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Globalization and Sustainability:

The Machine in the Global Garden

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> It is quite easy to fancy a state of society, vastly different from ours, existing in some unknown place like heaven; it is much more difficult to realise as a fact that the order of things with which we are familiar has so little stability that our actual descendants may be born into a world as different from ours as ours is from that of our ancestors of the pleistocene age.
>
> J. B. Bury, *The Idea of Progress*, p. 351.

I. Introduction: An Old Story in a New Version

"The genius of sustainable development," it is suggested, "is to finesse the perceived conflict between economy and environment and between the present and future" (Board of Sustainable Development, 1997, p. 13). Webster's defines "finesse" as to "handle delicate situations diplomatically," or, in the context of bridge or whist, "an attempt to take a trick with a lower card while holding a higher card" (*Webster's New World Dictionary*). In this paper I will explore some reasons why winning this trick is so difficult, focusing specifically on the deep-rooted tensions between sustainability and globalization, and the need for more detailed empirical research on their interaction.

Both sustainability and globalization are obviously ambiguous terms, chosen to describe different things by different parties, and valued as much for their ambiguity (the diplomatic form of finesse) as for their definition. Yet as A. K. Sen (1980) noted, description is a form of choice, upon which empirical prediction and normative prescription are ultimately founded. To choose to be ambiguous in describing a phenomenon is thus to encourage conflicting empirical predictions and valuative prescriptions in the name of "finesse."

"Globalization" nearly always describes international economic competition and its impact on "connectedness," specifically, the increasing transboundary flows of goods, services, bads and disservices, including not only materiel, but information, environmental pollution, and people. "Sustainability" provides similar scope as a covering concept for a wide variety of environmental and economic initiatives aimed at "meeting the needs of the present without compromising the ability of future generations" (World Commission on Environment and Development, 1987).

What is noteworthy about these concepts is not their obvious ambiguity, but their reflection of the interplay of two deeper forces at work since the early 19th century, in which ***natural history*** is counterpoised with ***technological change***. It is my view that globalization is a result of further technological change, and that sustainability is a projection of a view of natural history. The International Monetary Fund, in its 1997 World Economic Outlook, focused specifically on globalization (although not its environmental implications). The report gave technology the leading role, noting:

> New technological advances have sharply reduced transportation, telecommunication, and computation costs, greatly increasing the ease with which national markets may be integrated at the global level. Economic distances have shrunk and coordination problems have diminished to such an extent that in many cases it has become an efficient method of industrial organization for a firm to locate different phases of production in different parts of the world. The structure of foreign trade has increasingly become intra-industry and intrafirm, and foreign direct investment (FDI) serves as an important vehicle of globalization. More and more, countries depend on each other for technology transfer and learn from each other manufacturing methods, modes of organization, marketing, and product design. Research and development (R&D) spillovers are thus another aspect of economic linkages among countries. Moreover, these various elements of globalization--trade, direct investment flows, technology transfers--have become

> more closely linked and interconnected, and the world economy is becoming, more and more, the relevant context for economic decisions (pp. 45-46).

A recent report of impacts of globalization on the metropolitan area of Minneapolis-St. Paul also highlights technology, defining globalization as "a multifaceted process affecting society, politics, and the economy..." involving "rapid advances in the technology of communications and transportation," and "...increased cross border flows of information, goods and people" (Stanley Foundation, 1997).

While globalization is a process driven by technology, sustainability seems very clearly to reflect a perception of man's role in the history of nature. When stripped of economic or ecological jargon, the main issues are a concern for the well-being of future generations in the face of growing pressure on the natural environment to provide a variety of services including extractable natural resources, waste absorption, and ecological system resilience. These concerns have an explicit historical and temporal reference. Although forward looking, they also reflect concerns over whether current and past patterns of consumption and production are excessive if we wish to maintain the welfare of future generations (Toman, et. al., 1995).

Together, globalization and sustainability overlap mainly in terms of the role of technology both as a destroyer and creator of biological and thus environmental processes. These interactions are especially close in the fields of molecular biology and biotechnology (see Ruttan, 1996). This interplay, brilliantly analyzed as a social process by Leo Marx in *The Machine in the Garden* (1964), has attracted adherents to the causes of both the natural world, and the process of technological innovation. While the dividing line between celebrants of technology and critics of its impacts on the natural world are not always clear, the academic disciplines of economics on the one hand and ecology on the other seem to fairly represent these camps, despite a common etymology founded in ***ecos*** (the household) (see Norton and Toman, 1995).

In understanding such disparate reactions, it is important to appreciate that the study of natural history and technological change coevolved, converged and began to push against one another at about the same time, roughly in the first half of the 19th century. As Stephen Ambrose (1996) has written in describing the state of knowledge and technology at the time of Lewis and Clark's expedition into the uncharted natural wonders of Louisiana:

> The Americans of 1801 ... could not move goods or themselves or information by land or water any faster than the Greeks and Romans.... But only sixty years later, when Abraham Lincoln took the Oath of Office as the sixteenth President of the United States, Americans could move bulky items in great quantity farther in an hour than Americans of 1801 could do in a day, whether by land (twenty-five miles per hour on railroads) or water (ten miles an hour upstream in a steamboat). This great leap forward in transportation -- a factor of twenty or more -- in so short a space of time must be reckoned as the greatest and most unexpected revolution of all -- except for another technological revolution, the transmitting of information. In Jefferson's day, it took six weeks to move information from the Mississippi River to Washington, D.C. In Lincoln's, information moved over the same route by telegraph almost instantaneously (pp. 53-54).

Thus in the early 19th century was the conviction broken, as Henry Adams wrote, that "what had ever been must ever be" (p. 52). And so began a distancing of the forces of the garden from the machine, or in Adam's metaphor, of the virgin and the dynamo. By the end of the Civil War, knowledge of the vast natural treasures of not only the American West but the continents of South America and Africa had increased exponentially, and would continue to do so into and throughout the 19th century. Technological progress was equally rapid, entirely changing what J. B. Bury (1932) came to call the "idea of progress," and deepening the capacity of man to affect natural ecosystems as well as to understand the scientific principles underlying them.

In the 20th century, the capacity of technology to completely alter physical landscapes and change the order of natural systems and cycles has become more and more obvious. Total war, in Europe and, at the nuclear level, in Japan, has been one example. Extractive industry, such as strip mining or widespread clear-cutting of forests, has been another. These manmade disruptions have forced us to ask whether technology can continue to act on natural systems without ultimately destroying them. Yet at the same time, technology may hold the promise of reducing some of the ecological impacts of modern production methods, by substituting information or biological processes (including genetic information) for physical inputs, as in the case of plant biotechnology.

The current tension between sustainability and globalization is thus a surface phenomenon reflecting a deeper social and intellectual tectonics, in which views about natural history and technological change push against one another, a process that has produced numerous efforts to finesse the fault lines this pressure creates, of which "sustainable development" is only the most recent. The dynamic process of this interplay has produced distinct perspectives on technology and the natural environment:

- A view of technical change that is positively related to nature, capable of both exploiting but also preserving it, or *technological optimism*.
- A view of technical change that is *negatively* related to nature, in which technology displaces and destroys it, or *technology pessimism*.
- A separation of nature from technology, which takes a *positive and optimistic* form, insofar as technology substitutes for natural systems.
- A separation of nature from technology, which takes a *negative and pessimistic* form,

> in which technology drives out natural systems and immisenzes human and other biotic communities.

As a shorthand, we may think of these as positive complementarity, negative complementarity, positive substitution and negative substitution, summarized in Figure 1.

Figure 1

		Natural History (sustainability)	
		Complements	Substitutes
Technological Change (globalization)	Optimism	Positive Complementarity	Positive Substitutability
	Pessimism	Negative Complementarity	Negative Substitutability

The debate over sustainability and globalization may be located in the space of these interactions, all of which are illustrated in current debates over plant biotechnology or the consumption of fossil fuels. On the one hand, technological optimists see the process of globalization as productive of positive complements to natural resources or as an outright substitute for them. This view appears currently in the embrace of plant biotechnology on the side of complementarity, and in economic analysis of "backstop technologies" as substitutes for natural resources that become scarcer and more valuable (see Nordhaus, 1979). On the pessimistic side, critics of developments such as biotechnology emphasize its risks to natural biota (e.g., Krimsky and Wrubel, 1996), and note the potential of such technologies to substitute for and ultimately to drive out genetic diversity and resistance to various plant diseases or pests. It is interesting that the Union of Concerned Scientists, forged originally to combat the negative impacts of nuclear fission and fusion, has recently turned its attention to agricultural biotechnology, suggesting that it is technological pessimism that unites these two initiatives (see Rissler and Mellon, 1996).

If this analysis is accurate, it suggests that sustainability and globalization are surface descriptions of deeper issues involving technological change and its impact on the natural environment, likely to generate entirely different empirical and normative predictions and prescriptions, depending on which "box" the analyst occupies in describing their interaction *a priori*. To rise above these divisions of opinion it is necessary to consider the empirical record more carefully.

II. Two Hypotheses

A hypothesis is a statement subject to confirmation or disconfirmation through testing with empirical evidence (Quine and Ullian, 1970). I will offer two broad hypotheses describing the impacts of globalization on sustainability. The first is that globalization (defined broadly as above) is the cause of reduced sustainability of ecological systems, and is in fact destroying them. While many have focused on physical environmental resources in this process, there are similar arguments made respecting labor conditions and cultural resources. The trade/environment debate reflects the first issue, on which we will concentrate here. However, there is an equally lively debate over labor conditions and standards (including wage levels and worker safety, for example) and cultural issues such as the preservation of traditional heritage or language. In all cases, the hypotheses is that the transboundary flow of goods, services, bads and disservices, part of an elaborated cycle of technological change, negatively affects environmental quality, labor conditions or traditional culture. Mowery (1997) has noted that globalization, especially as it relates to R&D, is an elaborated form of a Raymond Vernon's "product cycle," in which demands for specific innovations first appear in a "lead market," then are diffused to other markets through direct foreign investment. If this process is enlarged to include not only goods but services, bads, and disservices, globalization represents the diffusion of all of the "products" of technological change across jurisdictional boundaries. Tests of this hypothesis suggest a complex picture, in which the hypothesis is by no means universally accepted.

The second, and in some ways more refined, hypothesis is that globalization, a largely market-driven phenomenon, carries with it effects that result from the failure of markets to account for environmental impacts (or, for that matter, labor conditions and cultural effects). Analyzing the second hypothesis is somewhat more difficult, but in my judgement more rewarding, since it leads to a decomposition of both the market and nonmarket impacts of global trade as they relate to environmental quality (as well as labor conditions and culture). I shall argue that the first hypothesis, the "globalization as destroyer" hypothesis, is unduly pessimistic as description of observable evidence. When used to describe the environmental impacts of globalization, it leads to a substantial number of false predictions and prescriptions. The second, or market failure, hypothesis is supportable, and implies the need for more substantial institutional innovations in response to these failures, of which the current world community and many nations have yet to show themselves capable, with some small but significant exceptions.

A. Globalization as Destroyer

The view that globalization is a dynamo of ecological, worker and cultural destruction has a substantial following. William Greider, in *One World, Ready or Not, the Manic Logic of Global Capitalism* (1997) argues that excessive levels of output will ultimately lead to global economic collapse. David Korten, in his *When Corporations Rule the World*, has argued explicitly against globalization and in favor of "localism," largely on the grounds that "maintaining a global economy allows us to be far less aware of whose resources we are dependent on" (Korten, in Danaher, 1996, p. 56). Trade, in this view, is the great destroyer, reflected in other, even more polemical works such as the recent *Corporations Are Gonna Get Your Mama: Globalization and the Downsizing of the American Dream* (featuring an introduction by Noam Chomsky, and contributions by Korten, Ralph Nader and others).

The empirical evidence is more complicated. While it would be too time consuming to review all of this evidence, the basic findings suggest that trade and associated GDP growth do lead to increases in various indicators of environment damage, but that in many cases these indicators then move positively at higher levels of income. Table 1 provides a summary of a number of studies examining this so-called "inverted U" or "Kuznets" function (analogous to the demographic transition hypothesis), in which pollution rises with increases in income at lower levels of GDP per capita, then begins falling once a threshold is reached. The table describes data sources, pollution measures, media and results, as well as the level of GDP per capita at which various pollution levels peak.

Lucas (Table 2), in a separate analysis, has looked not only at the relation to GDP/capita, but specifically at the relation between various environmental indicators and trade-openness measured by exports/GDP, finding that many pollutants are unassociated with export openness, and some indicators, such as wilderness area, are positively associated with openness, while deforestation is negatively associated with it.

In a recent report for the World Resource Institute (Table 3), I and others examined the relation between changes in export shares in Latin America and the Caribbean for numerous ISIC sectors, and found that the highest polluting sectors were basic metals, industrial chemicals and non-metal products, whilst the lowest were textiles and apparel, metal products and food products. When export growth in these sectors was examined, it was by no means clear that export share was growing more rapidly in the highly polluting sectors; if anything, the opposite trend seemed better supported (Runge, et. al., 1997).

Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Grossman and Krueger (1995)	GEMS[1]	Concentration (units of pollutant/volume of water or air)	SO_2	Air	Inverted U	cubic	4,053[5] (355)[6]
			Dark Matter or Smoke	Air	Inverted U	cubic	6,151 (539)
			Suspended Particles	Air	Downward	cubic	NA
			Lead	Water	Inverted U	cubic	1,887 (2,838)
			Cadmium	Water	Inverted U	cubic	11,632 (1,096)
			Arsenic	Water	Inverted U	cubic	4,900 (250)
			Mercury	Water	Inverted U	cubic	5,047 (1,315)
			Nickel	Water	Inverted U	cubic	4,113 (3,825) (1985
			Fecal Coliforms	Water	Inverted U	cubic	7,955 (1,296) US$[7])
			Total Coliforms	Water	Inverted U	cubic	3,043[8] (309)
			Nitrates	Water	Inverted U	cubic	10,524 (500)
			BOD[2]	Water	Inverted U	cubic	7,623 (3,307)
			COD[3]	Water	Inverted U	cubic	7,853 (2,235)
			Dissolved Oxygen	Water	U - Shape[4]	cubic	2,703 (5,328)
Lucas, Wheeler, and Hettige (1992)	World Bank PPS[9]	Emissions (Weight of releases/GDP)	Weight of 320 toxic releases	Air, Water and Land	Inverted U	quadratic	12,500 (1987 US$)

[1]Global Environmental Monitoring System
[2] Biochemical Oxygen Demand.
[3] Chemical Oxygen Demand
[4]Dissolved oxygen is a positive indicator of environmental quality, hence the relationship is the inverted with respect to the other indicators. The trough is reported under the pollution peak column.
[5] For cubic functional forms the peak level is a local maximum.
[6] Statistics in brackets are standard errors.
[7] Per capita income in purchasing power parity terms came from Summers and Heston (1991).
[8] The authors report a strange relationship with this pollutant. Total coliforms at first increase with income and then decrease. However, they then increase dramatically -- within the range of the data.
[9]World Bank Pollution Projection System

Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality, continued.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Shafik and Bandyopadhyay (1992)	World Bank	%of population with access to safe drinking water or sanitation, concentration[10], change in forest area, concentrations[11], kilograms per capita[12], metric tons per capita[13]	Lack of safe drinking water Lack of urban sanitation Dissolved oxygen Fecal coliform Annual deforestation Total deforestation[14] Suspended Particles SO_2 Municipal solid waste Carbon	Water Water Water Air Air Land Air	Downward trend Downward trend Downward trend Inverted U then Upward trend Inverted U Inverted U Inverted U Inverted U Upward trend Upward trend	linear, quadratic and cubic[15]	NA NA NA 1375 (PPP$) Not reported Not reported 3280 3670 NA NA
Holtz-Eakin and Selden (1992)	Oak Ridge Nat. Lab.	Emissions	CO_2	Air	Inverted U	quadratic	35428 (1986 US$)
Selden and Song (1994)	World Resource Institute	Emissions	SO_2 NO_x Suspended Particles CO	Air Air Air Air	Inverted U Inverted U Inverted U Inverted U	quadratic quadratic quadratic quadratic	8916-10682[16] 12041-21773 (1985 US$) 9811-9617 6241-19092

[10]Concentration measures were used for dissolved oxygen and fecal coliform bacteria in rivers.
[11]Concentrations in micrograms per cubic meter for suspended particles and SO_2.
[12]This measure is for municipal solid waste.
[13]This measure is for CO_2 emissions.
[14]Total deforestation in hectares since 1961.
[15]All variables were log transformed.
[16]Selden and Song estimated a fixed effects and random effects model for each pollutant. The first number is for the fixed effects model and the second for the random effects model.

Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality, continued.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Lucas (1996)	Oak Ridge National Laboratory, World Bank PPS, World Resources Institute	Emissions 1000 tons, lbs/year/million US$ of manufacturing output (toxic release and water), lbs/yr/thousand US$ of manufacturing output (air), Area in km^2, Area in 1000 ha, Volume km^3 (Water), tonnes (pesticides)	CO_2	Air	Increasing Trend	quadratic	24,568[23]
			Total Toxic Release[17]	All	Inverted U	quadratic	10,500
			Bioaccumulative Metals	All	Inverted U	quadratic	5,250[24]
			BOD	Water	Inverted U	quadratic	17,750[24]
			Suspended Solids	Water	Inverted U	quadratic	6,300
			Suspended Particles	Air	Downward Trend	quadratic	NA
			SO_2	Air	Downward Trend	quadratic	NA
			NO_2	Air	Downward Trend	quadratic	NA
			Fine Particles (PM10)	Air	Downward Trend	quadratic	NA
			Lead	Air	Downward Trend	quadratic	NA (1987 US$)
			VOC[18]	Air	Inverted U	quadratic	20,000
			Wilderness	Land	Inverted U	quadratic	1,715-11,740
			Deforestation	Land	Inverted U	quadratic	1,960
			Fresh Water Withdrawals	Water	Increasing Trend	quadratic	NA
			Pesticide Use	Land, Water	Inverted U	quadratic	1,715-13,750
			Threatened Species: Fish		Inverted U[19]	quadratic	Not Reported
			Amphibians		Increasing Trend[20]	quadratic	NA
			Reptiles		Not Related[21]	quadratic	NA
			Birds, Mammals		Inverted U	quadratic	9,000
			CFCs	Air	Increasing Trend[22]	quadratic	NA
			Solid Waste	Land	Inverted U	quadratic	13,000

[17] Weighted average of 320 toxic releases.
[18] Volatile Organic Compounds.
[19] This result was sensitive to inclusion of variables other than income per capita and population.
[20] This result was derived by the author from statistical results in Lucas (1990).
[21] Does not appear to rise or fall with income per capita.
[22] Lucas (1990) reports this as a weak inverted U-shape, but the peak level of income was beyond the range of the data.
[23] This income is outside the range of data.
[24] This estimate was calculated by the author from results provided in Lucas (1996).

Table 2. Estimated Relationship between Environmental Indicators, Growth, and Trade

Environmental Indicator[1]	Follows GDP/capita	Follows Growth in Income	Follows "Openness Index" (Exports/GDP)	Follows Time Trend	Population
(1) Annual CO_2 Emissions[2]					
(a) Total	+	0	0	0	NR[8]
(b) Solid Fuels	+	0	–	0	
(c) Liquid Fuels	–	0	0	0	
(d) Gas Fuels	+	0	0	+	
(e) Gas Flaring	+	0	+	–	
(f) Cement Manufacture	+	0	0	+	
(2) Pollution Intensity[2]					
(a) All media: total toxics	+	0	+	+	NR
(b) Water Polluting: BOD	0	0	–	0	
(c) Air Pollution					
i. Suspended Particles	0	0	–	+	
ii. SO_2	0	0	0	0	
(3) Wilderness Area[3]					
(a) Adjusted for Total Area	+	NR	+	NR	0
(b) Adjusted for Agricultural Land Use	+	NR	+	NR	0
(c) Adjusted for Forestry Practices	+	NR	+	NR	–
(4) Deforestation[4]					
(a) Adjusted for Total Area	+	NR	–	NR	–
(b) Adjusted for Agricultural Land Use	+	NR	–	NR	–
(c) Adjusted for Forestry Practices	+	NR	–	NR	–
(5) Freshwater Withdrawals[5]					
(a) All countries	+	NR	0	NR	+
(b) Adjustment for Total Water Available	+	NR	0	NR	+
(c) Adjusted for Agricultural Land Use	–	NR	0	NR	+

Table 2 (concluded)

Environmental Indicator[1]	Follows GDP/capita	Follows Growth in Income	Follows "Openness Index" (Exports/GDP)	Follows Time Trend	Population
(6) Marine Catch[6]					
(a) Adjusted for Exclusive Economic Zone	–	NR	0	NR	0
(b) Adjusted for Meat Output	–	NR	0	NR	0
(c) Adjusted for Freshwater Catch and Aquaculture	–	NR	0	NR	0
(7) Pesticide Use-Active Ingredients Used[7]					
(a) All countries	+	NR	–	NR	0
(b) Adjusted for Climatic Zone	+	NR	–	NR	0

Notes to Table:

[1]Entries of +, 0 and – indicate a significantly positive, insignificant and significantly negative statistical association at the one-tailed 95th percentile of confidence, respectively. These correspond to "positive," "none" and negative in the charts in Appendix I.

[2]Fixed Effects Time Series Models. Annual CO_2 emissions in 1,000 tons for 113 countries. All media, water pollutants and air pollutants measured as emissions flows in lbs. per year per U.S. million dollars of manufactured output for 96 countries.

[3]"Wilderness" defined as a minimum of 4,000 km^2 showing no evidence of human development. Data from World Resources Institute analysis of aerial photographs.

[4]"Deforestation" in units of 1,000 hectares.

[5]"Freshwater withdrawals" in km^3.

[6]"Marine Catch" in 1,000 tons.

[7]"Pesticides" in tons of active ingredient.

[8]NR indicates not reported.

Source: Adapted from R.E.B. Lucas. "International Environmental Indicators: Trade, Income and Endowments." Chapter 16 in M.E. Bredahl, et. al. (eds.) *Agriculture, Trade and the Environment: Discovering and Measuring the Critical Linkages*. Boulder, CO: Westview Press, 1996.

Table 3. Changes in Export Shares of Production for Low and High Pollution Intensive Sectors in Latin America

		Change in Export Shares of Production		
		Low-Intensity Polluters		
Country	*Time Period*	*Textiles, Apparel*	*Metal Products*	*Food Products*
Argentina	1993	13%	8%	14%
Belize	90 and 92	-	Rising (54-58%)	Falling (62-53%)
Bolivia	88-91	Rise then fall (19-32%)	Rising (2-3%)	Rising (9-21%)
Chile	86-91	Rising (2-9%)	Falling (45-9%)	Steady (18%)
Colombia	86-91	Rising (13-36%)	Fall and Rise (5-11%)	Rising (3-5%)
Costa Rica	86-91	Rising (27-43%)	Fluctuating (24-27%)	Rising (7-11%)
Ecuador	86-90	Rising (1-5%)	Rising (2-4%)	Fall then steady (56-10%)
El Salvador	92	43%	24%	7%
Guatemala	85-88	Rise then fall (19-9%)	Rise then Fall (14-6%)	Rise then fall (9%)
Honduras	85-88	Steady 5%	Fall (6-5%)	Falling (9-6%)
Mexico	86-92	Fall then rise (41-51%)	Rising (23-61%)	Falling (8-4%)
Panama	85-89	Rising (20-43%)	Rising (2-8%)	Falling (9-5%)
Paraguay	1991	33%	19%	56%
Peru	86-88	Falling (15-8%)	Falling (38-32%)	Rising (8-22%)
Uruguay	86-90	Falling (57-51%)	Falling (9-6%)	Fall then Rise (26%)
Venzuala	85-92	Rising (1-4%)	Fluctuating (4-7%)	Rising (1-3%)

		Change in Export Shares of Production		
		High-Intensity Polluters		
Country	*Time Period*	*Basic Metals*	*Industrial Chemicals*	*Non-Metal Products*
Argentina	1993	14%	8%	3%
Belize	90 and 92	-	-	-
Bolivia	88-91	-	-	-
Chile	86-91	Rising (48-62%)	Rising (7-10%)	Rise then Fall (1-3%)
Colombia	86-91	Rising (11-24%)	Rising (11-14%)	Fall and Rise (8-12%)
Costa Rica	86-91	-	Rising (16-21%)	Steady (16-15%)
Ecuador	86-90	Rising (0-2%)	Fluctuating (1-16%)	Rising (0-3%)
El Salvador	92	61%	15%	8%
Guatemala	85-88	Rise then fall (11-2%)	Rise then fall (15-8%)	Rise then Fall (11-5%)
Honduras	85-88	-	Falling (4-3%)	Rising (0-6%)
Mexico	86-92	Falling (22-13%)	Falling (21-16%)	Rise then Fall (14-10%)
Panama	85-89	Rising (11-22%)	-	Rising (1-6%)
Paraguay	1991	-	47%	0%
Peru	86-88	Rising (3-6%)	Steady (10%)	Steady (2%)
Uruguay	86-90	Falling (17-13%)	Rising (8-13%)	Rising (7-13%)
Venzuala	85-92	Falling (61-38%)	Falling (60-50%)	Falling (19-11%)

Source: P. McGinnis and P. Faeth, WRI, 1997, in Runge, et. al., 1997.

Hence, it must be concluded based on the evidence to date that export expansion and increases in GDP per capita as a measure of globalization are not unambiguously associated with reduced sustainability of ecological systems; rather, growth in income and exports appears to lead to increases in environmental damages at lower income levels, followed in some cases by reduction as incomes increase, implying that income growth is a precondition for environmental protection.

On the side of wages, recent work has suggested that globalization is associated with the convergence rather than divergence of wage levels. The main reason for this is the ***increase*** in real wages in low wage earning countries, which is not accompanied by comparable decreases in real wages in high income countries. Williamson (1996), in a study of industrial economies in three periods (1850-1914, 1914-1950, and 1950-present) finds that in the first and last periods, globalization and more open trade, as well as mass migration, caused a convergence in real wages, due to poor countries growing more rapidly than rich, or what new growth theorists call "beta-convergence," while the protectionism and contraction of the middle period caused a cross-country divergence. The process of global integration since 1950 has also involved convergence, but with the participation of an increasingly large group of countries. However, there is very little evidence of widespread net job destruction (see Krugman, 1997). What is most striking is the coincidence of this process and the divergence of real wages ***inside*** the U.S. economy, a phenomenon less convincingly laid at the feet of trade than at U.S. social and corporate compensation policies (see Freeman, 1996).

On the side of cultural diversity, the evidence also supports the proposition that convergence, rather than divergence, has resulted, although cultural indicators are less precise than real wage levels. In a study of the NAFTA countries using a variety of survey data, Inglehart, et. al. (1996), found that the U.S., Canada and Mexico were all converging respecting consensus views of democracy and market processes. The most striking changes appeared to be taking place in Mexico, which was moving from a highly centralized to a more pluralistic political system, a finding confirmed by the results of 1997 elections. Such changes are less obvious in Canada and the U.S., but here too movement appears toward higher levels of public participation, augmented by access among NGOs and others to the information superhighway. But all of this evidence, which remains fragmentary, begs the key question: What are the ***mechanisms*** behind this process? This brings me to hypotheses number two.

B. The Machine of Trade in the Garden of the World Environment

Leo Marx concluded his study of technology and the pastoral ideal (which was largely a literary exercise) with the prescient remark that "The machine's sudden entrance into the garden presents a problem that ultimately belongs not to art but to politics" (p. 365). The ***mechanisms*** by which globalization affect sustainability are not revealed by inverted U-shaped functions, which hide the political choices leading nations and individuals to respond to pollution as a "public bad." (Similar arguments over failures of the market can be made respecting wages, labor conditions and culture, but will not be pursued here.) These market failures demand attention to the incentives of individuals and nations to engage in collective actions to reduce these negative externalities over time (see Sandler, 1997). This leads to a decomposition of the impacts of trade on the environment which can allow us to discern if, how and why certain trends in the data occur, such as the inverted "U." Let me sketch five such impacts of trade on the physical environment (see Runge, 1995).

The first and most celebrated (since Adam Smith) is ***allocative efficiency***, the persuasive argument that specialization and comparative advantage more efficiently utilize natural resources that policies of national or local self-sufficiency, a view in direct contrast to that of Korten and other advocates of "localism." The second effect of trade is on the ***scale*** of economic activity, generally measured in terms of GDP per capita, involving the question of whether economic activity creates more ecological "wear and tear." The nonlinearities reported in the data (specifically inverted-U-shaped functions) suggest that other forces are at work, above and beyond scale effects. The third effect is on the ***sectoral composition*** of output: are more or less ecologically threatening sectors favored by trade? This was the focus of the Latin American exercise reported on earlier. A fourth way in which trade may affect the environment is by inducing ***technological innovation*** and transfer -- of both goods and bads. A final impact is on policy -- and politics. Whilst rising incomes may make environmental protection more affordable, the ultimate question is not only whether populations are ***able*** to pay for such protection, but whether they are ***willing to pay and can reveal this preference through the political process***. Market failure is thus joined by the possibility of government failure in causing negative environment impacts to which societies fail to respond.

Schematically (Figure 2), we can think of trade and globalization as inducing some allocative efficiencies, leading to increased growth and GDP per capita, with some negative scale effects. ***If*** these effects lead to increases in demand for environmental protection, revealed in a political process, then induced technical changes and shifts in composition are more likely. But the critical possibility for disconnection, assuming at least some negative scale effects are not overcome by allocative efficiencies and market-based technologies, is whether the political process responds to the need to reduce environmental externalities over time.

This question lies at the heart of the debate over sustainability and globalization. Obviously, the political process at both the national and the international level is only beginning to respond -- and grudgingly. Moreover, the data suggests that such responses are much less likely at lower levels of income, even in well-functioning democracies. In the United States and Western Europe, environmental responsibility and even corporate environmental activism are very much in favor with the public and a large part of the private sector. But in most developing countries, environmental regulation is regarded as at best an affectation of the rich, and at worst an excuse to deny market access to Third World exporters as a form of green protection. The central conundrum facing global environmental policy is how to connect incentives for upward harmonization of environmental standards to the dynamic process of trade liberalization, while avoiding the use of "environmental conditionality" as an excuse for closing off market access (see Runge, et. al., 1997; Vogel, 1995). Here, new institutions are required, including the possibility of a World Environment Organization (WEO), designed to function alongside the World Trade Organization in Geneva (Runge, et. al., 1994; Esty, 1994).

Figure 2

Trade Impacts on the Environment

Trade → Allocative Efficiency (+) → Growth in GDP/capita

→ Scale Effects (–) → Demand for Environmental Protection

→ Change in Policy → Change in Composition (+) → Change in Technology (+).

The plus sign denotes positive and the minus sign negative environmental impacts.

Source: Runge, 1995, p. 366.

Conclusions

Let me conclude by suggesting that the reconciliation of globalization and sustainability is unlikely to occur without political commitments to redirect some of the economic benefits generated by growth and trade towards targeted environmental improvements. How and where to ***target*** these improvements requires data on environmental impacts, and attention to the possibility that environmentalism can be hijacked for purely protectionist purposes. For these reasons, any real progress in sustainable development is unlikely until we have a clear empirical basis allowing interventions that maximize environmental benefits and discourage protectionism in green guise. Such detailed analysis and understanding requires investigators to temper *a priori* optimism or pessimism, and to admit the possibility of both positive and negative ecological impacts of globalization. This goes beyond efforts to finesse deep divisions over the impacts of economic change on the natural environment, acknowledging negative and positive effects when and where they occur, and encouraging political and policy decisions that promote positive and discourage negative impacts. This view is neither original or new, and is strikingly similar to that of Pigou's *Economics of Welfare* (1962). But the scientific essence of this effort is empirically accurate description, upon which prediction and prescription can then be built.

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