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Science, Technology, Environment, and Competitiveness in a North American Context

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ABSTRACT

Most economic activities pollute. Environmental regulations should serve the public good by providing incentives to reduce pollution caused by economic activity. Economic incentives include pollution taxes, subsidies for pollution abatement, and tradeable permits or allowances to pollute. Because of the political unacceptability of taxes and permits, much regulation imposes command and control measures and provides less incentive to minimize pollution. Efficient incentives would encourage pollution abatement up to the point where the cost of abatement equals the social and private benefit from the improvements in the environment. While these costs and benefits are difficult to measure, many analysts contend that the way environmental laws have been formulated and implemented in the U.S. leads to very inefficient pollution control. This inefficiency can contribute to a decline in economic competitiveness in the long run, although economic studies do not support the "pollution haven" hypothesis. Better analysis (foresight) of the cost of transboundary pollution, significant in the Great Lakes region and along the U.S.-Mexico border, as well as in rivers that flow between countries, is needed to formulate more effective policies and avoid sorry hindsight. Also, application of communal experience, technologies, and methods applied to shared problems can avoid costly duplication of searches for the optimal pollution abatement measures.

I. Introduction: Why we need environmental regulations

All sectors of the economy produce pollutants: industries and businesses produce waste products through their processes; autos and trucks release significant pollutants in their emissions; most electric utilities produce gaseous or solid wastes with fuel combustion; and the household sector produces municipal waste and, through less efficient use of energy, demands more electricity, which produces more waste. Other than waste collection fees for solid wastes, these emissions historically had no or low associated costs. Beginning in 1970, increasing numbers of environmental regulations began to impose costs or limits on pollutants in the U.S. These regulations were necessary because a liveable environment--clean air, water, and other natural resources--is a public good, like national defense or education. We all derive a benefit from it but cannot afford individually to provide it.

What types of incentives or regulations are needed to protect the public good, our environment? What is the role of environmental economics in policy formulation? How is this role affected by uncertainty? Will the environmental costs make us less competitive? What should we do as a continent to prioritize and solve current environmental problems and to prevent future ones?

II. The economic pros and cons of environmental regulations

A. Why environmental regulations can help competitiveness

Economic competitiveness is defined here as the capability to produce goods and services at a lower *total* cost than other states or nations. The emphasis on *total* costs implies that these costs should include pollution abatement costs. If they do not, the total cost of the good in the country where it is produced may exceed the price at which it is sold. If our goods undersold those of another country and did not include pollution abatement, they would do so at the expense of degrading our environment, which ultimately will extract a real cost. Where transboundary environmental effects are caused by the production of the good, both nations must receive adequate compensation or protection for the degradation of their environment while maintaining sovereignty.

Environmental regulations therefore do not always hurt competitiveness.[1] Indeed, efficient ones *never* degrade competitiveness if one considers a long time horizon. Efficient regulations, i.e., where the marginal cost of pollution abatement equals the marginal benefit, help competitiveness in at least the following four ways:

1. We're in it for the long term. Regulations should ensure that natural resources are preserved for future generations, so that the long-term factors of production exist to support future generations. An example is the adequate preservation of the Great Lakes so that fishing, transport, recreation, and health interests are protected for the future.
2. Regulations should encourage waste (and pollution) minimization, which results in more output of a saleable good per unit of input and prevents costly future cleanups. Energy efficiency poses a good example--many efficiency measures have a quick pay-back, result in lower long-term costs of production, and emit fewer greenhouse gases. Pollution minimization also avoids putting hazards into our environment that will later require costly cleanups. Given the short time horizon of interest

[1]The possible exception where differences in environmental regulations may hurt competitiveness is agriculture. Some environmental regulations preclude use of important, but possibly harmful, inputs to agriculture, such as growth hormones, fertilizers, and pesticides. Countries where use of these substances are allowed may gain a substantial competitive advantage.

to corporations and businesses, economic incentives such as tax breaks and subsidies should be considered to stimulate investment in longer-term efficiency and environmental improvements.

3. Producers minimize expenditures required to comply with environmental regulations by devising new, cheap technologies for compliance. These technologies may then be sold competitively on international markets. Examples are clean coal technology, which the U.S. Department of Energy expects to be saleable abroad.

4. Environmentally conscious manufacturing or production can be a form of product differentiation or advertisement. Faced with equal or even higher prices for a good produced by an environmentally conscious firm, many consumers will choose it over goods produced by polluting firms. Examples include tuna advertised as "kind to dolphins" and the boycott against Exxon by some consumers after the Valdez oil spill.

B. Why environmental regulations might hurt competitiveness

Inefficient regulations that set emissions limits too low or high, or that rely on too many command and control measures, can cause the following effects:

1. As mentioned above, the cost of compliance could be greater or less than the benefit received from compliance. This inefficiency will cause the cost of the good produced to be too high or too low, respectively. Krupnick and Portney's (1991) analysis of the Clean Air Act Amendments, described below under "lessons learned," illustrate this situation.

2. Command and control measures are unlikely to result in cost-minimizing pollution abatement. Therefore, amount of pollution abated per dollar spent under command and control measures is likely to be less than the amount abated per dollar under more market-based incentives, such as taxes and subsidies.

3. If other countries have more efficient regulations, their costs of production will be lower, and their goods will be more competitive. Also, it is argued that the cost of production is lower (and, hence, competitiveness is greater) in countries where environmental laws are lax. This is the "pollution haven" hypothesis that polluting industries use to oppose environmental regulations. It is discussed later in this paper under the section on trade effects.

4. The transaction costs of compliance (monitoring, permit fees, litigation costs, etc.) are money spent on non-productive goods. The more we spend on them, the less we spend on investment in productive capital. An example "in the making" is the hundreds of billions of dollars that the U.S. Department of Energy is planning to spend on environmental restoration; since their total budget is kept fairly constant, every dollar that goes into environmental restoration is one dollar less spent on research and development of products that may make the U.S. competitive.

III. Can we measure environmental costs and benefits?

A. What to count?

Environmental regulations are often designed with the best intentions of informed policy makers, but the transformation of policies during the political process can result in a "do nothing" regulation or, worse yet, create a monster. More economic impact analysis during all stages of regulation design, debate, passage, and implementation, coupled with education of the public, are critically needed to prevent expensive mistakes.[2] Economic analysis, i.e., determination of cost and benefits and the prediction of the impact of a policy on supply and demand, can be difficult to quantify, but economists have made progress in valuing social goods, and the production functions (equations that describe the quantity and relations of inputs to outputs) for a single industry can be approximated. The U.S. Environmental Protection Agency (EPA) recommends estimating the following costs for "end-of-the-pipe" measures to determine the impact of a regulation (United States Environmental Protection Agency, 1990):

- capital costs (plants, equipment, and construction); and
- operation and maintenance of pollution abatement processes (materials, equipment leasing, parts and supplies, direct labor, fuel and power, private contractor services, and research and development.)

If we use only EPA's guidelines, one might underestimate the costs, which will also include the following according to Portney and Krupnick (1989) and Booth and Trocki (1991):

- pilot tests;
- permit fees;
- life cycle reporting and monitoring costs;
- expected costs of litigation and insurance;
- overhead;
- health and safety protection;
- community relations program;
- government enforcement costs; and
- contingency (proportional to the uncertainty of performance of the abatement measure).

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[2]Multiattribute utility analysis (MUA), a list of criteria by which one ranks an alternative, is also frequently used to evaluate specific pollution abatement measures. The author prefers cost-effectiveness (CE) and cost-benefit (C-B) analysis to this technique because CE and C-B put all effects into one metric--the dollar or peso--which can be summed. MUA relies on combining scores from diverse measures and weights (e.g., public acceptability measured on a scale from one to ten and number of deaths expected per year) into a rank. In the hands of experienced practitioners, MUA is theoretically sound and useful. It is not used, however, to measure impacts of environmental regulation in the whole economy.

Another study (U.S. Congressional Budget Office, 1988) that outlines the issues of measuring the costs of environmental legislation categorizes most of the costs above as industry-wide compliance costs and adds to these the following:

- macroeconomic effects (changes in the level of income, employment, and final prices for the whole economy);
- trade effects; and
- changes in social welfare, including distributional effects (consumer inconvenience costs and decreases in consumer surplus[3]).

The benefits that must balance these costs are generally measures of the value of the environmental improvement, or the value of preventing further environmental degradation, i.e., *costs that society avoids*, such as the following:

- avoided health care costs;
- avoided morbidity costs;
- avoided litigation costs;
- avoided environmental damage costs; and
- the value that consumers place on the preservation of a resource (such as recreational use values, or an existence value[4]).

Measuring the up-front costs of an abatement measure is not enough information to determine if the costs are comparable to the benefits. We are dealing with a very complex natural system--the environment--or fairly complex machinery that may not be adequately maintained. One needs to know how the measure will perform in both the short term and the long term and what its effectiveness will be in reducing or eliminating environmental problems. Measurement of the costs and benefits may require sophisticated atmospheric or groundwater modeling and risk analysis to predict the effect of a pollution abatement measure. For example, shutting down a refinery in Mexico City is probably a good idea to lower air pollution and reduce health risks, but its effect on air quality must be balanced against the number of jobs lost, construction of a replacement refinery elsewhere, and possible increases in the cost of transporting refined products to Mexico City. Neither the effect on air quality nor the effect on the economy are easy to measure. The joint studies of the Mexican Petroleum Institute and Los Alamos on air pollution abatement

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[3]Consumer surplus is the sum of the incremental amount above the market price that each consumer would have been willing to pay for a good. For example, the more competitive market for petroleum allows a consumer who would have been willing to pay $30 per barrel buy it for $20 per barrel. The resulting surplus for that consumer is $10 per barrel. If pollution abatement costs increase the market price to $23 per barrel, the consumer's surplus decreases to $7.

[4]An example of a recreational use value would be the amount that I'm willing to pay to camp in a national forest campground or the cost of a fishing license. An example of an existence value is the amount that I'm willing to pay to prevent extinction of an exotic plant or animal that I may never see.

in Mexico City rely upon atmospheric dispersion and chemistry modeling to predict the effect of a measure that reduces release of pollutants on Mexico City air quality. Input-output modeling is one way that economists have measured economy-wide impacts. In other studies being performed by Los Alamos, we apply groundwater modeling to optimize remedial measures and compare the cost-effectiveness of alternative measures. Health risk analysis is commonly performed to evaluate alternative environmental remediation alternatives.

Although environmental economists have made progress in quantifying costs and benefits, most analyses require prediction of future events, which is fraught with uncertainty. Uncertainty levels exist for nearly every variable in the equation: compliance costs, costs of non-compliance, effects of compliance, measures of benefits, and the timeframe over which effects will occur. Levels of uncertainty are clearly visible in the international controversy over what should be done to abate greenhouse gases. Thus, a policy analyst does not compute a deterministic number, but reports an expected monetary value that represents the probability distribution of a variety of possible outcomes. Other important reporting requirements include results of sensitivity studies and the size of the uncertainty of results.

Another complicating factor in the analysis is the choice of an economic discount rate. One typically discounts the sum of multi-year costs and benefits to obtain a net present value in constant dollars. The choice of discount rate is controversial. High rates tend to discount the effects on future generations while low rates assume that new solutions won't be available to future generations and we have to value their utility almost equally to ours.

The choice of a pollution control level, and an environmental regulation in general, is often like buying an insurance premium--one never knows exactly how much to buy or how much will be used, but most people agree that they need some insurance.

B. Some "lessons learned"

1. Costs of analyzing policy options. Rubin (1991) offers a critical analysis of the recently-completed, ten-year-long National Acid Precipitation Program (NAPAP). The study began in 1980 with the goal of addressing five key questions, including "What are the estimates of future environmental conditions based on realistic assumptions about the effects of acid rain abatement alternatives?" and "What do comparisons of the effects of alternative scenarios mean?" Rubin finds that the massive study reported much scientific data but failed to interpret the results in a form that the policy maker could understand, i.e., the dollar value of benefits. He also criticizes it for failing to adequately address uncertainties and "The assessment does not take the lead in posing other questions. For example, as in Europe and Canada, one could first ask what

critical loads or changes in deposition are needed to avoid effects, and then work backwards to determine the appropriate emissions reductions. ... By not asking some of the right questions to begin with, the NAPAP assessment simply missed the boat in terms of influencing key public policy decisions." p. 919. Rubin implies that a complex effort that cost tens of millions of dollars had no effect.[5]

2. The U.S. Clean Air Act Amendment (CAAA). The value of this amendment has yet to be determined. The jury will be out on this one for a long time. The U.S. Congress passed the amendment in 1990 to require sharp reductions in sulphur dioxide emissions by electric power plants, to impose state-of-the-art control technology to prevent release of air toxics, and to impose more stringent measures on districts that are having difficulty with ozone compliance. Krupnick and Portney's (1991) evaluation of the costs and benefits of the CAAA estimated that control costs in the South Coast Air Quality Management District (the Los Angeles area) would amount to $13 billion per year and the benefits, $4 billion (based on avoided premature mortality, avoided ozone- and particulate-related morbidity, and material damages). They compared these costs and benefits with returns from an alternative health investments, where "In the health area alone, $10 billion invested in smoking cessation programs, radon control, better natal and neonatal health care, or similar measures might contribute much more to public health and well-being." p. 526.

Krupnick and Portney's conclusions on the applicability of environmental cost-effectiveness analysis re-affirm the theme of this paper:

> Finally, implicit in our discussion is discomfort with the premises on which our national air quality standards are now based. If, as seems likely, there are no pollution concentrations at which safety can be assured, the real question in ambient standard setting is the amount of risk we are willing to accept. The decision must be informed by economics. Although such economic considerations should never be allowed to dominate air pollution control decisions, it is unwise to exclude them. -- p. 527

3. The Comprehensive Environmental Response, Compensation, and Reliability Act (Superfund) and Superfund Amendments and Reauthorization Act. Superfund regulates cleanup of hazardous land pollution caused by past activities. It assigns responsibility and cost to owners who may not have even caused the pollution, which stifles potential investors. In addition, it has been implemented so poorly that the U.S. Office of Technology Assessment, in a report entitled "Are We Cleaning Up?," concluded that although $11 billion had been spent on cleanup or containment of a small fraction of the Superfund sites, little had been

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[5]Of course, the money was not entirely wasted. The opportunity still exists to quantify costs and benefits. However, since the alternatives and abatement measures that received so much analysis may not be the optimal ones, a considerable amount of work might need to be repeated to determine optimal levels of acid rain control.

accomplished in eliminating the hazards; the remediation would likely have to be done over again because the initial attempts were inadequate.

Abandoned Superfund sites will require a total of $80 to $120 billion to remediate, and federally owned sites will require an additional $75 to $250 billion. Estimates for the nuclear weapons complex cleanup total $300 to $700 billion over 30 years (Passell, 1991). Are the resulting reductions in health risks worth the benefits? Many think not.

> "To be sure, the problem of weighing the cleanup benefits against the costs is complicated by a lack of information about how dangerous individual chemicals are, and in what concentrations. Nonetheless, experts insist that what began as a crusade against polluters has become a diversion, siphoning money and technical expertise from more pressing environmental concerns." --Passell, (1991) p.1.

III. What do theory and lessons learned mean for competitiveness, and Canada, Mexico, and the U.S.?

A. Trade effects may not be significant

Studies of the effect of environmental regulation on trade and competitiveness were stimulated by the "pollution haven" hypothesis that polluting industries would relocate to countries where environmental regulations were less stringent or non-existent (i.e., developing countries) and would "trash" their environments; jobs and exports would be lost in countries with stringent environmental regulations. These hypotheses have largely proven wrong for several reasons. Leonard (1988) found that patterns of investment in industrialized and industrializing countries could not be correlated with relative pollution abatement costs in the countries. Tobey (1990) examined trade patterns and found similar results. Several other studies conclude that environmental regulations and pollution abatement costs are similar in industrialized countries, and, even where relative costs differ, other determinants of trade, such as relative labor rates, interest rates (i.e., cost of capital), the price of inputs, exchange rates, and political and economic stability, are far more important in determining competitiveness and levels of foreign investment in a country (U.S. Congressional Budget Office, 1988; and Cropper and Oates, 1991). Multinational corporations make it a practice to install state-of-the-art pollution control equipment in countries in which they invest, regardless of the national environmental regulations. This "premium" invested in good environmental practices protects them against future changes in environmental regulations and establishes good community relations.

Another reason why environmental control costs are not critical to competitiveness is that they are not very large. Cropper and Oates (1991) cite average control costs as "only 1 to 2 1/2 percent of total costs in most pollution-intensive industries" (p. 41). They cite another author's work that listed the highest cost to an industry as 5 1/4 percent of total costs for electric utilities.

EPA estimates that annualized pollution control costs[6] in the U.S. averaged 1.7 percent of Gross Domestic Product (GDP) in the 1980s and are expected to increase to 2 percent in the late 1990s. EPA cites a study by the Organization for Economic Cooperation and Development (1990) that reported annual[7] pollution control costs as a percent of GDP.[8] The results show that control costs as a percentage of GDP were highest in the former West Germany. With the exception of Norway, where annual costs were 0.82 percent, the relative costs are comparable among the countries included.

Based on the studies cited above, the U.S., Canada, and Mexico should not concern themselves with the effect of environmental regulations on competitiveness.

B. Who pays for what along borders?

Possible transboundary pollution problems between our three countries include the following: air pollution from industries on both sides of the border; pollution of rivers in the U.S. that deteriorate the water quality available to Mexico; Great Lakes pollution; potential off-shore oil spills that affect coastal waterways; inadequate waste treatment and migration of pollution to neighboring countries; and pollution caused by industries of one country operating in a neighboring country.

The country where the transboundary pollution originates should pay for damages caused by that pollution in neighboring countries. This is the equitable arrangement, but it is impossible to implement. One cannot conclusively prove that acid-rain damage to a forest along the U.S.-Canada border came from the Sudbury smelter or U.S. industry along the Great Lakes. We should, however, be able to allocate relative responsibility for damages caused by transboundary pollution from knowing total emissions from industries on both sides of the border and atmospheric conditions that determine a pollutant's direction of travel. The European Economic Community is considering the following options, which may offer some solutions to

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[6]To compute annualized costs, capital costs are spread out over an amortization period and include depreciation and interest. Annual operation and maintenance costs are added to the amortized capital costs to obtain the annualized costs of pollution control.

[7]Annual costs include all capital, operation, and maintenance expenses for pollution control incurred in a given year. Capital costs are not amortized.

[8]The household sector is excluded from the GDP, except for France and the United States, where percentages are reported relative to GDP with and without the household sector.

Canadian-U.S.-Mexican border issues: introduction of international pollution controls, such as the "national bubble" (a pollution quota within an imaginary bubble drawn around a country); establishment of critical loads (pollution standards for a given area); and payments from one country to another to reduce transboundary pollution (Wood, et al., 1989). In addition, the state implementation plans to redress ozone pollution in New York-New Jersey-Connecticut may provide some other models or mechanisms for dealing with transboundary problems.

We do not necessarily have to look to other regions or states to provide examples of how to solve border pollution issues. A working group for each environmental medium was formed to study pollution under the Binational Environmental Agreement between the U.S. and Mexico. The U.S. and Canada have made great progress in solving disputes over acid rain. In their study of pollution from the maquiladora assembly plants in Mexico, Perry et al. (1990) note that Mexico's Ley General del Equilibrio Ecologico y la Proteccion al Ambiente and associated regulations of 1988 specify that any hazardous waste generated by a maquildora industry must be returned to the country of origin. Since the maquiladoras are becoming "higher tech" and use increasing amounts of hazardous solvents, the number of maquiladoras exporting waste and the volume of the exports should grow. However, EPA records show that only 1 percent of maquiladoras operating in northern Baja California and Sonora requested shipment of hazardous waste to the U.S. The percentage of maquiladoras producing waste is much larger. The low number of shipments is either an information tracking problem or a lack of compliance. The Hazardous Materials and Waste Management Work Group, one of the Mexican-U.S. work groups formed under the Binational Environmental Agreement, is addressing this problem.

While we do not yet have many of the solutions for who pays for what along bor[illegible] nor how much they should pay, we are making significant progress in cooperative studies of the problems. In the future, more cooperation, compensation, and incentives are needed to minimize transboundary pollution.

C. Beyond the borders: A North American agenda for environmental cooperation

"Regionalism" seems to be the theme of many national security conferences these days. With the dissolution of a bipolar national security environment defined by two superpowers, analysts project increasing economic and political ties that strengthen regions. European economic integration of 1992, combined with the diminished role of the U.S. and Canada in the North Atlantic Treaty Organization, may weaken North American ties to Europe and possibly make North American goods less competitive in Europe. The Europeans more actively address shared environmental problems than do North Americans. In contrast to our "foot dragging" over Global Climate Change, Europeans are actively considering stabilization of greenhouse gas emissions by curtailing the use of fossil fuels in Europe. The Japanese are

developing clever new technologies to minimize carbon dioxide emissions from fossil fuel combustion. Leasing arrangements offered by the Japanese even mitigate the large, up-front capital costs required for energy and environmental efficiency improvements. When and if we decide to do something about carbon dioxide emissions, we will perhaps be following Europe's lead in fuel efficiency and diversification of energy supplies and buying Japanese equipment to accomplish these measures.

The global climate change issue is a prime example of the uncertainty surrounding formulation of an environmental policy, and a joint approach will require much time, effort, and concessions to develop. The three countries can, however, increase cooperation soon in several areas that might lessen emissions of greenhouse gases and solve other common environmental problems. Several examples of cooperation exist already because they made economic sense: exploitation of Canada's hydroelectric power to avoid further reliance on more polluting fossil fuels in the northeastern U.S.; and active consideration of a natural gas pipeline that could could allow more replacement of other, dirtier fossil fuels.

We should immediately begin sharing information and providing technical assistance to each other to avoid the perils and pitfalls of environmental policy formulation discussed earlier in this paper. At a time when the Canadian government is doubling environmental expenditures under the new Green Plan (Anonymous, 1991) and the Mexican government is implementing its new environmental law, joint studies to maximize preservation of our continent's rich natural resources at reasonable cost are ripe for implementation. None of us can afford to waste any more resources on inefficient environmental programs, such as the mistakes made under Superfund. Each of us alone would have to spend vast sums of money developing the tools to measure environmental costs and benefits. These tools should be shared among the countries.

Other areas besides policy formulation ("talking") and enforcement ("policing") can perhaps yield much larger benefits. The free trade negotiations present an excellent opportunity to increase the flow of "environment-friendly" technologies across borders. One area is more market penetration of energy-efficient technology. Since energy consumption causes many of the negative environmental side effects, increased energy efficiency becomes increasingly important from an environmental as well as an economic point of view. Much energy-efficient technology is already available, but has not been adopted because consumers do not appreciate its potential savings. We could cooperate on educating energy consumers through public information campaigns. We could also jointly consider the difficult political issues of increasing energy prices or imposing a carbon tax.

Another area for possible cooperation exists: the huge, polluted natural laboratories of Los Angeles and Mexico City. We should increase joint studies of air pollution, such as the one between the Mexican

Petroleum Institute and Los Alamos. Expensive models and technologies to characterize and abate air pollution can be shared.

Most importantly, beyond joint policy formulation and information sharing, we can encourage North American leadership in pollution abatement equipment manufacturing by opening a large regional market to such equipment and jointly producing the equipment. Joint venture arrangements between Canada, Mexico, and the U.S. should be considered.

The global nature of greenhouse warming and the regional nature of acid rain and water pollution mandate a coordinated North American approach to these environmental problems. None of us can afford to act alone to curtail air pollution if neighboring nations cancel our efforts by continuing to pollute.

IV. Conclusions

To preserve and increase quality of life and to protect our productive, economic resources, we need environmental regulations. These regulations should be implemented in an economically efficient manner, with use of taxes, subsidies, and pollution permit trading where possible. Since environmental regulations seek to control very complex systems, it is hard to predict if the full life-cycle costs of controls will equal the full life-cycle environmental benefits. Health risk analysis and equity issues deserve strong consideration in formulation of plans. Public education is also needed to focus attention on the most damaging hazards. Economic, risk, uncertainty, and equity analysis are all critical ingredients to formulation of effective environmental regulations.

Lack of perfect information is no excuse for inaction. Given the magnitude of the possible economic effects of environmental damage, we must take an expected value approach and begin to insure ourselves against these damages.

To date, costs of environmental controls have not been shown to affect economic competitiveness because these costs are relatively small and are overwhelmed by the cost of other production factors. However, spending several billion dollars annually on environmental controls and cleanup means several billions less will be spent on more productive private and social investments. Given the magnitude of the costs involved, it is critical to share knowledge and control technologies to maximize the amount of pollution abatement per dollar or peso spent. Diplomacy, good scientific and economic information, and equity analysis should govern our negotiations over transboundary pollution prevention and cleanup. Canada, Mexico, and the U.S. should place environmental technologies high on the priority list under the free trade

agreement. These technologies can help us to minimize our continent's pollution, to become more efficient producers, and to compete in world markets in a growing technology area.

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References

Anonymous, 1991, "Canada's Green Plan: Blueprint for a Healthy Environment," Environment, v. 33, no. 4, p. 18.

Booth, S.R. and L.K. Trocki, 1991, "Cost-Effectiveness Analysis of New Environmental Technologies," Proceedings (forthcoming), HAZMAT South, September, 1991, Atlanta, Georgia.

Cropper, M.L. and W.E. Oates, 1991, "Environmental Economics: A Survey," Resources for the Future Discussion Paper QE90-12-REV.

Krupnick, A.J. and P. R. Portney, 1991, "Controlling Urban Air Pollution: A Benefit-Cost Assessment," Science, v. 252, pp.522-527.

Leonard, H.J., 1988, Pollution and the Struggle for the World Product, Cambridge, England: Cambridge University Press.

Organization for Economic Cooperation and Development, 1990, "Pollution Control and Abatement Expenditure in OECD Countries: A Statistical Compendium," OECD Environment Monographs, No. 38, November, 1990, p. 40.

Passell, P., 1991, "Experts Question Staggering Costs of Toxic Cleanups," New York Times, September 1, 1991, p.1.

Perry, D.M., R. Sanchez, W.H. Glaze, and M. Mazari, 1990, "Binational Management of Hazardous Waste: The Maquiladora Industry at the U.S.-Mexico Border," Environmental Management, v. 14, no. 4, p. 446-7.

Portney, P.R. and A.J. Krupnick, 1989, "The Benefits and Costs of Superfund Cleanups: An Information Assessment," Illinois Institute of Technology/IIT Research Institute Report No. IITRI N08020-IV.

Rubin, E.S., 1991, "Benefit-Cost Implications of Acid Rain Controls: An Evaluation of the NAPAP Integrated Assessment," Journal of the Air Waste Management Association, v. 41, no. 7, pp 914-921.

Tobey, J.A., 1990, "The Effects of Environmental Policies on Patterns of World Trade: An Empirical Test,", Kyklos, Fasc. 2.

U.S. Congressional Budget Office, 1988, "Assessing the Costs of Environmental Legislation," Staff Working Paper No. PB90-202698, 37 p.

United States Environmental Protection Agency (EPA), 1990, Environmental Investments: The Cost of a Clean Environment, EPA Report No. EPA-230-11-90-083, p. 1-4.

Wood, W. B., G.J. Demko, and P. Mofson, 1989, "Ecopolitics in the Global Greenhouse," Environment, v. 3, no. 7, p.16.