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The dominant position of economists on trade and environment is that increasing trade raises living standards, which provide the economic basis for reduced pollution. Professors Chapman, Agras, and Suri present a perspective that raises very different points. First, the dramatic growth of manufacturing in East Asia for global markets is based entirely (or nearly so) on the importation of processed pollution-intensive raw materials. For a typical product in this global system, a U.S. consumer purchasing an Asian product made from imported resources benefits from a lower price and a cleaner local environment; however, energy use and pollution associated with the fabrication of the product occur in the country of origin of the raw materials, and in the country where the final product is manufactured.

Second, a modest logical exercise in economic theory shows that the presence of trade between two regions with strongly different pollution control practices can increase world total pollution. Turning again to empirical data, the decline in energy per real dollar of GNP in the OECD countries has been exactly offset by an increase in energy intensity elsewhere. As a result, world energy intensity (energy use per real dollar of GNP) has stayed almost constant, and world energy use has been accelerating. Gross World Economic Product per capita has not risen above its value of 14 years ago.

Actual data on global emissions are limited. However, estimates of three major world air pollutants show each with accelerating growth. It is likely that actual data, if available, would show exponential growth now for nuclear waste accumulation, sewage, toxic metals and chemicals exposure, and other types of pollutants.

The empirical perspective we see is very different from the commonly held viewpoint. In summary, on a global basis, the

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international economy is characterized by increasing trade and world economic product, stagnation in gross economic product per capita, accelerating energy use, and exponential growth in emissions of major pollutants.

I. INTRODUCTION

The literature on trade and environment is extensive. Taken together, Cropper and Oates and the World Bank reviewed more than thirty papers published prior to 1992.[1] Recently, Agras et al. reviewed more than forty papers, of course with coverage of earlier work.[2] Of these, no more than four authors seem to find trade and environment to be adversely linked.[3]

The dominant view is expressed by the World Bank:

> Evidence shows that developing countries do not compete for foreign investment in "dirty" industries by lowering their environmental standards. . . . Rather, . . . data . . . suggest the opposite: because it is cheaper for multinational corporations to use the same technologies as they do in industrialized countries, these firms can be potent sources of environmental improvement.[4]

Grossman and Krueger carry this point further, arguing that trade will cause "the movement of the dirtier economic activities to the more highly regulated production environments."[5]

Metaphorically speaking, the conclusions cited from the World Bank and from Grossman and Krueger could be assumed to be multiplied forty-fold to

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1. Maureen L. Cropper & Wallace E. Oates, *Environmental Economics: A Survey*, 30 J. OF ECON. LITERATURE 675 (1992); WORLD BANK, WORLD DEVELOPMENT REPORT 1992, at 25-43 (1992)[hereinafter WORLD BANK]; INTERNATIONAL TRADE AND THE ENVIRONMENT, WORLD BANK DISCUSSION PAPER, NO. 159. (Patrick Low, ed.).

2. JEAN AGRAS ET AL., ENVIRONMENT AND TRADE: A REVIEW OF THE LITERATURE 33 (Cornell University Department of Agricultural, Resource, and Managerial Economies Working Paper No. 94-11 1994).

3. WAYNE B. GRAY & RONALD J. SHADBEGIAN, ENVIRONMENTAL REGULATION AND MANUFACTURING PRODUCTIVITY AT THE PLANT LEVEL (Department of Commerce Center for Economics Studies Discussion Paper CES 93-6, 1993); *see* Duane Chapman, *Environmental Standards and International Trade in Automobiles and Copper: The Case for a Social Tariff*, 31 NAT. RESOURCES J. 449 (1991); *see* Emily Hoffnar et al., *Mexico's Maquiladora Trade and the Industrial Flight Hypothesis*, 8 J. BORDERLANDS STUDIES 91, 92 (1993); *see* Ramon Lopez, *Environmental Degradation and Economic Openness in LDCs: The Poverty Linkages*, 74 AM. J. AGRIC. ECON. 1138 (1993).

4. WORLD BANK, *supra* note 1, at 67.

5. GENE M. GROSSMAN & ALAN B. KRUEGER, ENVIRONMENTAL IMPACTS OF A NORTH AMERICAN FREE TRADE AGREEMENT 35 (National Bureau of Economic Research Working Paper No. 3914, 1991).

represent the dominance of this viewpoint in current economic literature. Briefly, the main themes in the literature reviewed by Agras et al. are: (1) although environmental costs may have been underestimated, they do not erode international competitiveness, nor are they the chief cause in the migration of dirty industries; (2) open trading regimes may be better for the environment; (3) internationally uniform environmental standards (harmonization of standards) are not economically efficient; and (4) cooperation between nations in formulating environmental regulations offers a superior alternative to unilateral action.

In this paper, our modest goal is to make these empirical points: (1) industrial growth in East Asia is based upon imported resources; (2) trade between regions with different environmental protection policies can increase total emissions; (3) global levels of major pollutants are increasing; and (4) living standards, measured by gross economic product per capita, are not increasing and may be declining.

II. RESOURCE DEPENDENCY AND INDUSTRIALIZATION IN ASIA

Industrial growth in Japan, South Korea, and Taiwan is widely recognized. Less widely known, however, is that these countries depend almost wholly upon the importation of processed industrial raw materials for their manufacturing. Tables 1-3 show the magnitude of resource dependency for six major resources. These six resources are essentially the basis for manufacturing. For example, the three metals constitute seventy-five percent of the weight of a new car, and petroleum derivatives add another fourteen percent.[6]

In addition, the three energy resources in the Tables constitute more than five-sixths of the energy consumption for each country and for the group as a whole.[7] Given this magnitude of industrial resource importation, it is clear that Asian manufacturers' demand for raw materials contributes to pollution emissions in the regions that supply their industrial resources. Typically, metal ores are processed near mines, and it is the initial processing which releases most of the pollution associated with metal smelting.

6. GOVERNMENT AFF. DIV., AM. AUTO. MFRS. ASS'N, AAMA MOTOR VEHICLE FACTS AND FIGURES '93, at 50 (1993).

7. U.S. ENERGY INFO. ADMIN., DOE/EIA-0219(91) INTERNATIONAL ENERGY ANNUAL 1991, at xvi (Dec. 1992).

TABLE 1
Korean Industrial Resource Dependency
1990, units of contained metal or fuel

Mineral or Fuel	Mine Production or Field Output	Consumption of Refined Primary Metal or Fuel	Measure of Resource Dependency
Aluminum ('000 tons of Bauxite)	0	*	100%
Coal (trillion Btu)	342	949	64%
Copper ('000 M T)	0	324	100%
Iron Ore ('000 tons Fe content)	299	22,870	99%
Petroleum ('000 barrels per day)	3	1,025	100%
Uranium (tons U)	*	*	100%

8. Table prepared by authors. *See* G.J. LOFTY ET AL., WORLD MINERAL STATISTICS, 1986-1990, VOLUME 1: METALS AND ENERGY PRODUCTION: EXPORTS: IMPORTS2, 5, 55, 75 (1992); OECD NUCLEAR ENERGY AGENCY & THE INT'L ATOMIC ENERGY AGENCY, URANIUM: 1991 RESOURCES, PRODUCTION, AND DEMAND 158-61, 163-65 (1992); *U.N. Conference on Trade and Development*, 1991 UNCTAD Commodity Y.B. 4, U.N. Sales No. E/F.91.II.D.9; U.S. ENERGY INFO. ADMIN., *supra* note 7.

*The following applies to Tables 1, 2, and 3:

(1) Korea does not import any bauxite, but for their aluminum production they import alumina and unwrought aluminum, making their resource dependency measure 100%.

(2) Korea has substantial uranium reserves, but they are currently not economically retrievable. Current nuclear fuel is imported.

(3) The consumption of uranium for Taiwan was not reported, but any amount consumed will make them 100% dependent on outside resources.

(4) "mt" means metric tons.

(5) "Mine Production" means the metals content of mined ore.

TABLE 2
Taiwanese Industrial Resource Dependency
1990, units of contained metal or fuel

Mineral or Fuel	Mine Production or Field Output	Consumption of Refined Primary Metal or Fuel	Measure of Resource Dependency
Aluminum ('000 tons of Bauxite)	0	*	100%
Coal (trillion Btu)	0	493	100%
Copper ('000 M T)	0	297	100%
Iron Ore ('000 tons Fe content)	0	7,760	100%
Petroleum ('000 barrels per day)	6	542	99%
Uranium (tons U)	*	*	100%

9. Table prepared by authors. *See* LOFTY, *supra* note 8, at 5; OECD NUCLEAR ENERGY AGENCY, *supra* note 8, at 5; *U.N. Conference on Trade and Development*, *supra* note 8, at 5; U.S. ENERGY INFO. ADMIN., *supra* note 7, at 4.

TABLE 3

Japanese Industrial Resource Dependency

1985, units of contained metal or fuel

Mineral or Fuel	Mine Production or Field Output	Consumption of Refined Primary Metal or Fuel	Measure of Resource Dependency
Aluminum (10^3 mt)	0	2,814	100%
Coal (10^{12} Btu)	530	3,540	85%
Copper (10^3 mt)	43	1,172	96%
Iron Ore (10^3 mt)	212	179,419	100%
Petroleum (10^3 barrels)	3,929	1,517,676	100%
Uranium (10^3 kg)	7	650	99%

10. Table prepared by authors. *See* LOFTY, *supra* note 8, at 5; OECD NUCLEAR ENERGY AGENCY, *supra* note 8, at 5; *U.N. Conference on Trade and Development*, *supra* note 8, at 5; U.S. ENERGY INFO. ADMIN., *supra* note 7, at 4.

Figure 1 shows the distribution of copper from Zambia, one of the world's major copper producers.[11] Zambia utilizes only three percent of its own production. As raw materials are processed and shipped to manufacturing centers, the pollution remains behind. This is typical. Six developing countries (Chile, Zaire, Philippines, Peru, South Africa, and Zambia) produce sixty percent of the world's copper identified by country of origin, yet they utilize only five percent of their own mine production locally.

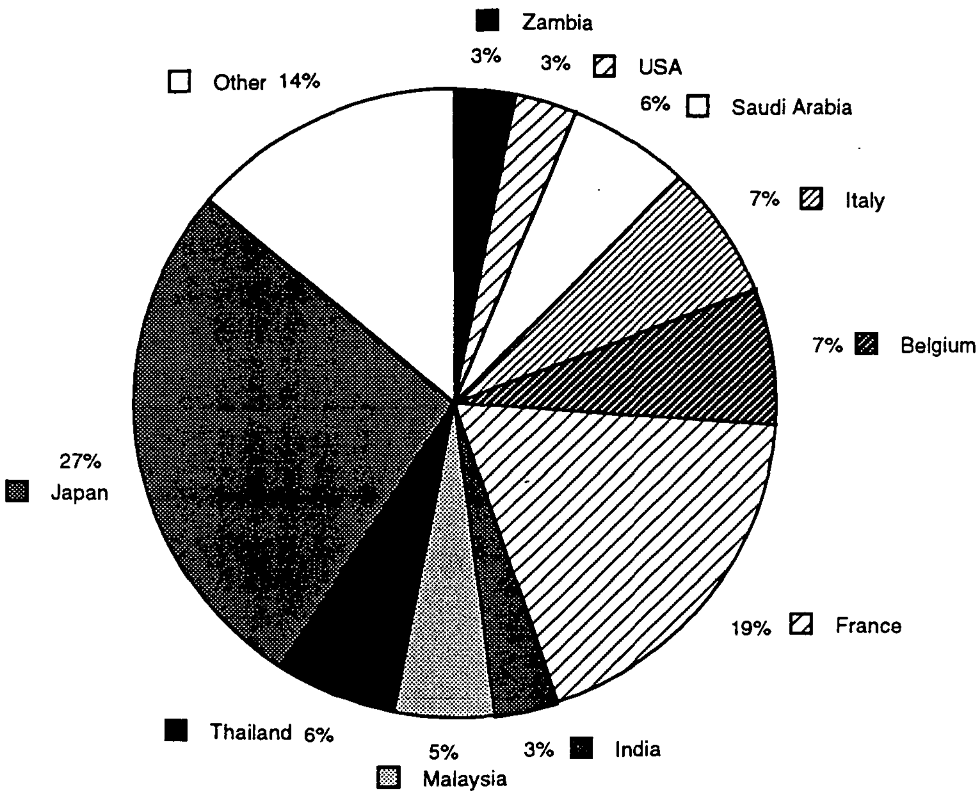
The problem, then, is this: raw materials producers in developing countries supply industrial resources. The pollution-intensive initial processing takes place in their own countries. The industrial resources are then exported for manufacturing in Europe, North America, and Asia, whose final products play a significant role in world trade.

Consequently, the economic beneficiaries of the absence of industrial pollution control in developing countries are the manufacturing centers and the final consumer. In the United States, for example, it was estimated that one-third of total copper consumption was embodied in imported goods,[12] and this amount exceeds the quantity imported as metal for direct use in manufacturing in the U.S.[13]

Increasingly, the world's manufactured goods are fabricated in Asia. Table 4 shows an approximate six percent annual growth rate of industrial production in East Asia. Now, consider this rapid growth in industry in the context of resource dependency. The three leading East Asia manufacturers in Table 4 (Japan, South Korea, Taiwan) are essentially wholly dependent on imported industrial raw materials. Much of their contribution to global pollution is actually released in the countries of origin that process their raw materials.

11. ZAMBIA CONSOL. COPPER MINE, LTD., Annual Report 49 (1992) [hereinafter ZCCM].
12. Chapman, *supra* note 3, at 457.
13. *Id.*

Figure 1. Sales Distribution of Zambian Copper (Own production copper-tonnes)



Source: ZCCM, p. 49.
(E. Smith, April 1994)

14. ZCCM, *supra* note 11.

Table 4: **Industrial Production and Growth in Asia, 1965-1990**[15]
(1990 U.S. dollars)

	Industrial Production (U.S.$ million) 1965	1990	Growth Factor
EAST ASIA			
Taiwan (China)	485	66,774	137.6
Indonesia	2,722	42,743	15.7
S. Korea	6,984	109,819	15.7
Thailand	2,985	31,810	10.7
Malaysia	2,084	16,536	7.9
Japan	320,914	1,234,938	3.9
Philippines	4,567	15,466	3.4
TOTAL	340,256	1,435,537	5.9
SOUTH ASIA			
Pakistan	1,964	10,010	5.1
India	22,212	85,772	3.9
Bangladesh	1,130	3,359	3.0
TOTAL	26,010	101,769	3.9
CHINA			
China, **TOTAL**	20,937	155,331	7.4
OTHER COUNTRIES COMPARISON			
Australia	46,893	91,571	2.0
Germany	402,585	583,608	1.5

15. Table prepared by authors. *See* CARTER BRANDON & RUMESH RAMANKUTTY, TOWARD AN ENVIRONMENTAL STRATEGY, 65 (World Bank Discussion Paper No. 224, 1993).

It bears repeating that final consumers in North America and Europe are typically the beneficiaries of the lower cost goods produced without pollution control. At the same time, pollution is released in the countries of origin of raw materials, and there is significant pollution growth in Asian manufacturing centers.

The pollution impact is significant, as may be expected. One analysis projects that Asia will contribute forty-five percent of the global growth in CO_2 emissions in this decade.[16] In SO_2 emissions, Asia will exceed the combined total of European and U.S. emissions in ten years.[17]

Figures 2-4 show the historic lower growth in gross domestic product (GDP) relative to the major pollutants for three East Asian countries. The lower shaded line represents the slower growth of GDP, relative to the rapid rise of pollutants, including sewage, sulfur dioxide, and toxic chemicals and metals.

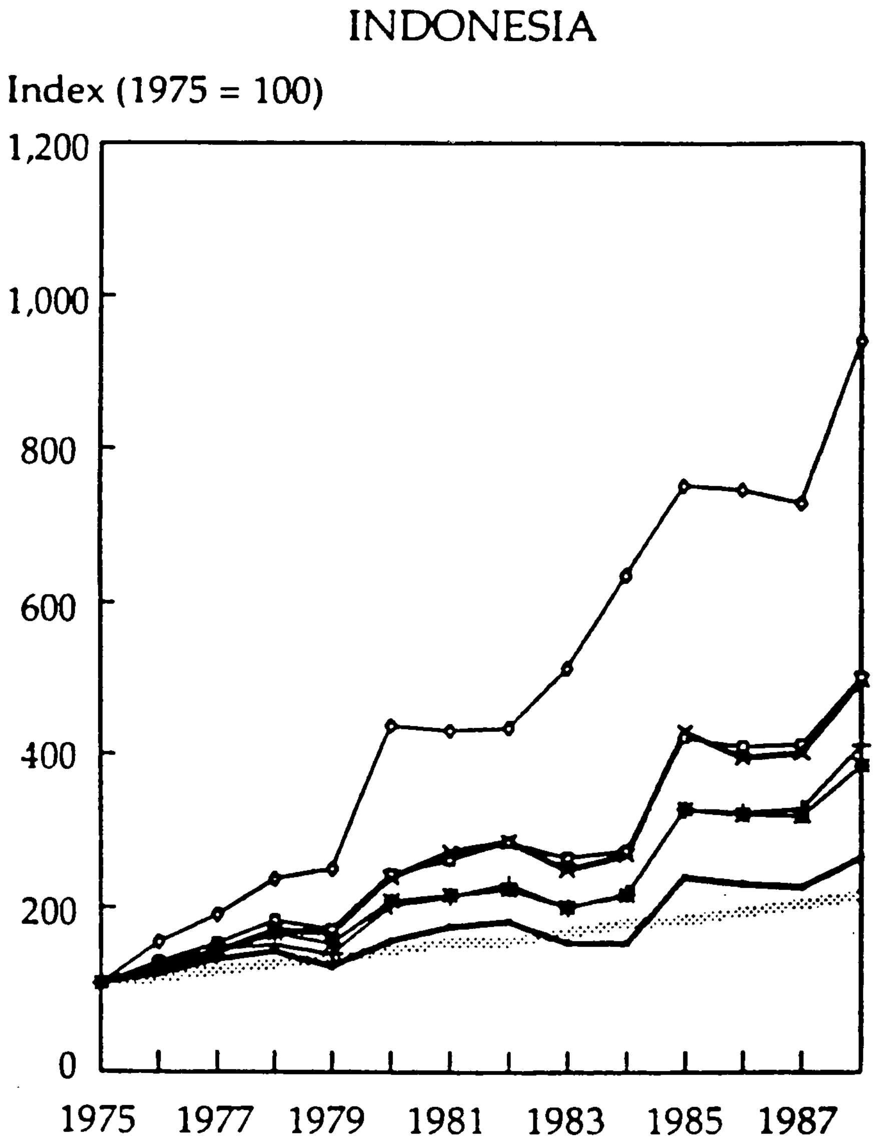
The implication of these data is that global pollution is increasing, in part because of the interaction of trade and industrialization. The limited data available on global pollution will be discussed below.

III. TRADE, INDUSTRIAL POLLUTION, AND ENVIRONMENTAL PROTECTION

Part A of Figure 5 shows two hypothetical regional supply relationships. Each curve indicates the amount of refined copper that would be offered for sale at the price levels on the vertical axis. S_{IB}, for example, represents the supply function for the world's industrialized region producers before new sulfur regulations are implemented. S_D represents the supply response for developing country producers. Note that S_{IB} is to the left of S_D: at any price level, less quantity will be supplied by industrial region producers.

16. *Id.* at 24.
17. *Id.* at 25.

Figure 2 **Industrial Pollution, GDP in Indonesia**[18]



■ Biochemical oxygen demand, ┼ Suspended solids, ★ Sulfur oxides, ⊟ Particulates, ⁎ Toxicity, ◇ Heavy metals, ▒ Growth in real GDP.

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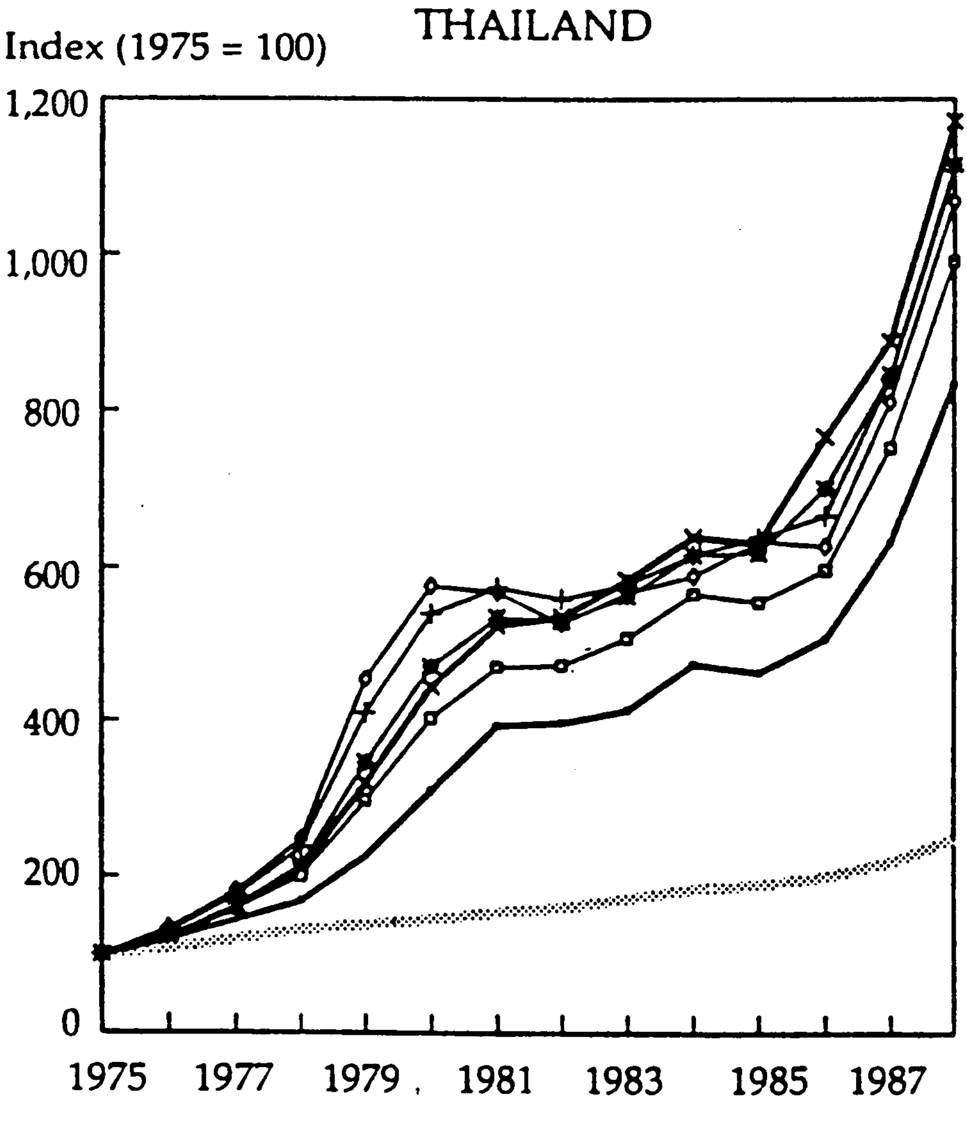
18. *Id.* at 67.

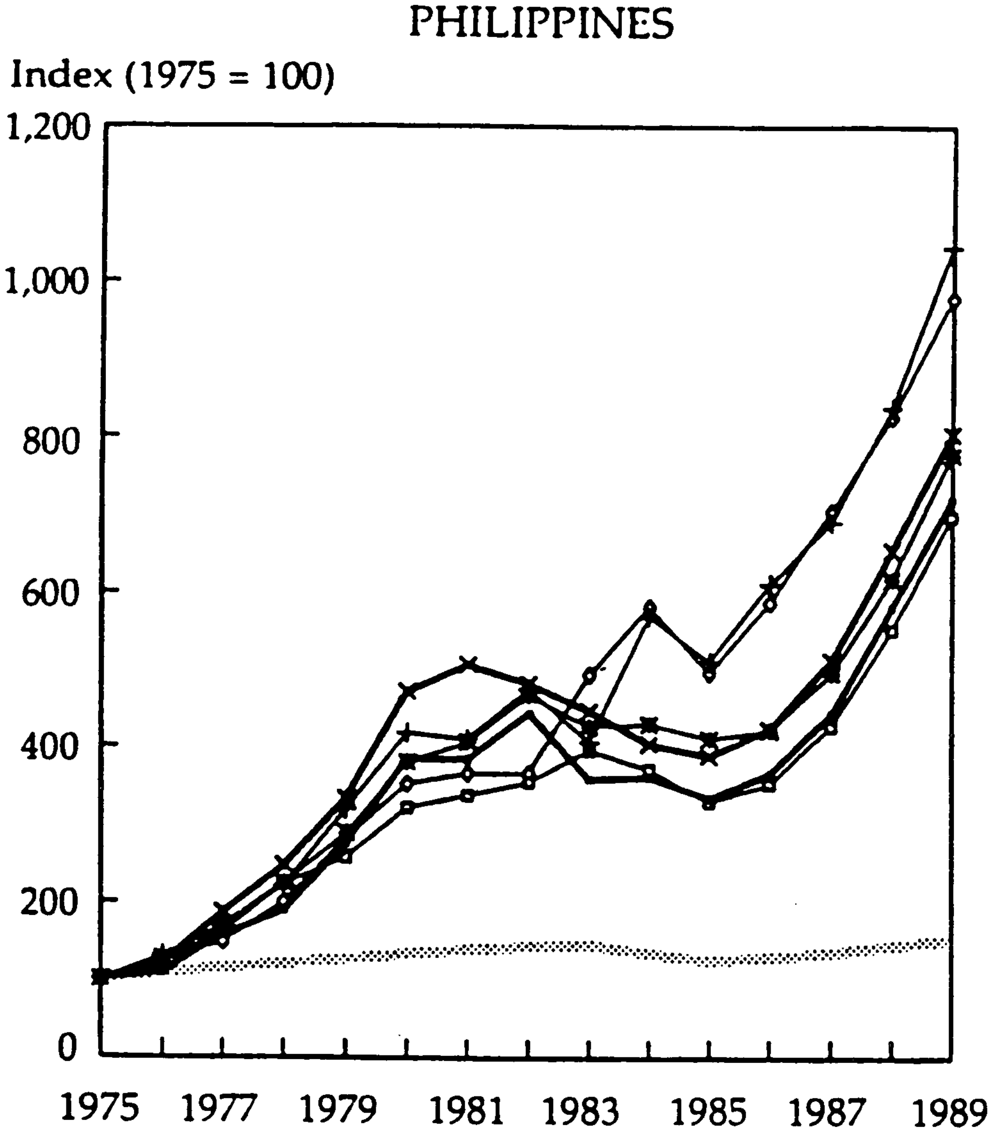
Figure 3 **Industrial Pollution, GDP in Thailand**[19]



■ Biochemical oxygen demand, ┼ Suspended solids, ★ Sulfur oxides, ⊟ Particulates, ⁎ Toxicity, ◇ Heavy metals, ░ Growth in real GDP.

19. *Id.*

Figure 4 **Industrial Pollution, GDP in the Philippines**[20]



■ Biochemical oxygen demand, ┼ Suspended solids, ★ Sulfur oxides, ⊟ Particulates, ⁎ Toxicity, ◇ Heavy metals, ▒ Growth in real GDP.

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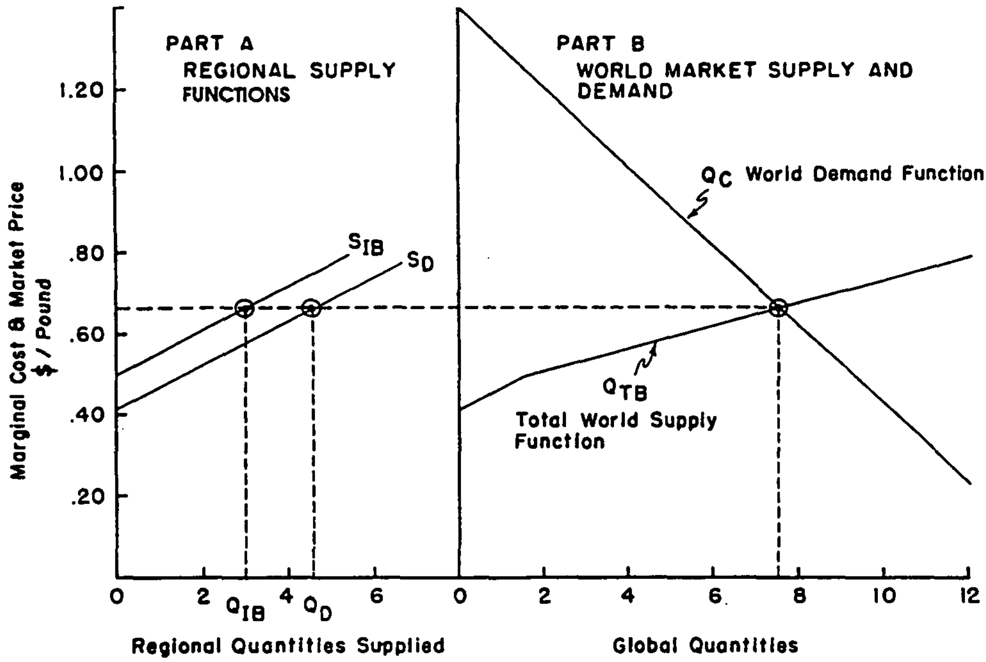
20. *Id.*

FIGURE 5. WORLD SULFUR MARKET BEFORE NEW REGULATIONS, MILLION METRIC TONS



21. Figure prepared by authors.

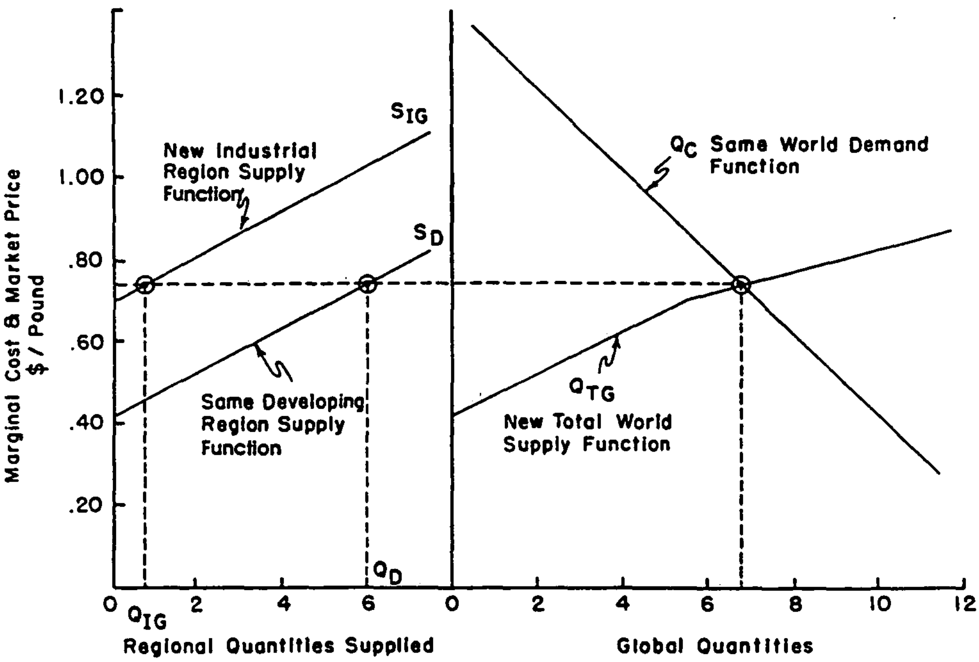
In economic theory, the supply price is equivalent to the marginal or incremental cost of production for increasing quantities supplied.

Part B shows the world copper market. Q_{TB} is the total industry supply function for both regions, the sum of the two regional relationships. The downward-sloping customer demand function, Q_C, indicates that customer demand increases as market price declines. Market equilibrium is defined by the intersection of the upward-sloping supply function with the downward-sloping demand function, providing identical prices and quantities to customers and producers. The global equilibrium is at about 7.5 million metric tons (mmt) of world production, at a world price of about 66¢ per pound.

This market equilibrium price in Part B defines the regional production levels in Part A: Q_{IB} is at 3.0 mmt, and Q_D is at 4.5 mmt. The higher marginal production cost for the industrial region reflects a considerable degree of sulfur control. This is about sixty-seven percent, as discussed below. Consequently, global sulfur dioxide emissions total 11 mmt: 9 mmt from developing country producers and 2 mmt from industrial country producers. This is assuming a typical ratio of one-to-one for the sulfur-copper ore ratio and a two-to-one sulfur dioxide-sulfur ratio.

Now suppose industrial regional countries tighten their sulfur control to 95% removal. In Figure 6, supply function S_{IG} reflects the higher cost of the new regulations control level. S_D for developing countries is unchanged. The new total supply function is Q_{TG}. The world demand function is unchanged at Q_C. Supply and demand are now in equilibrium at 76¢ per pound, and a world use level of 6.7 mmt. The dramatic change is the displacement of industrial country producers. Their production level is 0.7 mmt. Q_{IG} market share is now ten percent, compared to forty percent before the new regulations.

FIGURE 6. NEW INDUSTRIAL REGION REGULATIONS AND GLOBAL MARKET, MILLION METRIC TONS



22. Figure prepared by authors.

This theoretical analysis has been purposefully constructed to give this result: global sulfur dioxide emissions are higher. For the industrial region, ninety-five percent control on 0.7 mmt copper production means 0.07 mmt sulfur dioxide emissions. The developing country sulfur dioxide emissions are twelve mmt for the Q_D production level of 6 mmt copper. Total world sulfur dioxide emissions have grown to 12.1 mmt. Incidentally, Moller estimates total global anthropogenic sulfur pollution emissions at 70 mmt, and associates 10 mmt with sulfur emissions from metal processing.[23]

In this exercise, a further tightening of industrial region sulfur emission control is associated with 1) a rise in global emissions, 2) a rise in world prices, 3) falling world output, and 4) a severe contraction in production in the controlled region and displacement to uncontrolled regional producers.

The same argument can be stated more formally: suppose an international manufacturer can use the same technology in regions A and B, and assume that trade and capital movements are unrestricted. Cost minimization is the goal, with these assumptions:

$$(1) \quad E_T = E_A + E_B,$$

$$(2) \quad E_j = \epsilon_j \; (1 - S_j) \; Q_j, \qquad j = A, B,$$

$$(3) \quad MC_j = \beta_0 \; Q_j^{\beta_1} \; S_j^{\beta_2}, \qquad j = A, B.$$

E_T represents total global or continental emissions from regions A and B. ϵ is the uncontrolled ratio of emissions to production. MC is the marginal cost of production of Q in region j and comes from a Cobb-Douglas production function. S is an index of control, ranging from 0 to 1. So β_1 is the economy of scale in production, and β_2 is the "diseconomy" of scale in pollution control.

Assuming there are no pollution controls in region B ($S_B = 0$), the following first order condition results as shown in the appendix:

23. Detlev Moller, *Estimation of the Global Man-made Sulphur Emission*, 18 ATMOSPHERIC ENVTL 12, 19 (1984).

$$(4)\quad \frac{dE_T}{dS_A} = \varepsilon\, Q_A \left[\frac{\beta_2}{\beta_1} - 1\right].$$

So, if β_2 (the diseconomy of scale in percentage pollution control) exceeds β_1 (the economy of scale in output parameter), then Equation 4 is positive. Higher standards in region A result in higher overall global pollution levels.

In many actual applications, β_2 may be approximated by integers. The first increment of pollution control can be very inexpensive. For example, moving from high to medium sulfur coal when both are readily available at comparable cost can be done at low incremental cost. As scarcer low sulfur coal is purchased, the cost of reducing emissions rises. Sulfur scrubbing is still more costly, and the increment in cost from ninety percent to ninety-five percent sulfur removal could be comparable to the increment from fifty percent to ninety percent. In Equation 4, if β_2 is greater than β_1, the interaction of trade with increasing regulation in region A leads to an increase in total global emissions: the dependent variable is positive.

Obviously, again, the empirical reality is very important. If β_2 is small, there is no problem. However, if β_2 is much larger than β_1, the interaction of trade with differential environmental standards may be significant.

IV. INTERNATIONAL LAW: GATT, NAFTA, AND RIO

As the global economy becomes formalized through new world and regional agreements, it is evident that environmental protection has not been considered a significant domain of trade policy, nor has trade been considered relevant to environmental policy. The General Agreement on Tariffs and Trade (GATT) has no explicit discussion of the problem of reconciliation or harmonization of environmental policies. The GATT Secretariat explicitly offered this judgment: "In principle, it is not possible under GATT's rules to make access to one's own market dependent on the domestic environmental policies or practices of the exporting country."[24] Similarly, the attempts of the North American Free Trade Agreement (NAFTA) to address this question have been to no avail.[25]

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24. GATT SECRETARIAT, TRADE AND THE ENVIRONMENT 10 (1992).

25. Executive Office of the President, NAFTA (1993). U.S. Trade Representative Office, Executive Office of the President, Review of U.S.-Mex. Environmental Issues (1992).

In practice, GATT has generally been interpreted as prohibiting import taxes or controls based upon environmental cost or policy differences. In the dolphin/tuna case, the GATT panel simply overturned the applicability of the U.S. Marine Mammal Protection Act on the apparent basis that the Act regulated dolphin catches, and therefore could not be a basis for regulating tuna imports. Consequently, the status of GATT and the Act seems to be this: tuna boats cannot sell tuna caught with dolphins if they are U.S. boats selling their product in the United States. If, however, a U.S. boat moves to Mexico, it can sell tuna caught with dolphins in the U.S. market, and under GATT, the United States cannot regulate or tax this practice.[26] As Strand et al. have pointed out, U.S. boats moved and dolphin populations continue to decline.[27]

In a similar industrial case, the U.S. tax on imported chemical products was overturned by a GATT panel. The United States had sought to partially equalize environmental protection costs by applying a tax on imports equivalent to the Superfund tax borne by domestic production.[28]

If NAFTA and GATT are implemented in line with existing precedent, it is apparent that the ability of U.S. policy to influence environmental practice by its trading partners will be strictly limited.[29] Consider a hypothetical situation. An Asian auto manufacturer develops a new facility and community in Mexico, near the border, for producing vehicles for sale in the United States. Since municipal sewage control is not common in the new Asian manufacturing centers,[30] municipal taxes are not collected and no facilities are built. The untreated sewage from the facilities' new workers enters the United States. Can trade or environmental policy be invoked? Apparently not, according to current NAFTA and GATT provisions.

Further, NAFTA institutionalizes a *de facto* exemption permitting Mexico to continue its nonreporting of pollution emissions. Since the Clinton Administration and Congress reviewed NAFTA in extensive detail, the

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26. U.S. INT'L TRADE COMM'N, PUB. NO. 2554, THE YEAR IN TRADE: OPERATION OF THE TRADE AGREEMENTS PROGRAM 1991, 19 (1992).

27. Ivar E. Strand et. al., *Trade, Institutions, and Preferences for Living Marine Resources*, 74 AM. J. OF AGRIC. ECON. 1150,1151-54 (1992).

28. U.S. INT'L TRADE COMM'N, INTERNATIONAL AGREEMENTS TO PROTECT THE ENVIRONMENT AND WILDLIFE 2-3 (1994).

29. U.S. INT'L TRADE COMM'N, ENVIRONMENTAL COSTS AND NAFTA: POTENTIAL IMPACT ON THE U.S. ECONOMY AND SELECTED INDUSTRIES OF THE NORTH AMERICAN FREE TRADE AGREEMENT (1992) (testimony of Duane Chapman).

30. WORLD RESOURCES INSTITUTE, WORLD RESOURCES 1992-1993, at 42-43 (1992); Susan Chira, *Wealthy Japan's Spartan Style*, N.Y. TIMES, Oct. 30, 1985, at D1.

absence of substantive consideration of this subject from the Supplemental Agreements implies an acceptance of nonreporting.

In a 1994 speech to the GATT Plenary Committee, U.S. Vice President Al Gore discussed the creation of a Committee on Trade and Environment within GATT's World Trade Organization.[31] As yet, there is no formal program of analysis or policy which will affect trade-environment interactions.

The Rio Environmental Summit in June 1992 focused on a very different facet of trade-environment relations. Its major emphasis was on the global environment, for which the Climate Convention was particularly important. One of the most significant parts of this treaty may be the commitment of signatories to publish greenhouse gas emission data.[32] There is, however, only voluntary agreement to limit growth of CO_2 emissions. Is it possible that increased energy efficiency in the sense of reduced energy per dollar of GNP may provide a partial market solution without governmental intervention? Howarth and Schipper, et al. analyzed eight Organization of Economic Cooperation and Development (OECD) countries and found continuing declines in energy-industry GNP ratios.[33] It must be remembered, though, that many consumer and intermediate goods are manufactured in rapidly industrializing countries; this displaces energy previously required in developed countries to manufacture the same products. Table 5 shows changes in aggregate energy intensity on a macro basis between 1965 and 1990. Note that energy used per dollar of GNP for the OECD countries declined as expected from 13,600 Btu/$ to 10,000 Btu/$. This supports the Howarth-Schipper argument but, in contrast, the rest of the world increased from 23,300 Btu/$ to 28,100 Btu/$. The apparent world average declined very slightly from 16,000 Btu/$ to 15,400 Btu/$ over the twenty-five year period. There seems to be no factual basis for the assumption of an exogenous reduction in energy use per dollar of economic product.

31. Vice President Al Gore, Remarks Prepared for Delivery Meeting of the GATT Plenary Committee. (Apr. 14, 1994) (transcript available from the White House Press Office).

32. Jerald L. Schnoor, *The Rio Earth Summit*, ENVTL. SCI. AND TECH. 27(1), 18-22 (1993).

33. Richard B. Howarth et al., *Manufacturing Energy Use in Eight OECD Countries*, ENERGY ECONOMICS, Apr. 1991, at 135-42.

Table 5: **Aggregate World Energy, GNP Data: 1965, 1990**[34]

	World		OECD		Rest of World	
	1965	1990	1965	1990	1965	1990
ENERGY INTENSITY						
kBtu/$	15.997	15.436	13.600	10.461	23.231	28.053
growth rate/y		-0.1%		-1.0%		+0.7%
TOTAL GNP						
trillion 1990$	$9.602	$22.299	$7.235	$15.993	$2.367	$6.306
POPULATION						
billions	3.317	5.284	0.649	0.777	2.668	4.507
PER CAPITA VALUES:						
Energy MBtu/capita	46.3	65.1	151.6	215.3	20.7	39.3
GNP $/capita	$2,895	$4,200	$11,148	$20,170	$887	$1,399

34. WORLD BANK, *supra* note 1. MBtu means million Btus. Some calculations will differ because of rounding error.

V. PROBLEMS IN EVALUATING DATA

The dominant perspective on trade and environment among U.S. economists is that increasing trade raises living standards, which provide the economic basis for reduced pollution. Of more than forty papers on the subject reviewed by the authors, only four held the other position, that trade is likely to increase overall pollution levels, or that the absence of pollution control can be a positive factor in industrial location.

The studies reviewed by Agras, Suri, and Chapman usually used federal survey data, which have excluded a number of potentially significant types of environmental and worker protection costs. The analysis which follows is based upon discussion with personnel in the Bureau of Economic Analysis, the Bureau of the Census, and management personnel at factories, mines, and smelters in the United States, Mexico, Chile, Zaire, Zimbabwe, Russia, and South Africa.[35] There are six sources of error in the types of cost factors which have been excluded.

One important factor is that many labor-intensive environmental activities that are part of a production process may not be reported. For example, the labor, fuel, and equipment costs of dust control in a pit mine by use of watering trucks may not be reported. Similarly, collateral protection devices that are a secondary part of production equipment may not be reported. Relevant examples here would be the capital and labor costs of a dust hood on an ore conveyor, or fans and hoods on a grinder.

Second, monitoring and planning activities may be excluded. Four examples of environmental protection expenses that have been excluded would be: (1) professional time spent with visitors inspecting protection systems; (2) meteorological monitoring of ambient air quality; (3) environmental planning; and (4) time and expense in report preparation and meetings with state and federal regulatory personnel.

A third omission from survey data is the cost of protecting workers from environmental hazards. Roll bars, respirators, monitoring: all of these types of items are excluded from environmental cost reports.

Fourth, interest expense or opportunity cost for investment in protection equipment is not included in the survey data. This could be significant for capital-intensive pollution control practices.

35. Chapman, *supra* note 3.

A fifth factor in under-reporting environmental costs in surveys may be vintage. Current management may not perceive practices which preceded them as protective, and instead focus on environmental practices introduced during their tenure. Examples are previously installed respirators and tall stacks. Finally, productivity loss has been excluded from the surveys. When production stops or is slowed because of environmental problems, this output loss is not counted as an environmental expense. New work by Gray and Shadbegian and the Bureau of the Census finds that the cost of productivity loss may be three or four times higher than the cost implied by capital expenditures data.[36]

Recent analysis by the U.S. Office of Technology Assessment generally supports the minority view given here that global trade and differing environmental regulations affect pollution levels.[37] It is also widely believed that world living standards have been rising, in part because of the growth of world trade (Figure 7). However, as Figure 8 shows, Gross World Product per capita in real dollars has been fluctuating for fifteen years. The highest value in the series was actually in 1980, with another peak in 1990 not quite reaching that level. The current value is somewhat below the 1980 value.

Turning again to empirical data, the decline in energy per real dollar of GNP in the OECD countries has been exactly offset by an increase in energy intensity elsewhere. As a result, world energy intensity (energy use per real dollar of GNP) has remained almost constant, and world energy use has been accelerating.

Actual data on global emissions are very limited. One recent report revealed accelerating emissions of sewage and air pollutants in association with rising GDP in three countries with major growth in industry and GDP. The question arises as to whether this is a global trend.

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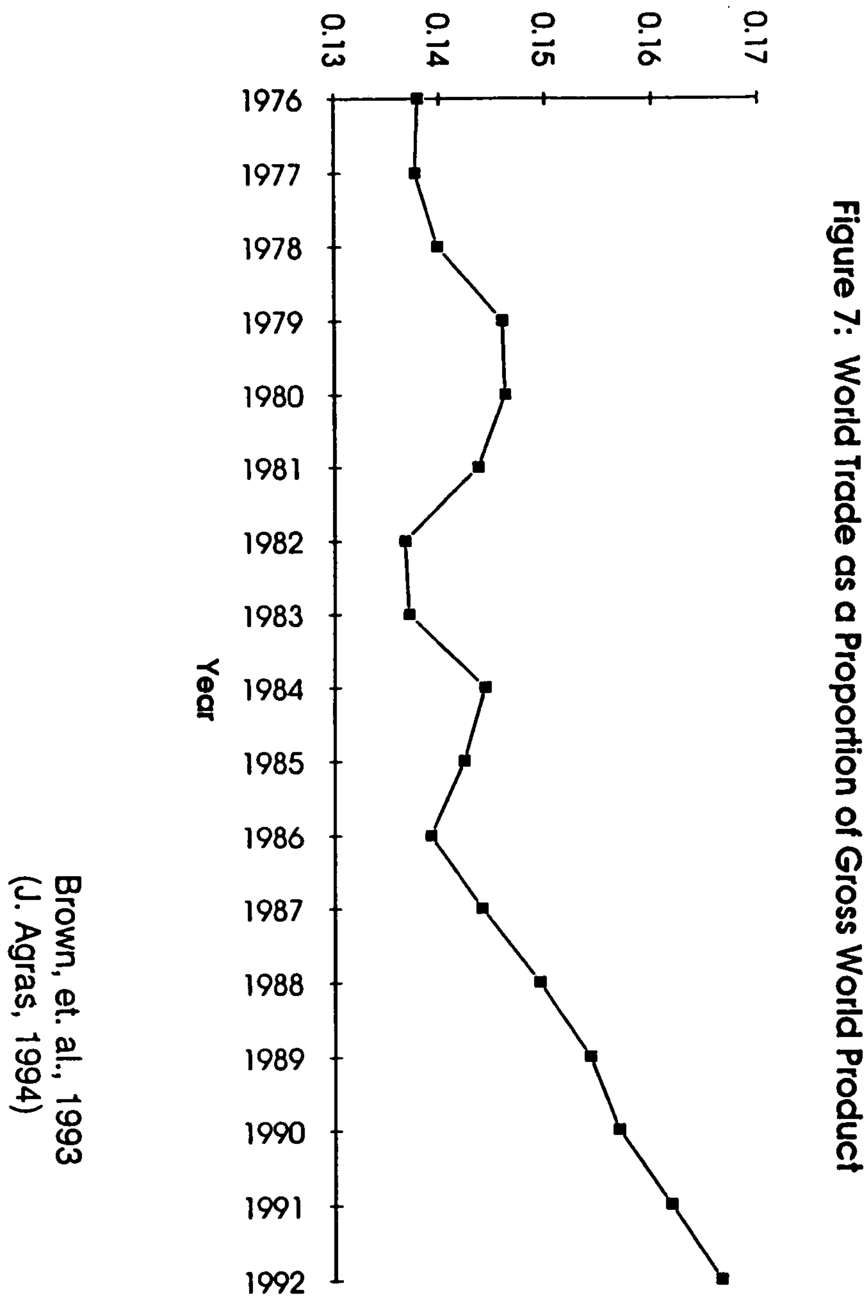
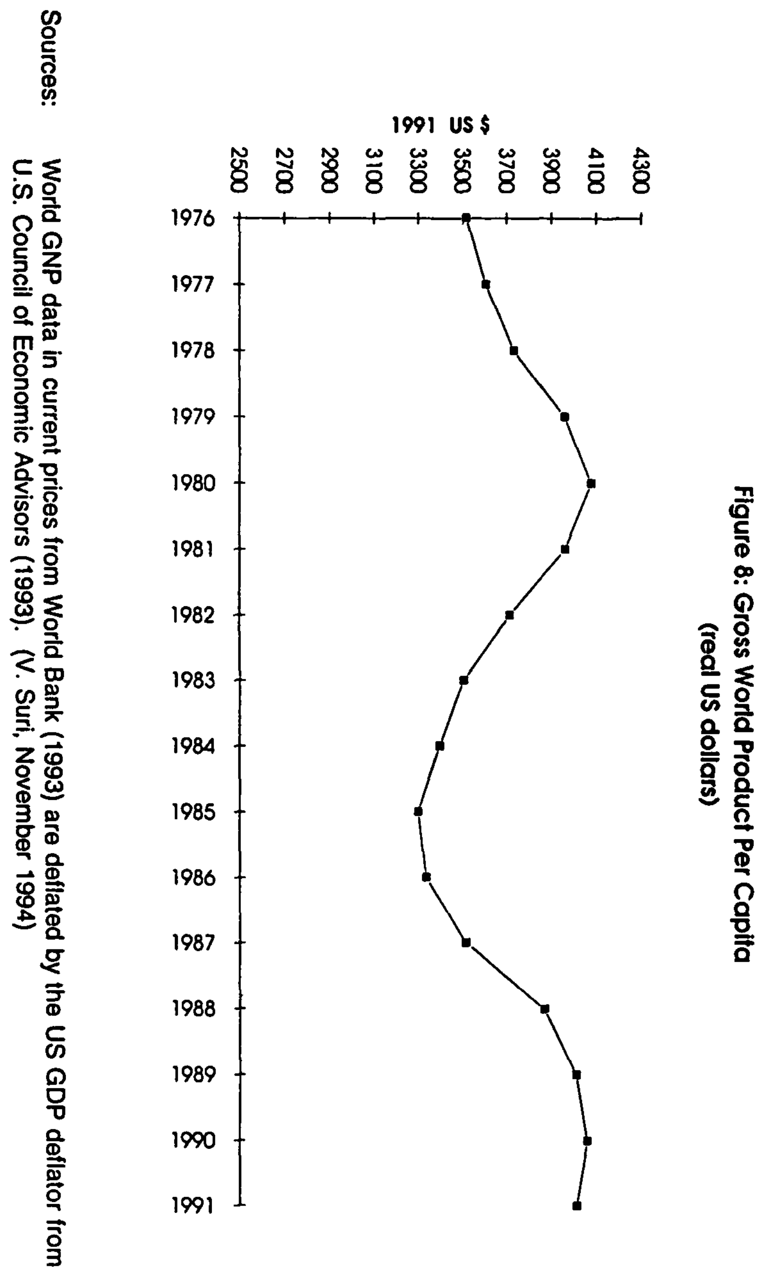
36. U.S. DEPT. OF COMM. ECON. & STAT. ADMIN., U.S. BUREAU OF THE CENSUS, STATISTICAL BRIEF NO. 93-13, MEASURING THE PRODUCTIVITY IMPACT OF POLLUTION ABATEMENT (NOV. 1993); GRAY & SHADBEGIAN, *supra* note 3.

37. U.S. OFFICE OF TECH. ASSESSMENT, TECHNOLOGY AND THE ENVIRONMENT 196-200 (1994).



38. Jean Agras, World Trade as a Proportion of Gross World Product (Apr. 1994) (figure prepared by author, data on file); LESTER R. BROWN, ET AL., VITAL SIGNS 1993: THE TRENDS THAT ARE SHAPING OUR FUTURE 75 (Linda Starke, ed., 1993); World GNP data in 1993 prices from World Bank are deflated by the U.S. GDP deflator from U.S. Council of Economic Advisors (1993).



39. Vivek Suri, Gross World Product Per Capita (Nov. 1994) (figure prepared by author, data on file); World GNP data in 1993 prices from World Bank (1993) are deflated by the U.S. GDP deflator from U.S. Council of Economic Advisors (1993). *See* U.S. COUNCIL OF ECON. ADVISORS, ECONOMIC REPORT OF THE PRESIDENT TOGETHER WITH THE ANNUAL REPORT OF THE COUNCIL OF ECONOMIC ADVISORS (1993); THE INT'L BANK FOR RECONSTR'N & DEV., THE WORLD BANK, WORLD TABLES (1993).

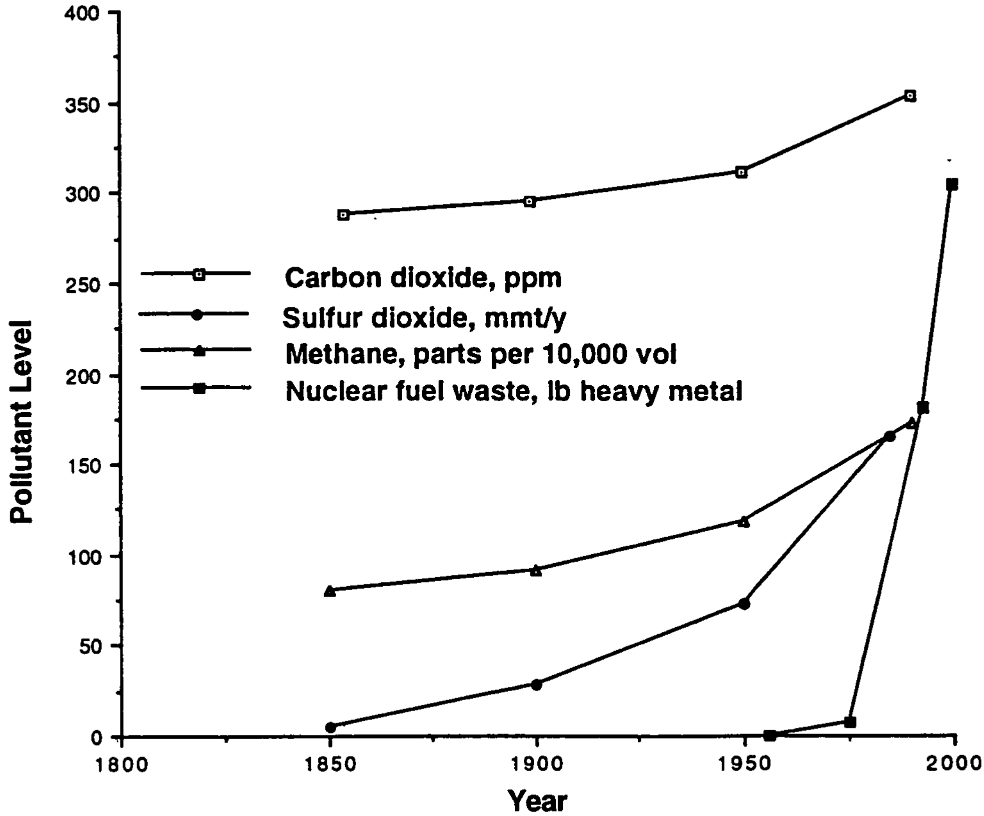
Figure 9 reports estimates of four major world pollutants, each of which shows accelerating growth. It is likely that actual data, if available, would also show exponential growth now for sewage, toxic metals and chemicals exposure, and other types of pollutants.

VI. CONCLUSION

Our perspective raises very different points than those held by the majority. The dramatic growth of manufacturing in East Asia for global markets is based almost entirely on the importation of processed pollution-intensive raw materials. For a typical product in this global system, a U.S. consumer purchasing an Asian product made from imported resources benefits from a lower price and cleaner local environment. However, energy use and pollution associated with the fabrication of the product occur in the country of origin of the raw materials and in the country where the final product is manufactured.

A modest logical excercise in economic theory shows that the presence of trade between two regions with strongly different pollution control practices can increase total world pollution. The implementation of the GATT and NAFTA agreements has severed the link between trade and actual environmental practices. It seems likely that total global pollutant levels are also increasing exponentially. In summary, on a global basis, the international economy is characterized by increasing trade and world economic product, stagnation in gross economic product per capita, accelerating energy use, and exponential growth in emissions of major pollutants.

Figure 9. Global Pollutants are Accelerating



Sources:
Carbon dioxide, Boden, et al., Houghton, et al.
Sulfur dioxide, McClive
Methane, Houghton, et al.
Nuclear fuel waste, Chapman, 1994.
(E. Smith, Nov. 1994)

40. DUANE CHAPMAN, GLOBAL POLLUTANTS ARE ACCELERATING 3 (1995) (figure prepared by author, data on file); Duane Chapman, Notes on Nuclear Fuel Waste Accumulation Data, (Cornell University). *See* GROSSMAN, *supra* note 5; CLIMATE CHANGE: THE IPCC SCIENTIFIC ASSESSMENT: INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 365 (John T. Houghton et al. eds., 1990); T. MCCLIVE, ESTIMATION OF GLOBAL SO_2 EMISSIONS: AN ECONOMIST'S PERSPECTIVE 13 (Department of Agricultural, Resouce, and Managerial Economics Working Paper No. 90-1, 1990).

APPENDIX. Total Global Emissions and Regional Standards
Commencing with Equation 3 in the text,

$$(A1) \quad Q_j = (\beta_o S_j^{-\beta_2} MC_j)^{\frac{1}{\beta_1}}, \quad S_j > 0.$$

$$(A2) \quad E_T = (1 - S_A)\, \varepsilon\, Q_A + (1 - S_B)\, \varepsilon\, Q_B,$$

$$(A3) \quad \frac{dE_T}{dS_A} = (1 - S_A)\, \varepsilon \frac{dQ_A}{dS_A} - \varepsilon\, Q_A + (1 - S_B)\, \varepsilon \frac{dQ}{dS}$$

$$(A4) \quad \frac{dE_T}{dS_A} = (1 - S_A)\, \varepsilon \frac{dQ_A}{dS_A} + (1 - S_B)\, \varepsilon \frac{dQ_B}{dQ_A} \frac{dQ}{dS}$$

$$(A5) \quad \frac{dE_T}{dS_A} = \varepsilon \frac{dQ_A}{dS_A} [1 - S_A + (1 - S_B) \frac{dQ_B}{dQ_A}] - \varepsilon\, Q$$

$$(A6) \quad \frac{dQ_A}{dS_A} = - \frac{\beta_2}{\beta_1} \frac{Q_A}{S_A},$$

$$assume \ S_B = 0 \ and \ \frac{dQ_B}{dQ_A} \cong -1.$$

$$(A7) \quad \frac{dE_T}{dS_A} = \varepsilon\, Q_A [\frac{\beta_2}{\beta_1} - 1].$$

Or, if $\frac{dQ_B}{dQ_A} \neq -1$,

$$(A8) \quad \frac{dE_T}{dS_A} = \frac{\beta_2 \; Q_A \, \varepsilon}{\beta_1 \; S_A} \; [S_A \; (1 - \frac{\beta_1}{\beta_2}) - (\frac{dQ_B}{dQ_A} + 1)].$$

If $\frac{dQ_B}{dQ_A} \cong -1$ and $S_B > 0$,

$$(A9) \quad \frac{dE_T}{dS_A} = \varepsilon \, Q_A \; [\frac{\beta_2}{\beta_1} * \frac{S_A - S_B}{S_A} - 1].$$