of the late 1970s and early 1980s). The analysis presented here assumes that OPEC acts to maintain a constant market share.[4]

2.2 The Cost of Conservation

We examine conservation policies by reducing oil consumption in participating countries below the levels shown in Table 1 and allowing the world oil price to adjust to restore a balance between oil supply and demand conditions. Analytically, we used a tax to reduce oil consumption. The tax approach assumes that conservation measures are applied across all end uses.

From these simulations, we construct cost curves using a welfare-theoretic approach described by Brown and Huntington (1994a) and Felder and Rutherford

(1993).[5] The resulting cost curves take into account the effects that conservation in the participating countries will have in reducing world oil prices, and therefore in inducing increased oil consumption in non-participating countries and transferring wealth from oil-exporting nations to oil-importing nations. These transfers augment an oil-importing country's wealth, and operate to offset some of the costs that an oil-importing country incurs by imposing conservation policies.

To maintain the emphasis on the substantial difference in market response to the inclusion of additional countries, our analysis abstracts from a number of important considerations that would be incorporated in a more refined analysis. These conditions include: explicitly accounting for different types of goods (Felder and Rutherford, 1993 and Pezzey, 1992); the design of taxes and redistributive mechanisms (Hoel, 1991b); the effect of pre-existing energy taxes and other taxes, which could be reduced to offset some of the costs of a new conservation policy (Hoel, 1991b), or which, if left in place, would affect the estimated costs of imposing a new conservation policy (Newberry, 1992), and the examination of alternative policies for distributing conservation goals across countries (Whalley and Wigle, 1991; and Brown and Huntington, 1994b). Similarly, for some LDCs removing subsidies to the energy sector could reduce energy use and improve economic efficiency, in contrast to our assumption that conservation is achieved through taxes that impose costs the economy. Alternatively, some LDCs may have supply-constrained energy consumption, and the costs of their conservation efforts would be higher than we estimate here.

3. Differing Incentives for Oil Conservation

In figure 1, the cost curve labeled "WORLD" shows how much each additional barrel of world oil conservation costs all nations collectively. The construction of this curve assumes that conservation is first adopted wherever it is cheapest. The net transfers toward oil-importing nations that are induced by lower energy prices are simply matched by net transfers away from oil producers. Thus, the curve incorporates only the direct costs, measured at the world level, associated with shifting resources toward energy-conservation activities.

The cost curve labeled "OECD" shows how much each additional barrel of world conservation costs the OECD countries if only they act to conserve oil. As such, this curve is constructed to reflect the increase in non-OECD consumption that will result from lower world oil prices induced by unilateral OECD action to conserve oil. For lower levels of conservation, the curve falls below the world cost curve, reflecting the positive effect of wealth transfers from the rest of the world to the OECD that result from lower oil prices. At about five million barrels per day of world oil conservation, the marginal cost reaches zero, and is positive thereafter.

Although the OECD cost curve starts below the WORLD cost curve, it rises more sharply with increased conservation for two reasons. The wealth transfer to the OECD becomes smaller as greater conservation reduces imports. In addition, the direct costs increase more sharply for the OECD curve than for the WORLD curve because conservation projects can be selected from only the OECD rather than worldwide. As a consequence, for conservation levels of about seven million barrels per day and higher, the OECD cost curve lies above the WORLD cost curve.

The OECD and WORLD cost curves illustrate that the oil-importing OECD countries, acting as a group, have an incentive to select a level of oil conservation that is not optimal from a world perspective. Whether unilateral OECD action that is not matched by other countries leads to too much or too little emissions reduction, however, cannot be determined by the cost information alone. This issue can be resolved only by knowing where the curve representing the estimated benefits of (or damages avoided by) conservation intersects the two cost curves.

Many analyses suggest a flat marginal damage curve. Peck and Teisberg (1992) explain that marginal damage costs are essentially unaffected by the emissions levels in any given decade. This conclusion rests on the finding that temperature change depends upon gas concentration, which is not greatly affected by the emission levels in any given decade. We adopt this characterization by assuming horizontal damage curves that depict a constant level of benefits for any level of oil conservation.

Figure 2 illustrates the situation for two hypothetical benefit curves--one at $5 per barrel and one at $20 per barrel. We estimate that when the benefits of oil conservation are below $12.63 per barrel, the cost curves reveal an incentive for the OECD to pursue more oil conservation than is optimal from a world perspective. In this range, OECD's cost curve is to the right of the WORLD cost curve. As a result, the benefit line intersects the OECD curve further to the right than it intersects the WORLD curve.

Moreover, at benefit levels below $12.63 per barrel, cooperation from non-OPEC LDCs will exacerbate the discrepancy between what is optimal from a world perspective and what participants would have the incentive to choose. Cooperation between the OECD and the non-OPEC LDCs shifts the participant's cost curve for world oil conservation from the one labeled "OECD" to the one labeled "OECD+LDC."[6] At benefit levels below $12.63 per barrel, the equilibrium amount of oil conservation selected by the participating countries will move further to the right--producing even more abatement of CO_2 emissions than would be optimal from the world's perspective.

When the benefits are above $12.63 per barrel, the cost curves reveal an incentive for the OECD to pursue less oil conservation than is optimal from a world perspective. Under these conditions, the marginal benefit line intersects the OECD's marginal cost curve to the left of its intersection with the world's marginal cost curve. Unilateral OECD action would result in too little oil conservation. Some limited cooperation from developing countries could help ameliorate this problem by shifting the cost curve outward, but full cooperation from all developing countries would shift the curve far to the right, and the participants would seek more conservation than would be optimal from a world perspective unless the benefits of oil conservation were at least $31.91 per barrel.

4. The Benefits of Reducing CO_2 Emissions

Damage estimates for CO_2 are in their infancy. Economic evaluations attempt to monetize both market and nonmarket impacts of greenhouse gas concentrations, and the resulting estimates vary considerably. Key uncertainties include the dynamics of the carbon cycle governing the effect of emissions on concentrations, the effect of concentrations on temperature change, and the consequences of temperature change on market and nonmarket damages. Differences in discount rates for evaluating potential impacts over horizons of 100 years or more account for a significant part of the differences in damage estimates. Finally, estimates vary depending upon the decade for which they are computed; estimated damages increase for later decades.

Table 2 reports estimates from several prominent studies providing monetized estimates of the marginal damages arising from CO_2 emissions in the decade 2001-2010. Researchers usually report their estimates in U.S. dollars per ton carbon (tC), as shown in the first column. We convert these estimates to U.S. dollars per barrel of oil in the second column. In oil-equivalent terms, the mean damage estimates range from about one to three dollars per barrel across different studies. Emphasizing the dramatic uncertainty in these estimates, the Fankhauser study provides a range from less than $1 per barrel to almost $6.50 per barrel, depending upon key parameter assumptions.

Excluding the outer uncertainty range in the Intera approach, Hope and Maul (1996) provide similar estimates to the range shown by Fankhauser without specifying the decade. Using the PAGE model and the inner uncertainty range of the Intera approach under similar assumptions, they find damages from marginal CO_2 emissions to range from $12 to $45 tC for the PAGE model and from $3 to $50 tC for the Intera estimates. The outer uncertainty range of the Intera analysis, which should be accorded a very low probability because it combines many events, each of which is accorded only a 5 percent probability by experts is $0 to $270 tC. Hope and Maul suggest that policy makers taking seriously the threat of global warming should use a precautionary principle and penalize sources of CO_2 according to the high estimates found with the PAGE model or the inner uncertainty range of the Intera estimates, which would amount to \$5.63 (PAGE) or \$6.50 (Intera) per barrel of oil.

Even for those taking a precautionary approach to reducing CO_2 emissions, the available damage estimates fall well below \$15 per barrel of oil. Combined with the cost curves of oil conservation presented above, these damage estimates suggest that unilateral action by the OECD will lead to excessive oil conservation, and that adding the LDCs would exacerbate the problem.[7] At \$0 to \$33.75 per barrel, the outer uncertainty range of the Intera approach emphasizes the possibility (but low probability) of higher damage estimates, and thus indicates the need for further study of the benefits of reducing CO_2 emissions.

5. Conclusion: The Costs of Extending Cooperation

The preliminary evidence suggests that during the next two decades OECD action to conserve oil to reduce CO_2 emissions is likely to result in more oil conservation than is optimal from a world perspective. For the OECD, cooperative oil conservation would reduce world oil prices and yield wealth transfers from oil-exporting countries to the oil-importing countries that are undertaking the oil-conservation policies. These wealth transfers are sizable and positive for the OECD nations, which collectively are heavily dependent upon oil imports. For relatively small oil-conservation strategies, as are suggested by the nascent literature on the damages from CO_2 emissions, these wealth transfers will dominate the direct costs of conservation and lead to excessive conservation from a world perspective. This result contrasts sharply with the standard perspective that unilateral OECD action is likely to lead to insufficient oil conservation.

Under these conditions, extending cooperation to the oil-importing developing countries will exacerbate the problem. Participants' costs will be reduced, leading to even larger discrepancies between emissions levels chosen by the self-interested participants and those seen as optimal from a world perspective.

These seemingly anomalous results are obtained precisely because the nations most likely to cooperate in conserving oil are likely to exclude the oil-exporting nations and thus ignore the costs that conservation imposes on the latter group. From a world perspective, transfers to energy-importing countries are exactly offset by transfers from net energy exporting countries. From the more limited perspective of the oil-importing countries participating in a coordinated policy of energy conservation policy, these wealth transfers are not offset, but operate as an incentive to conserve energy and reduce emissions. Because CO_2 damages are currently unpriced in the market, these additional incentives to conserve oil may be a good thing. Nonetheless, the current estimates of the costs of CO_2 damages are not sufficiently high to justify concern that OECD countries do not have sufficient incentive to act unilaterally to reduce emissions.

These preliminary conclusions depend very critically upon the size of estimated damages from CO_2 emissions. If future estimates of damages should prove to be higher by a factor of 5--a possibility suggested by the outer uncertainty range of the Intera estimates--the analysis could be reversed. In such a case, our cost estimates would suggest that OECD countries, would not have sufficient incentives to conserve oil and eliciting LDC cooperation could improve the outcome from a world perspective. In this respect, one implication of our analysis is that the desirability of extending cooperation in global energy conservation policies is essentially an empirical issue, rather than a conceptual one.

In addition, our conclusions pertain only to CO_2 emissions with a global impact. The local and regional benefits from reducing energy use (e.g., the damages avoided from local pollution) may well be more important than the benefits derived from global strategies to reduce worldwide environmental threats (See Hall 1990 and 1992).

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Notes

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1. Sensitivity analysis using a range of alternative assumptions about the outlook for 2010 and the responsiveness of consumption and production to changes in price yielded qualitatively similar results to those reported here.

2. The estimates are taken from Huntington (1992, 1993).

3. Griffin (1985) and Dahl and Yücel (1991) provide empirical estimates of OPEC behavior that are broadly consistent with this view.

4. A sensitivity analysis using alternative assumptions that allow modest adjustments in OPEC's market share confirm our general findings. In the extreme, OPEC could maintain a given price and accept a substantial loss in market share in the face of reduced demand. Under these conditions, the OECD would not obtain wealth gains from lower oil prices with which to offset the direct costs of unilateral oil conservation policies.

5. The authors will provide a mathematical appendix upon request.

6. The cost curve is constructed to reflect the gains in non-participant oil consumption that will result from lower world oil prices induced by the cooperative action to conserve oil. As such, it reflects participant costs of world oil conservation.

7. Sensitivity testing, through the use of parameters to replicate the behavior of several of the prominent energy models that participated in a recent Energy Modeling Forum study (1991), yielded qualitatively similar results.

Table 1: Baseline World Oil Market Conditions, 2010

	Quantity (10^6 Bbl/day)[a]	Price Elasticity[b]
Consumption		
OECD	45.6	-0.47
non-OPEC LDCs	17.9	-0.30
C/EE/former SU[c]	15.3	-0.15
OPEC	7.1	-0.30
Total	85.9	
Production		
OECD	15.4	0.43
non-OPEC LDCs	12.2	0.40
C/EE/former SU[c]	15.3	0.30
OPEC	42.7	*
discrepancy[d]	0.3	n.a.
Total	85.9	

a Mid-Price Case from EIA's 1993 International Energy Outlook. Price is 29.30 per barrel (1991$).

b Percent change in quantity for each one percent change in price. Based on Energy Modeling Forum (1991), except for C/EE/former SU which are based on authors judgement.

c China, Eastern Europe and the former Soviet Union.

d includes net stock withdrawals.

* OPEC responds to hold a constant market share. See text.

Figure 1
Marginal Cost of World Conservation

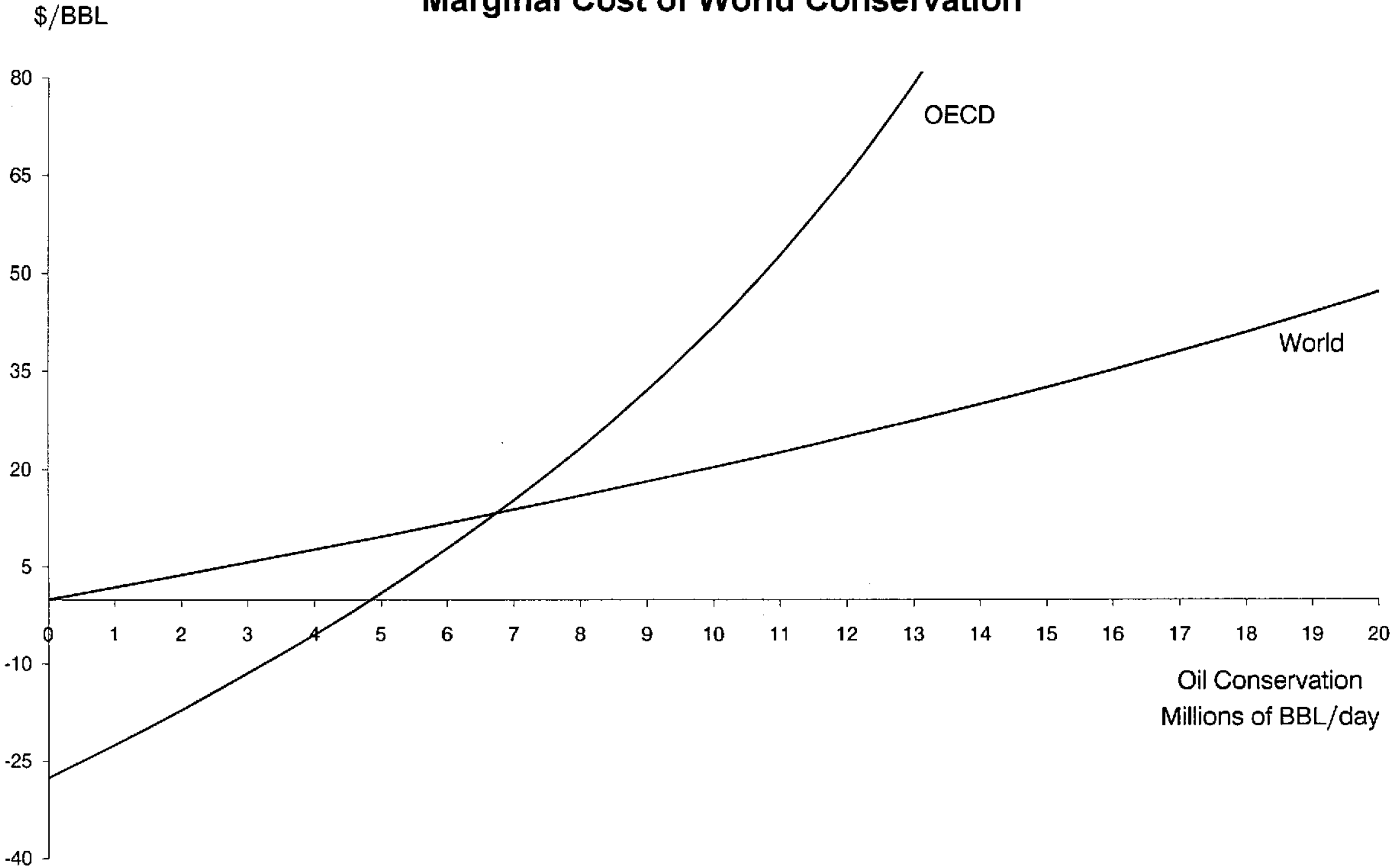

Figure 2
Marginal Cost of World Conservation

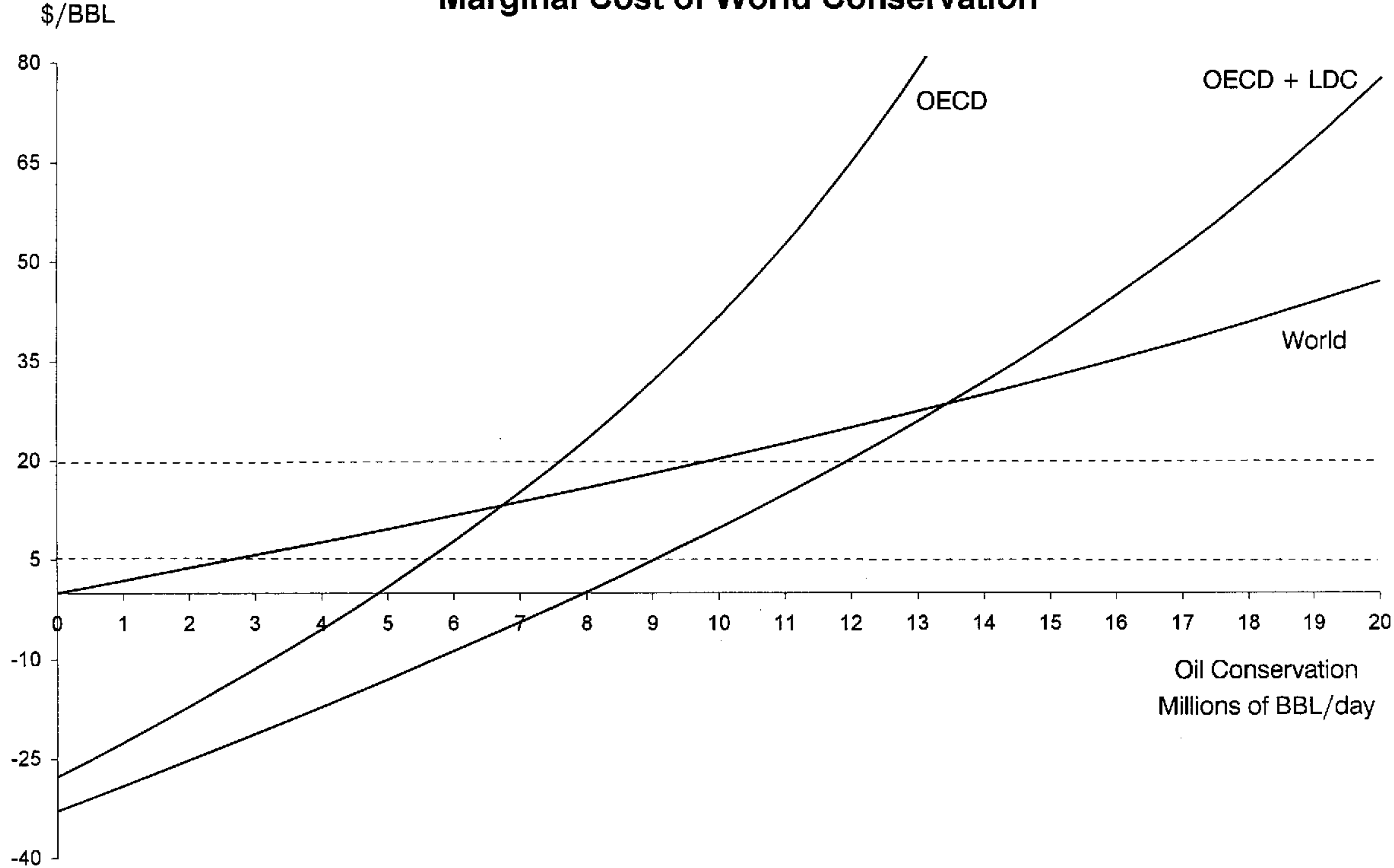

Table 2: Estimated Damages from CO_2 Emissions for Decade, 2001-2010

Study	$/tC	$/Bbl*
Nordhaus (1991a,b)	7.3	.89
Nordhaus (1992)	6.8	.85
Peck-Teisberg	12-14	1.46-1.71
Fankhauser		
Mean	22.8	2.78
5th percentile	7.4	0.90
95th percentile	52.9	6.45

Source: Fankhauser (1994)

* Authors' estimates based upon a conversion factor of $8/tC equals $1/Bbl.

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