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Cornell University, Ithaca, New York 14853-7801 USA

ENVIRONMENT AND TRADE: A Review of the Literature

Jean Agras, Vivek Suri, and Duane Chapman

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ENVIRONMENT AND TRADE:

A Review of the Literature

by Jean Agras, Vivek Suri and Duane Chapman*

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*Department of Agricultural, Resource, and Managerial Economics at Cornell University, Ithaca, NY. The authors wish to thank Eleanor Smith for her invaluable assistance in the preparation of this manuscript.

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I. INTRODUCTION

With advances in communications and other technologies, the world is, in some respects, shrinking. Countries are becoming more interdependent on one another through multilateral trade agreements. Traditional trade theory suggests that this increase in openness will encourage growth and development. But what will this mean for the global environment? Will there be a worsening of global pollution, will there be an acceleration of regional differences in pollution intensity, or will free trade lead to a general improvement in environmental protection?

Three issues of equal significance within the environment and trade literature need to be addressed. However, these topics do not receive equal coverage in the literature. First, environmental costs could be a major factor in the relocation of industry from environmentally protected economies to "pollution havens." However, all but a few authors estimate environmental costs to be low enough so as not to be a deciding factor in industrial relocation. Second, the hypothesis that trade encourages growth (often through industrialization), which in turn reduces pollution, seems counter-intuitive. Leading us to the final issue, which receives the least coverage in the literature, but may be the most important, are global pollution levels affected by trade? By increasing growth through industrialization in countries where little to no environmental regulations exists, is it possible to decrease or even maintain global pollution levels?

This review of the literature on environment and trade attempts to address some of these issues. The first section, on environmental costs and international trade, looks at the influence of environmental costs on the migration of dirty industries in the context of trade between nations. Next, the issue of cooperation in alleviating environmental

problems and the debate over harmonization of standards across countries is reviewed. Current issues in trade liberalization are the focus of the following section. Papers on NAFTA address some of the questions of how trade and growth will affect the environment. Finally, the potential role of technology transfer in promoting growth in developing countries while protecting the local environment and the global commons is explored.

II. ENVIRONMENTAL COSTS AND INTERNATIONAL TRADE

In an international setting, the differences in environmental regulations and their related costs between countries can have three potential implications for trade, industrial location, and pollution emissions. First, the country which imposes stricter environmental controls would, *ceteris paribus*, lose in terms of competitiveness. Second, differential costs of pollution control might cause investment in polluting (or dirty) industries to be displaced to the so called pollution havens. Since environmental controls are typically less stringent in developing countries, it is here that the displaced industries would relocate. Third, the existence of free trade between countries with differential environmental protection practices could lead to greater total pollution levels than would otherwise be the case.

These international implications of environmental control are certainly interrelated. However, researchers have usually concentrated on one or the other of them. Each is discussed in turn below. Dean (1992) provides a thorough discussion of many of the papers reviewed in this section, as well as other papers relating to this subject.

A. Environmental Costs and International Competitiveness

Environmental regulations impact the cost structure of an industry in two ways: 1) directly, due to the environmental expenditures of a particular industry itself and 2) indirectly, through increased costs of inputs from other industries also incurring environmental expenses. The indirect impacts are usually incorporated by employing input-output (I-O) (or inter-industry) tables.

Walter's (1973) study represents one of the earliest attempts to measure the direct and indirect impacts of environmental controls on the international competitiveness of the United States (US). Pollution related costs were found to contribute 1.75% and 1.52% to the total value of US exports and imports, respectively. This difference was not considered large enough to conclude that environmental costs would significantly impact the US balance of trade.

The study by Robison (1988) is similar to Walter's but is updated and more refined. He augmented the standard I-O coefficients matrix to include a portion of abatement costs left out by other studies: those implicit in the capital goods used in the production process. By examining the pollution abatement content of the value of US imports and exports for the years 1973, 1977, and 1982, Robison found that pollution control programs have changed the US comparative advantage so that more high-abatement-cost goods are imported and more low-abatement-cost goods exported.

To estimate the impact that this changing pattern of trade would have on the balance of trade, Robison built on the theoretical work of Baumol and Oates (1975), which modelled balance of trade conditions for a two-good, two-country world. These conditions were extended to 78 industries. Indirect effects, not considered by Baumol

and Oates, were also included. If additional abatement costs raise the sectoral price by 1%, Robison estimated that the adverse impact on the balance of trade was less than 1% of the total value of US trade in the three years studied. An interesting finding is that these adverse impacts grew by 218.9% between 1973 and 1982.

Both Walter and Robison assumed that environmental costs pass through fully to prices. Moreover, both studies ignored mitigating effects on the balance of trade that might occur through macroeconomic adjustments, such as exchange rate movements or improved terms of trade. Thus, according to Robison, his estimates represent an upper bound for trade impacts.

These macroeconomic feedback effects were modelled explicitly in a study by Mutti and Richardson (1977). There is much to be gained from this methodological improvement. They modelled the impacts of environmental regulations in a general equilibrium framework under two different sets of macroeconomic assumptions. The first is a "macro-orthodox" approach in which prices are invariant to the scale of economic activity and the system is demand dependent. Income is endogenous and balance of trade is equilibrated through exchange rate movements. The second is a "classical" approach where a supply equation is introduced into the model. Wages and prices are flexible and balance of payments behaves according to the "monetary" approach. In addition, for each case their analysis was carried out under two methods of financing environmental control: the polluter pays principle and subsidization out of general tax revenues. They concluded that partial-equilibrium input-output methods that ignore macroeconomic feedbacks tend to overstate the consequences of environmental controls (as Robison acknowledges). They are, however, not sure which one of the two

refinements is desirable, because the predictions under the two sets of assumptions are quite different, especially when the tax-subsidy mode of financing is chosen.

Environmental costs imposed on US industry also reduce the effective rate of protection afforded to it by the existing tariff structure. Pasurka (1985) employed an I-O table to quantify this loss. The loss in the effective rate of protection was estimated for two cases for the year 1977: first, when only direct environmental control costs affect the net level of protection and second, when the higher costs of environmental controls are passed along through higher input prices. In the aggregate, Pasurka found that the loss of protection (19.67% for the second case above) did not impose an unreasonable burden on the competitive position of US industry.

All of the above studies reached a similar conclusion: environmental costs do not significantly impact the overall competitive position of the US. All these studies do, however, agree that certain industries will be affected much more than others and that their loss in competitiveness could be substantial. The sectors affected most severely are chemicals, primary metal industries, paper, and petroleum and coal products.

A weakness of these studies is that since data on foreign abatement costs are not available, they are assumed to be the same as those incurred by import competing sectors in the US. But, since US environmental costs are generally higher than in the rest of the world, the environmental loading of US imports is likely to be overestimated.

There are also strong reasons to believe that the real costs of pollution abatement to US industry are much higher than those suggested by recorded data. All the studies reviewed above used data collected through surveys by the Bureau of Census and the Bureau of Economic Analysis. Chapman (1991) conducted a detailed

review of copper production costs and found that environmental protection and worker safety costs were highly underestimated by survey data. He attributed this to a number of factors. Many environmental activities that are part of the production process may not be reported in surveys, e.g. the costs of dust control in a pit mine by use of watering trucks. In addition, monitoring and planning activities may be excluded from survey data. An important omission relates to the cost of protection for workers from environmental hazards. Environmental costs that are reported are also influenced by the perception of the current management. Typically this leads to non-reporting of environmental expenditures that were initiated in the past, tall smoke-stacks are an example.

Low (1992) also notes that certain abatement related expenditures appear to be excluded from recorded data. He points out that the capital costs, from which the depreciation allowance for pollution abatement machinery are taken, are themselves based on end-of-the-pipe adjustments to installed equipment and not to new machinery. In addition, Low observed that there may be certain lower cost production processes which are prohibited and therefore do not appear in reported data, imposing a hidden cost on affected users.

Gray and Shadbegian (1993) analyzed environmental costs from a somewhat different perspective and concluded that their impact is more significant than is generally believed. They examined the effects of environmental regulation (as measured by compliance costs) on the Total Factor Productivity (TFP) of an industry, in an econometric framework. The industries analyzed included paper, oil refining, and steel. They estimated that, on average, a $1 increase in compliance costs reduced

TFP by the equivalent of $3-$4. Thus, growth accounting studies (e.g. Denison 1979), which assume a dollar-for-dollar impact of compliance costs on productivity, substantially underestimate the effect of environmental regulation.

B. Environmental Costs and Industrial Displacement

The issue of migration of dirty industries to countries with lower environmental standards has been recently addressed by Lucas et al. (1992) and Low and Yeats (1992). Lucas et al. used a fixed-effects pooled regression model to examine the behavior of toxic emissions per unit of total and industrial GDP (toxic intensity) across countries and over time (1960-1988). They found that the toxic intensity of *total* GDP exhibited an inverse U-shape with relation to income (per capita GDP). On the other hand, toxic emissions per unit of *industrial* GDP continued to rise with income. From this they infer that the fall in toxic intensity of total GDP was merely the result of a compositional shift in favor of industrial production. Importantly, they found that toxic intensity of industrial production has risen faster in developing countries, implying that dirty industries have moved into them.

Low and Yeats (1992) reached a similar conclusion through a different route. They examined trade share data and found that the share of dirty industries in total world trade declined between 1965 and 1988, largely as a result of trends in industrial countries. Over the same period, the share of dirty industries in the exports of many developing countries rose, which provides an indication of migration. They strengthened their argument by using the concept of revealed comparative advantage (RCA). If the share of a certain industry in a country's manufacturing exports is larger

than the share of the same industry in total world trade in manufactured goods, then the country has an RCA in that industry. In the period studied, Low and Yeats found that developing countries acquired RCA's in dirty industries at a much faster rate than industrialized countries. Also, this rate for developing countries was higher than their average for all other industries.

Lucas et al. and Low and Yeats, however, did not address several issues. Does the growth of dirty industries in developing countries simply reflect their process of development, since the industries usually characterized as dirty are those which tend to predominate in the early stages of industrialization? Or does it reflect their resource endowments in the sense that developing countries do actually have a comparative advantage in these industries? If either of these is the case, then it implies that dirty industries have only been dispersed, rather than dislocated from countries with stricter environmental standards.

It is sometimes asserted that the comparative advantage that developing countries might have in the more polluting industries stems not only from their natural resources but also from their larger assimilative capacity for pollutants relative to the industrialized world. Pearson (1987) considers this latter source of comparative advantage a misconception and puts forth reasons why this may be so. One reason is that industrial production within individual developing countries tends to be highly concentrated in zones where infrastructure requirements are available. Any relocation of industries from the developed world is likely to take place into these zones where the local assimilative capacity is already near exhaustion. This argues against automatically assuming that developing countries have a comparative advantage in polluting industries.

Leonard and Duerksen (1980) and Leonard (1984) argue strongly that environmental factors have not been key determinants in the location decisions of the majority of dirty industries. Both studies are of a similar nature, with the latter being more detailed and updated. Leonard (1984) analyzed foreign investment and import trends by US firms between 1970 and 1982 to test the industrial flight and pollution haven hypotheses. He concluded that, despite stricter environmental regulations, the investment patterns of US industries have not changed significantly. Overall, the imposed regulatory burden has not overridden the more traditional factors that determine the location of industries, namely, market considerations, transportation and labor costs, and political stability. This, however, is not to say that environmental regulations have not had any impact at all. Leonard also notes that pollution control and workplace health standards have played the chief role in relocating industries that produce highly toxic substances, like asbestos, and some basic mineral industries, like copper, zinc, and lead processing.

An important point made by Leonard relates to demand conditions and technological factors. Industries that have been dislocated have generally been those faced with reduced demand and lagging technological innovation. On the other hand, some highly polluting industries which experienced strong demand conditions have stayed in the US. This happened because producers found technological improvements that are more economically efficient than moving overseas.

Tobey (1990) employed the Heckscher-Ohlin-Vanek model of international trade to study whether the environmental endowment of a country, measured by the stringency of environmental regulations, has an impact on trade patterns. His

econometric study complements the less rigorous analyses of Leonard to arrive at similar conclusions. Tobey used resource endowments as explanatory variables in a regression model, with trade across countries in a specific commodity as the dependent variable. Two approaches were used to capture the effect of the environmental endowment. In the first approach, it was represented by a qualitative variable. In the second, the environmental endowment variable was omitted from the regression and the bias in the residuals was investigated. Tobey found that the strict environmental regulations that came into effect in the late 1960s and early 1970s in many industrialized countries have not measurably affected international trade patterns in dirty industries.

Birdsall and Wheeler (1992), however, argue the opposite of Tobey based on their study of a cross-section of Latin American countries over the period 1960-1988. They regressed pollution intensity of GDP on per capita income, growth of per capita income, and the degree of openness. Among other things they sought to study the displacement effect of stricter OECD regulations by introducing dummy variables for the 1970s and 1980s. They found that growth rates of pollution intensity in Latin America were generally higher after OECD environmental regulations were tightened, thereby lending support to the displacement hypothesis. This also led Birdsall and Wheeler to infer that the fully-accounted costs of pollution control may be much higher than suggested by previous work.

Hoffnar et al. (1993) find evidence in support of industrial flight from US to Mexico in their study of the maquiladora industry. They contend that an increase in pollution abatement costs (PAC) in the US has contributed to the growth of the maquila industry in Mexico.

In their model, the gains from shifting production from the US to Mexico is a function not only of differential PAC but also of "moving costs". If PAC and moving costs are positively correlated then the latter tends to erode the abatement cost advantage. This is expected to happen in the case of highly capital intensive industries. The authors regard this relationship between moving costs and PAC as an empirical question.

In order to test for the industrial flight hypothesis, the gains to moving from the US to Mexico is regressed on labor intensity in the US and Mexico, the relative wage, and abatement costs in the US. A panel data set of nine maquila sectors matched to the same number of two-digit-SIC industries in the US from 1979-1988 was used. Two proxies were used for the dependent variable - percentage change in value added in the maquila sector and percentage change in the number of maquila firms in the particular sector.

The operating expenditure component of PAC when entered separately was found to be positive and significant in most of the model specifications, thereby supporting the industrial flight hypothesis. Capital expenditures for pollution abatement were found to be insignificant. This is perhaps due to the counteracting effects of moving costs, which were not included in the regression.

Interestingly, the coefficient of labor intensity was found to be negative for Mexico. The authors assumed this implied that maquiladora growth was generated by non-labor intensive industries. One explanation that the authors' provide is that firms wishing to introduce capital intensive methods of production in the US are prevented from doing so by labor unions and find it easier to do so in Mexico.

However, the labor intensity variable for both countries was calculated as a proportion of revenue, with wage rate times labor input in the numerator. An increase in either wages or the amount of labor used would imply that profits would fall. Lower profits means slower growth, indicating that the Mexican coefficient should be negative and the US coefficient should be positive, as they are.

Whalley and Wigle (1991) provide a different perspective on industrial displacement. They considered what might happen to trade patterns when policies aimed at reducing global CO_2 emissions are put into force. They modelled the effects of a 50% cut in emissions through various tax schemes and a per capita ceiling on CO_2 emissions in a static computable general equilibrium (CGE) framework. In the scenarios considered, developed countries changed from net exporters to net importers of energy-intensive goods (which are also pollution intensive). This supports the likelihood of displacement of dirty industries to developing countries.

III. COOPERATION VERSUS NON-COOPERATION IN POLICY MAKING

Achieving cooperation among countries is often a difficult process of negotiation and implementation. However, one can see from the literature that, to achieve the optimum welfare for the world as a whole, cooperation is often the best course of action. Although economists argue against harmonization of environmental standards as a basic policy, a recent *New York Times* article (Golden, 1993) highlights the importance of harmonization for the well-being of the planet. Mexico's recent proposal for the construction of a new power plant near the US border has raised the concern of people in the US. In today's world, with new technologies available for emission control

in plants, the threat of further air pollution in the US and Mexico is deemed unnecessary. However, Mexico argues that the cost of abatement technologies is too expensive to be considered for their nation. This section reviews reasons for cooperation among nations and ways in which this may be accomplished.

A. Optimal Policies Under Cooperation

The debate in the literature on multilateral versus unilateral action concerning trade and the environment almost unanimously sides with cooperation. Theoretical models generally find unilateral action to be a suboptimal choice. However, most authors acknowledge that there are many difficulties and obstacles involved in multilateral agreements and some examine second best policy actions when cooperation is not possible.

In an applied study, Strand et al. (1992) showed how preferences, trade, and institutions coevolved in the case of living marine resources in the 1960s and 1970s. The high demand for fish and improved technology resulted in the depletion of many of the world's fish and whale populations. In the early 1970s, 20% of the world's marine resource production was redistributed, mainly through UN treaties giving coastal nations exclusive rights within 200 miles of their coast. This shifted much of marine production to developing countries, reducing the size of distant water fleets and the amount of energy used in harvesting marine resources. While stocks can still be depleted by a single country, the assignment of these "property rights" allows individuals within countries to bring suits against their own governments for management failure (i.e., conservationist groups in the US have done this). In contrast, they showed how

unilateral trade sanctions by the US were ineffective in protecting dolphin populations and preserving the US tuna industry.

Blackhurst and Subramanian (1992) cited a number of obstacles to cooperation on environmental issues involving transboundary pollution. These include interpretations of scientific evidence, priorities, disagreements over blame, and free-riders. While Blackhurst and Subramanian did not explicitly mention non-availability of data, one can see that many of the obstacles could indirectly be blamed on lack of data. With a better understanding of where the pollution is coming from, there might be less disagreements over blame and possibly the free-rider problem could be solved.

Blackhurst and Subramanian also looked at cooperation through a game theory model and found that without cooperation in a single-play game a suboptimal solution will always occur. However, through repetition and trust-building strategies a more optimal solution can be achieved. To promote cooperation, they discourage negative incentives, such as trade sanctions, and encourage positive incentives, such as side payments and trade provisions.

Safadi and Low (1992), like Blackhurst and Subramanian, also examined international pollution spillovers and optimal policy responses. Safadi and Low noted that international cooperation, as either binding international agreements or implicitly cooperative agreements, was necessary for good environmental policy. They developed a game theory model of implicit cooperation to show how this policy could be used in place of a binding agreement. While their model does not show implicit agreements to be superior to binding agreements, it illustrates that under some circumstances implicit agreements can be equally effective.

Safadi and Low identified a number of problems with international agreements, similar to those identified by Blackhurst and Subramanian. These include the number of countries involved in the agreement, uncertainty of revealed information, and the costs of binding agreements. As the number of countries involved increases, a binding agreement may be preferable. However, the costs of implementation, negotiation time, the inefficiency of indirect regulation, and the uncertainty of the information available make binding agreements less attractive.

Rauscher (1992) analyzed the changes in environmental quality and policy in Europe in response to the removal of trade barriers. Like the authors cited above, he used a game theory approach and developed some interesting results. With economic integration, in a two country model, if emission taxes are constant in both countries, the capital-rich country will reduce emissions and the capital-poor country will increase its emissions. With openness to trade this prediction holds for small countries, but is not necessarily true for a large country. A general result of his model, however, is that at least one country will reduce emissions with economic integration and capital-poor countries will increase their emissions if environmental charges or standards are not changed.

Chapman (1991) predicts that, ultimately, cooperative global agreements will govern world emissions of major pollutants. However, until such agreements are established, he suggests that "environmental or social" tariffs - based on cost advantages obtained by avoiding environmental control - have a role to play. As an example, Chapman considered trade in copper (a raw material) and automobiles (which use copper as an input). A country like Germany imports nearly all its copper from

countries with very low environmental costs. The US on the other hand produces nearly two-thirds of the copper it consumes. This gives German auto exports to the US an advantage over domestically produced autos since environmental costs for the latter are much higher. He suggests a tariff on the cars imported from countries like Germany equal to 50% of the avoided environmental cost. The proceeds from such a tariff could be used to finance pollution control in developing countries or to fund research in international environmental issues.

In general, game theory models are typically used when analyzing cooperation among countries. However, the following three papers use more traditional trade models, production theory, tax curves, and international oligopoly models in combination with game theory to make arguments for cooperation.

Due to the existence of common property resources, Markusen (1975) believes that the welfare of one country depends on the internal economic behavior of other countries. He had three objectives in his paper: 1) to develop a model in which the national government tries to maximize social welfare by use of production/trade taxes; 2) to try to find an optimal tax structure when the tax-imposing country behaves in a Cournot fashion in a two-country world; and 3) to analyze the dependence and interaction between these countries in the presence of a bilateral externality. He assumed that there is one eyesore pollutant, produced as a joint-product, and that the disutility comes from flows not from stocks.

Markusen's conclusions show that for Country I to achieve a national optimum it must decrease its production tax in response to an increase in Country II's production tax, implying an increase in Country I's welfare. A national optimal strategy selected by

each country depends on the output of the other country, while the effects of the increase or decrease of pollution on each country are not considered. On the other hand, to achieve an international optimum there exists some distribution of world income such that both countries are better off acting cooperatively, implying that Country I must maintain a higher production tax than it would under a national optimal strategy. With cooperation some international transfer payments could be involved such that Country I would be willing to offer Country II a per unit bribe. If cooperation occurs through an adjustment of tariffs and taxes, welfare will increase, but a Pareto optimal allocation will not be attained. A Pareto optimum requires that optimum production taxes and transfer payments occur simultaneously.

McGuire (1982) examined the regulation of production processes by using a model that is identical to the Heckscher-Ohlin (H-O) model in all ways but one: the environment is incorporated as a regulated factor of production. He assumed that the government wants to economize on the environment and, therefore, taxes its use. This causes industry to conserve the environment so that its marginal product will have a positive value rather than zero. McGuire further established that production process regulation is the same as neutral technical regress or negative progress. If commodity prices are held constant, the factor used relatively intensively in the non-regulated industry will gain absolutely in terms of both goods. Uncoordinated regulation destroys links between uniform world commodity prices and mobile factors will move out of a regulated economy.

Conrad (1993) argues that, from a theoretical point of view, subsidies for environmental abatement efforts should be granted only to environmental activities

generating external global benefits. He presented a rationale for this kind of thinking in the context of an imperfectly competitive world. The behavior of governments and firms was modelled as a two-stage subgame-perfect Nash Equilibrium. He allowed governments to choose emission tax rates to regulate environmental quality, while firms determined the degree of abatement and then chose output levels. Conrad contended that environmental policies should be modified to reflect the existence of imperfect competition. He found that there are national incentives in using subsidies as an environmental policy. If emissions are taxed, subsidies for abatement or inputs should be granted to help firms capture more of the world market. Subsidies can be defended by governments as part of the package to improve the global environment, since tax rates within the nation will be higher.

B. Harmonization of Environmental Standards

As Rauscher (1992) so eloquently states, economists usually think that "harmonization would imply the introduction of identical standards all over ... regardless of the assimilative capacity of nature and of social preferences." Shafik (1992) points out that environmentalists, on the other hand, tend to think of harmonization as making producers in different areas compete on a level playing field by including environmental costs. Shafik's comments get right to the heart of the debate. Environmentalists want production costs across countries to be equal, while economists think that imposing identical standards is unfair since production conditions differ across regions and countries should be able to use their comparative advantage. Shafik notes that there is some commonality in these two points of view. As an economist, she argues that,

since environmental costs are usually quite low, avoiding them does not necessarily imply a large trading advantage. However, harmonization may be necessary when international externalities are involved. Since there has been little economic research done on the case for harmonization in terms of world public bads, most of the articles cited in this section argue against harmonization on economic grounds.

Zilberman (1992) looks at the example of pesticide use in different countries to show why harmonization would not work. He notes that different climates require different amounts of pesticide use. For example, in California, the state can impose strict pesticide regulations since the dry growing season is not favorable for pests. However, if California tries to impose those same standards on areas where more pesticide use is necessary, it will gain an unfair trade advantage. This argument encompasses two issues in pesticide use: 1) internal effects (worker safety and/or groundwater contamination) and 2) external effects (food safety). California has no right to block trade on the grounds of the first reason; that is for the producing nation to decide. Only reasons of food safety are applicable for blocking imports. After a minimum standard of safety, foods could be labelled to allow for different preferences.

Robertson (1992) also disagrees with the need for harmonization of national environmental policies to allow fair competition. Liberalization of trade barriers does not require harmonization of other economic policies, and therefore, should not include environmental policies either. He suggests that those who argue for harmonization of environmental policies to avoid the creation of new trade restrictions, are ignorant of the mechanisms that provide efficiency gains from international trade. Harmonization may be sought for particular motives, but it is not necessary in order to optimize return from trade liberalization.

Pearson (1987) sees harmonization as a misconception of the relationship between standards and costs, and of the supply and demand for environmental services in developing countries. He notes that environmental protection standards take many forms: ambient standards, emission and effluent standards, environmentally related product standards, and exposure standards. The economic costs of achieving a particular ambient air or water quality standard depend on the level and the composition of economic activity, its spatial dispersion, and topographical and climate conditions, all of which vary across countries. Even if harmonization was a desirable objective, internationally uniform ambient environmental standards would not harmonize environmental control costs, nor equalize international competitive positions.

Therefore, harmonization is not desirable from an economic point of view. Rauscher (1992) states that by harmonizing standards one reverses the direction of the movement of mobile factors that occurs when barriers to international capital flows are lowered. With initial optimal solutions, harmonization can only generate negative welfare effects for both (all) countries involved.

IV. TRADE LIBERALIZATION

A. The NAFTA Debate

As the US, Mexico, and Canada began negotiations for the North American Free Trade Agreement (NAFTA), many people became interested in how trade liberalization would impact the environment. Environmentalists attacked the agreement, claiming that it would degrade the environment in both Mexico and the US. Their claims were usually supported by photos and documentation from the maquiladora region in Mexico.

The maquiladora region was created in the mid-1980s to lower trade barriers to the US market for industries in Mexico along the US border. As industries relocated to this region a noticeable deterioration of the environment occurred in both countries. Undeniably, lower wages attracted many of the industries, but an argument can also be made for Mexico's lax enforcement of its environmental regulations. However, the lack of data on emissions, water quality, or waste has rendered any good economic study virtually impossible. The one exception seems to be agricultural information, and a few applied studies have been carried out. Consequently, the few applied models that have been attempted use world-wide data and then apply their results to Mexico.

One of the most influential papers in the NAFTA debate was written by Grossman and Krueger (1992). They created a cross-sectional econometric model to develop a relationship between air quality and economic growth. They used data collected by the Global Environmental Monitoring System (GEMS), which is aimed at monitoring the concentrations of several pollutants in a cross-section of urban environments. GEMS collected information on suspended particulate matter and sulphur dioxide (SO_2). The data is quite extensive, covering 47 cities in 28 countries, in the case of SO_2. Grossman and Krueger regressed the median and 95th percentiles of SO_2, dark matter, and suspended particulates on a cubic equation of per capita GDP, with a number of dummy explanatory variables included. They found that concentrations of emissions increase with per capita GDP at low income levels, and then decrease at higher per capita GDP levels, with a turning point at approximately $5000 per capita GDP. Since Mexico's GDP is currently at just under $5000, Grossman and Krueger predicted that with the inception of NAFTA, Mexico would exceed the turning point and begin attempting to alleviate its environmental problems.

Grossman and Krueger mention that their findings must remain tentative until better data is available. This is especially true for many developing countries, where available data is often very sketchy and incomplete. However, in the NAFTA debate, this paper has been heralded as the final word on trade liberalization by many who want to show that free trade will be beneficial to the environment. Their conclusions have often been taken out of context by the news media and the media has ended up by saying that "trade makes countries richer and rich pollute less" (*Economist*, 1992).

There are other problems with Grossman and Krueger's analysis, in addition to the problem of incomplete data. Lee (1992) reiterates our concern over the policy implications of the Grossman and Krueger paper. Grossman and Krueger's paper deals with only SO_2 and suspended particulate matter, but there are other pollutants that are known to increase continually with increasing per capita GDP (see Shafik and Bandyopadhyay below). However, the basic problem is that the relationship they show between air pollution and income is a correlation: no causal link has been shown. In addition, the data, while numerically extensive, was concentrated in developed countries and a few developing countries with the characteristic low per capita GDP and high ambient air emissions (for example, China constitutes 23% of the overall data points). For all these reasons, these results cannot be taken for granted; more analysis needs to be done to validate or invalidate their findings. However, the problem of incomplete data cannot be solved by economists and remains to be alleviated by individual countries or an international organization.

Shafik and Bandyopadhyay (1992) use a similar regression model as Grossman and Krueger, but look at many more pollutants (see Figure 1 in their paper). They

confirm some of Grossman and Krueger's results, and note that "it is possible to 'grow out of' some environmental problems, but there is nothing automatic about doing so." Most environmental indicators deteriorate with rising income at lower per capita GDP, but then improve as countries approach a "middle income" level. These indicators include SO_2, suspended particulate matter, and deforestation. Other environmental indicators, such as lack of safe water and lack of urban sanitation, continually improve with increasing income. However, some of the more problematic pollutants, carbon emissions and municipal solid waste, are continually increasing with higher per capita GDP levels.

With respect to agriculture and NAFTA, farmers have many of the same fears as industrialists. Harold and Runge (1993) note that northern farmers fear lower costs of environmental compliance by competitors from the south, movement into low-regulation areas, importation of tainted produce, and environmentally questionable production methods (such as the use of banned pesticides) in the south. While some of these fears may be justified, one must be careful to distinguish legitimate environmental measures from trade distorting measures that have little environmental backing.

To try to address some of these concerns, Harold (in Harold and Runge, 1993) undertook a cross-country study of fertilizer use and the potential impacts of trade liberalization. She tested the relationship between the intensity of agricultural production, as measured by fertilizer use per hectare, and the level of producer subsidies. Total fertilizer use for nitrogen, phosphorous, and potassium per hectare of cropland were used as the dependent variables, and the Producer Subsidy Equivalent (PSE), GDP and GDP squared, and producer prices of wheat, corn, and rice were

included as exogenous variables. Using Shafik and Bandyopadhyay's finding that most environmental indicators demonstrate an inverted U shape, she anticipated and discovered a negative coefficient on the square of GDP and a positive coefficient on GDP. The positive coefficient on the PSEs implied that a one unit increase in the producer subsidy equivalent across all countries would lead to a 15.4 kilogram per hectare increase in fertilizer use. Therefore, her study supports the claim that environmental improvements occur from reducing producer subsidies.

B. Environmental Implications of Economic Openness

Another issue related to the migration of dirty industries concerns the broad policy stance of host countries in terms of relative openness or closedness. Countries with low or few tariff barriers and those which impose few restrictions on foreign investments are generally characterized as being open. Lucas et al. (1992) found that the toxic intensity of relatively closed developing economies increased at a higher rate than the more open ones. Birdsall and Wheeler (1992) also reported similar results from their study of Latin American countries: highly polluting industries tended to move into less open Latin American economies. According to Birdsall and Wheeler, pollution havens are to be found in protectionist economies, whereas openness promotes cleaner industries. They used anecdotal evidence for Chile in support of their argument. They considered Chile as an example of a country which is open to trade and has very limited controls on industrial emissions. Lax environmental regulations should have made Chile a haven for polluting industries, but this has not happened. They suggested that in Chile openness is associated with (and may be contributing to)

the opposite of a pollution haven effect. Their regression analysis (discussed in a previous section) further supports their argument.

A next logical question is what would be the implications for the environment if the protectionist or closed economies rolled back their tariffs and other restrictions on foreign trade and investment. Both Lopez (1992) and Anderson (1992) address this question. They agree *a priori* that it is difficult to predict what would happen as a result of trade liberalization. Removing the price distortions that were due to restrictive trade practices would align domestic and international prices. This could lead to positive or negative changes in the levels of world production of different commodities and could also relocate the production and consumption sources.

The implications for the environment, according to Anderson, would depend on the nature of specific commodities and require case studies to identify the impacts. The two commodities that Anderson considered are coal and food. First, he demonstrated analytically that trade liberalization in these products would generate large income gains globally and would also reduce environmental damage. Next, he used a multi-commodity simulation model developed by Tyers and Anderson (1992) to confirm empirically the analytically derived effects of liberalizing food trade.

Lopez (1992) relied on the results of several case studies to outline a mechanism that links environmental degradation and rural poverty in the context of outward oriented policies. International commodity price booms increase the profitability of resource based sectors leading to a large scale commercialization of the rural sector. This in turn results in a destruction of the traditional institutions that govern the use of natural resources in a sustainable manner. The new practices, which care little for the

environment, set off a vicious cycle of poverty and environmental degradation. Lopez considered the archetypal structure of a small developing economy where the import substitute (manufacturing) sector is protected, while the resource-based export sector is taxed. Domestic relative prices in this economy are biased against the exportable sector. Trade liberalization, in this case, increased the profitability of the resource-based sector which attracted more capital and labor. In the absence of complementary policies, it is highly probable such growth in the resource-based sector would trigger the cycle of environmental destruction and poverty described above. If, however, firms are forced to pay the full shadow cost of the natural resources then liberalization can have beneficial effects.

V. TECHNOLOGY TRANSFER

Technology transfer should be one of the easiest issues concerning environment and trade to resolve. It seems obvious that the developed countries should aid developing countries in their acquisition of newer, cleaner, more efficient technologies. However, this is not a widespread practice. In cases where this has occurred, authors are divided as to the cause of the assistance: some feel that it is a question of what stage of development a country is in, while others argue that it depends mostly on the openness to trade of the developing country.

According to Lopez (1992), not all developing countries are successful in attracting investment in what he calls dynamic activities, which tend to be capital intensive. He states that the poorer countries are most likely to get stuck with backward industries, such as textiles and food processing, in spite of their attempts to

subsidize investment. For example, increased foreign investment the Philippines resulted in a worsening of income distribution and the destruction of natural and institutional capital for some short-run income gains, but little long-run growth effects. Middle income countries with adequate physical and human capital tend to be more successful in attracting dynamic activities which lead to medium- and long-run growth. These countries may use their environmental resources to attain growth, but these resources will be spared if they receive sufficient transfers from developed countries to finance the investment that may have otherwise come from exploitation of their natural capital.

Zilberman (1992) states that technology transfers tend to increase the production possibility frontiers for receiving nations. He does not, however, make a distinction between low- and middle-income countries. In an agricultural setting, he notes that developing countries will have little incentive to preserve genetic diversity if the economic benefits of doing so belong only to western pharmaceutical companies. The development of royalty schemes and *ex ante* payments can help the source-countries receive more economic benefits and encourage them to preserve their natural environments.

In contrast, Wheeler and Martin (1992), in an analysis of the pulp industry, show that a country's development level had no independent effect on the adoption of cleaner technologies. But adoption is fundamentally affected by a country's policy orientation and the scale of its existing pulp industry. These are the results of an econometric analysis using first adoption and subsequent adoptions of a new technology as dependent variables in separate equations. Explanatory variables included: changing

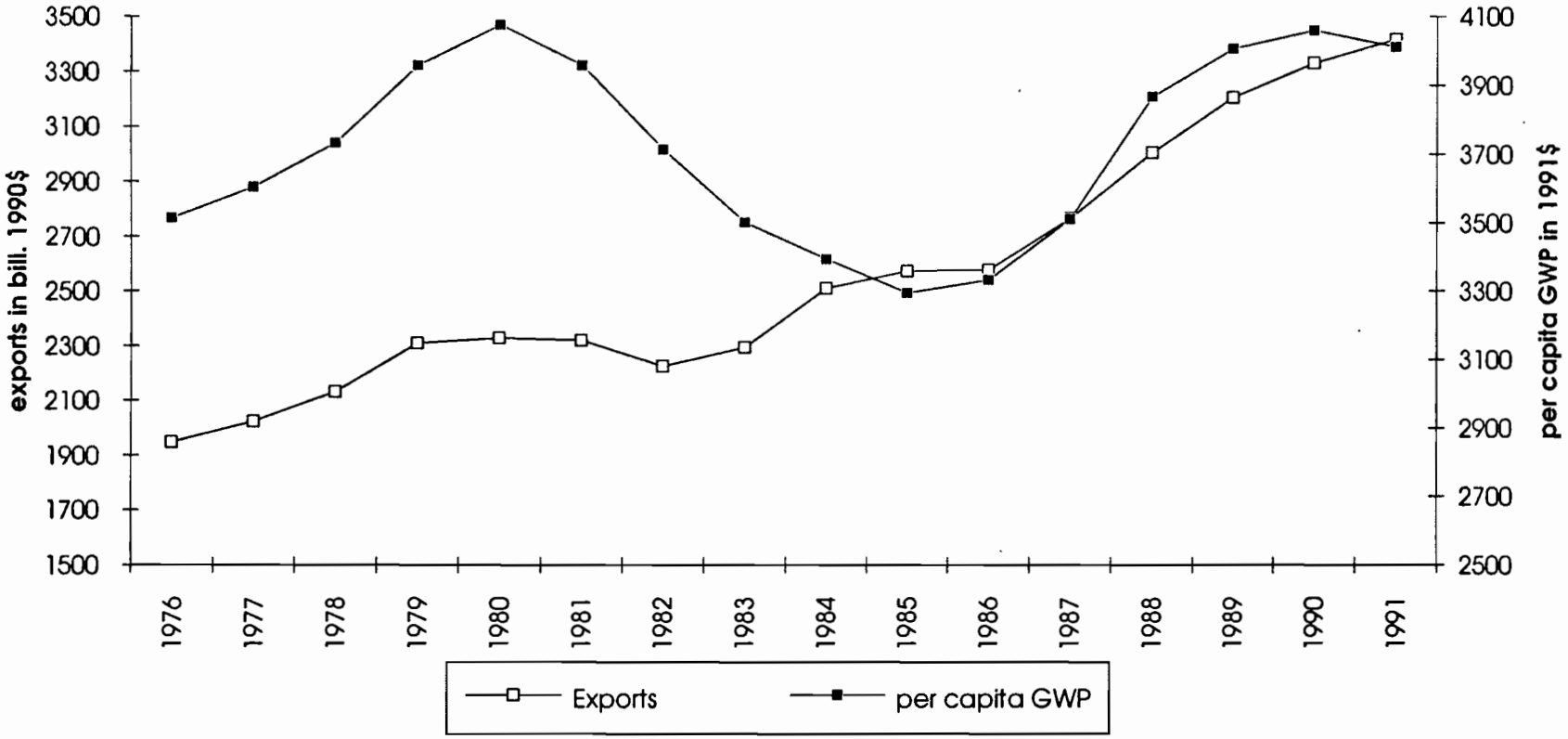
relative prices for critical inputs, per capita income, industry scale, and policy regime. In a simulation run with these results they found that the difference in policy regime alone was responsible for 10-20% of the reduction in pollution associated with new pulp capacity. They attribute these results to several reasons as to why clean technologies may spread rapidly: technology bundling, green consumerism, rapid growth, and anticipation of local regulation.

While Wheeler and Martin's results seem encouraging, Diwan (1992) cautions against generalizing from this case study. He points out that the new technology developed in the paper industry in the 1970s was both cleaner and more cost effective than other existing technologies. But this is rarely true in other industries. In most industries the choice between cost of production and environmental restraint is more meaningful, and in these cases the country's development level will make a difference. Wheeler and Martin's study can only be generalized to industries that are prone to fast technological innovations.

VI. CONCLUSIONS

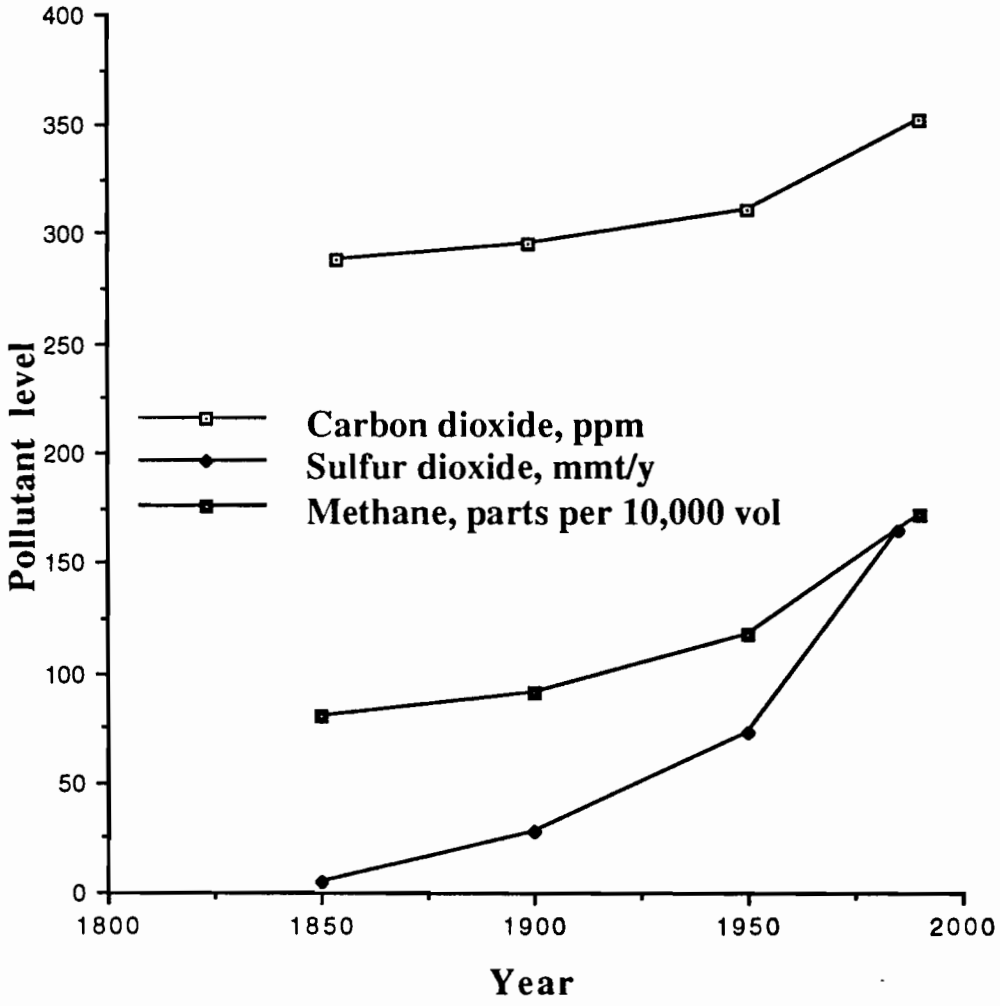
Most of the authors reviewed here predict a positive global outcome with respect to trade and environment. There seems to be a preconception among the authors that living standards and incomes will rise as trade increases. Figure 1 illustrates some of the problems with this argument. While trade has increased continually over the last twenty years, per capita levels of Gross World Product have not shown an upward trend, and in fact have never reached their 1980 level. As well, these per capita GWP levels do not take into account the potentially environmentally damaging effects of

FIGURE 1: TRADE GROWTH vs. per capita GWP



Sources: Export data are from Brown et. al., 1993.
Per capita GWP data are from Chapman, D. J. Agras, V. Suri. in press. "Industrial and Resource Location, Trade, and Pollution," in T. Mount, H. Shue, M. Dore, eds. *Equity and the Global Environment.* Blackwell Publishing: Cambridge, MA.

Figure 2. Global Pollutants are Accelerating



Source: Chapman, D., J. Agras, and V. Suri. in press. "Industrial and Resource Location, Trade, and Pollution," in T. Mount, H. Shue, and M. Dore, eds. Equity and the Global Environment. Blackwell Publishing: Cambridge, MA.

economic activity (Brown et al. 1993). Inclusion of environmental degradation would have shown sharper decreases, and smaller increases in per capita GWP. Therefore, the prediction that trade will promote growth needs further analysis. Worldwide, this does not seem to be the case, but on a national basis we will see some winners and some losers. However, it is obvious that the losers must outnumber the winners to have generated these periodic decreases in per capita GWP.

Noting that trade may not promote higher standards of living, the conclusion that growth will promote a demand for better environmental quality is also in doubt. Figure 2 shows some data for worldwide pollution levels over the same time period. It is obvious that for the major pollutants there has been no decrease in overall levels. Many of the developed countries are beginning to decrease their levels, but the developing countries are increasing their emissions at an even faster rate.

One can see an implicit link in all of the topics discussed in this review: development. Even though many studies do not support this view, there is concern that environmental costs will shift dirty industries to developing countries, thereby further exacerbating their environmental problems. At another level it is felt that growth, perhaps as a result of industrialization, within developing countries will lead to a greater demand for higher environmental standards. It is important to note, however, that it might be extremely costly, or impossible, to renew an environment that is degraded in the growth process. It is therefore logical to ask whether it is possible to simultaneously achieve the objectives of growth and a cleaner environment (i.e. do win/win strategies exist?). Technologies with a win/win potential do exist, but are concentrated in the hands of Northern industrialists. Making them available to developing countries will

require technology and capital transfers of unprecedented levels. Progress on this front has, however, been tardy.

Many questions pertaining to trade, environment, and development remain unanswered due to the lack of adequate and reliable data. Since meaningful policy analysis in this area requires a quantification of the variables involved, more investment in data collection is necessary and justified.

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