From Estimation to Simulation: Assessing the Links between Trade and the Environment

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The present paper looks at the empirical evidence concerning the trade-environment nexus. A large body of estimation approaches has led to inconclusive results. Based on a brief discussion of these contributions the paper will present ways to overcome the existing shortcomings. While this includes extensions to the estimation procedures the emphasis will be on a simulation approach that allows one to quantify the effects of very narrowly defined trade and environmental policy measures.

1. Introduction

There is a global trend towards increasing economic as well as ecological integration. The former has come about through a steady increase in global trade and foreign direct investment, and the latter reflects an increased awareness of transboundary pollution and global environmental threats. These trends have resulted in increasingly fierce opposition of environmentalists and protectionists alike to free trade. They argue that liberalizing international trade increases pollution and accelerates the deterioration of environmental quality because pollution-intensive activities will expand where they are least regulated while production in tightly regulated countries shrinks. Consequently, trade restrictions are an appropriate tool for protecting the environment and restoring the international competitiveness of countries applying high environmental standards. To what extent are their claims really justified?

Theoretically, the effects of trade on the environment can be decomposed according to Grossman and Krueger (1993) into a (i) scale effect, a (ii) composition effect, and a (iii) technique effect. The scale effect measures the impact of trade through the expansion of economic activity while holding both output and input coefficients constant. The composition effect isolates the changes in environmental quality caused by shifts in the output structure while the input coefficients and the size of the economy are constant. Then the technique effect measures the impact of only changing input coefficients. If lax environmental standards alone determine comparative advantage the composition effect would unambiguously increase pollution through trade and thus result in pollution havens, i.e. a global shift of pollution-intensive industries to countries with lax environmental regulation. However, this could be offset by the technique effect as trade causes income growth, which may in turn via tougher regulation induce the adoption of cleaner technologies (Dean, 1996). Moreover, it is not clear whether standards alone determine the sign of the composition effect. For example: Pollution-intensive industries tend to be capital intensive.[1] Therefore, a capital abundant developed country could have a comparative advantage in pollution-intensive industries, even though it applies relatively tough environmental laws (Copeland and Taylor, 1996). While the emerging theoretical literature remains ambiguous the present paper will present ways to address the issue empirically.

2. Estimation Approaches

One of the earliest studies often cited in relation to the pollution-haven debate is the empirical investigation by Tobey (1990). The basic idea of the paper is to include a measure of the stringency of environmental regulation as a country-specific explanatory variable in a HOV cross-country regression model of trade. Tobey's proxy for environmental standards is not significant in determining the trade pattern for any of the pollution-intensive industries for which he runs the cross-country regressions.[2] However, the findings can at best be described as tentative.[3] The data set only includes 23 countries, of which 13 are developed countries, and environmental policy is measured on a rough or

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1 Mani and Wheeler (1997) find that capital intensity is substantially higher in dirty sectors while clean sectors are more labor intensive on average.

2 In addition to this, an omitted variable test is performed. Using the same model without the environmental indicator (which allows a cross-country regression for a larger set of 58 countries) does not result in a significant bias in the error term for high-income countries. This is despite the fact that they have consistently higher standards in environmental protection. Moreover, alternative specifications of the basic model seem to support the findings.

3 Given the difficulties empirical studies of HOV models have in predicting trade patterns, the results may not be surprising at all, regardless of the prior the researcher may have with respect to the role of environmental regulation. Note in this respect that in Tobey's model only two to four coefficients of the eleven endowment variables are significant.

almost arbitrary scale from 1 to 7.[4] More importantly for the purpose of this essay, however, is the objection that Tobey's approach does not consider any role for trade policy or openness of a country. Therefore, it does not address the relationship of trade liberalization and migration of dirty industries.

A more direct approach in this respect is taken in Lucas, Wheeler and Hettige (1992). They regress the change in the pollution intensity of output, measured for the 1960-1988 period, on the Dollar (1992) index of openness interacting with per capita income growth and some other controlling variables (such as initial per capita income).[5] Excluding OECD countries from the regression, the results imply for low- as well as middle-income countries that fast-growing closed economies would experience the highest increase in pollution intensity during the entire sample period, whereas fast-growing open economies would observe a decline in toxic-release intensity of their output during the 1980s.[6] One wonders what results would be obtained if the change of pollution intensity were regressed on the change of openness (possibly interacting with some country characteristics) rather than its level.[7] Furthermore, the regression does not include a direct measure of environmental stringency and thus fails to account for its possible interaction with trade policy. Apart from this, the chosen measure for openness is only one of many (Edwards, 1992) which casts doubt on the robustness of the results

[4] The classification is based on a 1976 UNCTAD survey. Comparing grades for the US (7), Austria (4), and Colombia (5) casts some doubt as regards the accuracy of the data.

[5] Pollution intensity of output is obtained in a two-step procedure. First, Toxic Release Inventory (TRI) data by the U.S. EPA is matched with plant level output data by the Census of Manufactures in order to compute the aggregate toxic releases per unit of output for 37 ISIC industries in 1987. Then these results are matched with UN annual sectoral output data during the period 1960-1988.

[6] This result is obtained by inserting parameter values for growth, openness and income in the estimated equation. However, the authors fail to address the degree to which their taxonomy of cases (e.g. fast growing closed low income countries) is relevant given real world observations.

[7] Consider two small "open" countries, one of which was "closed" at the beginning of the observation period and the other was "open". If both have maintained the same low environmental standards, then,

with respect to alternative indicators. The same may hold true for the measure of pollution intensity.[8]

Lucas (1994) uses fixed effects and cross-country regressions of environmental indicators on export performance, GDP, and other country-specific variables (e.g. natural endowment, population). The indicators for environmental quality include emissions of several air pollutants, toxic releases, the extraction or exploitation of natural resources, and the disposal of different kinds of waste. In this study openness is measured by the share of exports in a country's GDP. The estimated effect of openness on the environmental indicators is mixed. Also, the turning point of an inverted U-relationship between per capita income and pollution appears to vary substantially (between \$ 6,000 for water pollutants and \$ 24,000 for CO_2 emissions). Although this study presents a very comprehensive set of alternative regressions, notably with respect to the wide range of environmental indicators, the analysis lacks a clear theoretical motivation. The "independent" variables are endogenous and may significantly correlate with each other (e.g. population and export share, or GDP growth and export share). Moreover, no alternative measures of openness are used in the analysis, which may explain the inconclusive results in this respect. Furthermore, the study ignores the role of country-specific endowments, such as population density, share of urban population, or the fraction of arid land, in determining the level of environmental standards.

Rather than focusing on sectoral shifts in output as a proxy for the migration of dirty industries, Kolstad and Xing (1995) ask whether lax environmental regulations

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ceteris paribus, pollution intensity of the formerly "closed" economy should increase whereas it remains the same for the other economy. This difference remains unaddressed in the model used by the authors.

8 TRI data does not include any measures for atmospheric pollution. Rock (1996, p. 474) contends, that cross-country correlations between toxic-release intensities and CO_2-intensities are not significant.

attract foreign direct investment from the US chemical industry. Their approach has an interesting feature: Effective or actual environmental regulation is difficult to observe because it is not only a matter of laws but also one of enforcement. Their suggestion is to estimate first the degree of laxity of a country's effective (policy and enforcement) environmental regulation. These estimates are then used as an explanatory variable among other possible determinants (such as market size or per capita income) in a model of foreign direct investment. Looking at FDI from the US chemical industry into 23 host countries, the authors find that laxity of environmental regulation is a significant determinant. The approach, however, gives rise to objections both to model specification and measurement of variables. In order to estimate a country's environmental policy in the first stage the authors use data on air pollution only. However, the chemical industry may be more sensitive to regulation regarding water pollution or soil contamination. Also, the idea of migrating dirty industries is taken too literally in their approach and generally goes beyond mere FDI patterns. Migration of industries merely implies that somewhere production activities contract and elsewhere they expand. FDI is neither a necessary nor a sufficient condition for this.[9]

The analysis by Rock (1996) also suggests that dirty industries migrate to countries with relatively lax environmental regulation or, in this context, developing countries. Like Lucas, et al. (1992), the author uses pollution intensity of output as dependent variable in his regression model.[10] Explanatory variables include four alternative measures of trade orientation (country dummy, growth rate of export share,

9 For example, shifts in the distribution of global production caused by the pollution-haven effect may not require an increase in FDI, as local investors may respond themselves to changes in comparative advantage and/or trade policy.

growth rate of exports, and the Dollar (1992) openness index), per capita income and the manufacturing share of GDP. This model specification is not without flaws. Some of the independent variables are endogenous, possibly a function of trade policy, and there may be considerable simultaneity bias in the estimates. Notably, the manufacturing share of GDP is very similar to the dependent variable, since the latter itself is constructed from sectoral output mix. But again, as regards the objective of this essay, the most important objection to the model by Rock is that it does not include any direct measure of environmental policy, which may differ substantially across the 47 countries in the sample. Hence, this model also fails to quantify directly the impact of the interaction between trade liberalization and environmental policy.

To summarize, previous empirical work has failed to model directly the interaction of trade liberalization and sources of comparative advantage, of which one may be lax or absent environmental regulation.[11] Unteroberdoerster (1998, ch.3) addresses this issue. The study measures migration by the growth of the share of a dirty industry in a country's output. Such a measure captures the composition effect of trade and is more comprehensive than an account of foreign direct investment flows. This approach reveals that the extent of migration or the number of developing countries which attract a dirty industry differs across industries. Furthermore, comparing the migration pattern across countries the set of dirty industries whose share is growing

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[10] Whenever detailed pollution data is not available, the author makes use of the indices computed by Lucas et al. (1992). Separate regressions with comparable results are run for pollution intensity either related to human health risk or heavy metals.

[11] In addition to the above regression models there are several studies with a more limited approach. Some look at the relationship of pollution and trade of a special country or country pair (e.g. Abimanyu, 1996; Grossman and Krueger, 1993; Low, 1992) while other studies provide suggestive evidence by analyzing trends (e.g.. Low and Yeats, 1992; Leonard and Duerksen, 1988; Walter, 1982).

varies substantially. In short, the migration pattern depends on the type of dirty industry and the kind of developing country. Furthermore, including several proxies for environmental standards in this study reveals substantial differences across developing countries.

Findings from regressions, directly accommodating those industry- and country specific differences, suggest that there is neither explicit (controlling for environmental regulation) nor implicit evidence that freer trade results in a shift of dirty industries to developing countries. The coefficients on measures of openness and trade liberalization are only sometimes statistically significant. But, if they are, negative signs suggest that more outward orientation tends to suppress specialization towards dirty industries. On the other hand, tougher environmental regulation, in particular when measured by participation in international conventions (Maffei et al., 1996), often has a significantly negative effect on the growth of dirty industries. The findings of a pooled regression analysis, that the growth rate of dirty industries increases with the degree of dirtiness, indirectly confirms this effect of environmental standards. However, as Unteroberdoerster concludes, that does not support the pollution-haven hypothesis. Even when lax standards foster the growth of dirty industries, the results suggest that freer trade does not in any significant way enhance this effect but rather tends to mitigate it instead.

3. Simulation Approaches

All estimation procedures face the difficulty of measuring the two key variables of the trade-environment nexus: a country's openness or trade policy and the stringency of environmental standards. Therefore, simulations may provide a direct and more accurate account of the interaction between trade liberalization and environmental regulation. Unteroberdoerster (1998, ch.4) uses a multilateral trade model combined with environmental submodels to quantify the effects of such policy variables for APEC. This region is chosen because it has the potential to emerge as the world's largest free trade area, encompassing both developed and developing countries. At the same time environmental standards vary substantially among its members. Thus the region presents itself as a likely breeding ground for pollution havens. The following two sections give a brief outline of the model and summarize the major findings.

3.1 Model Structure and Data

The multi-country trade model is within the typical lines of many CGE models. On the production side, a constant-returns-to-scale technology is specified with fixed input coefficients for intermediate goods and value added.[12] The latter is a constant-elasticity-of-substitution aggregate of two primary factors, labor and capital. The demand system is modeled as a hierarchy of nested CES functions. There is only one type of final demand, consumption, which is first allocated to specific commodities. Then total demands by commodity are calculated, by adding final demand and intermediate demand, and split into demand for domestic goods and imports. The resulting composite import demand for each commodity is then distributed among the model's several regions, which give the imports by commodity from each of the model's regions. Hence the

[12] For a survey of supply and demand-side characteristics in CGE trade models see Shoven and Whalley (1984) pp. 1036 ff. Four out of six multi-country-trade models presented there make use of CES value-added functions plus fixed coefficients for intermediate inputs.

model is "Armingtonized" in that each commodity is differentiated by country of origin and the elasticity of substitution is less than infinite.

Perroni and Wigle (1994) make a first attempt at embedding an environmental sub-model into a multi-country framework, in order to assess the effects of trade liberalization on the environment.[13] The main features of the model used here are borrowed from their approach. At the same time a more realistic approach to policy enforcement is taken here. This allows a comparison of trade liberalization effects under four different environmental policy scenarios, which will be outlined in detail further below.

The major assumptions implemented here are as follows: There is only one type of pollutant, which results from both production and consumption. In the basic model, pollution is strictly local and only affects the environmental quality in the country or region where it originates.[14] The model is static, which implies that pollution has no stock feedback effects, and does not accumulate.

It is assumed further that environmental policy requires firms and consumers to abate a certain fraction of emissions they cause. In a command-and-control scenario this

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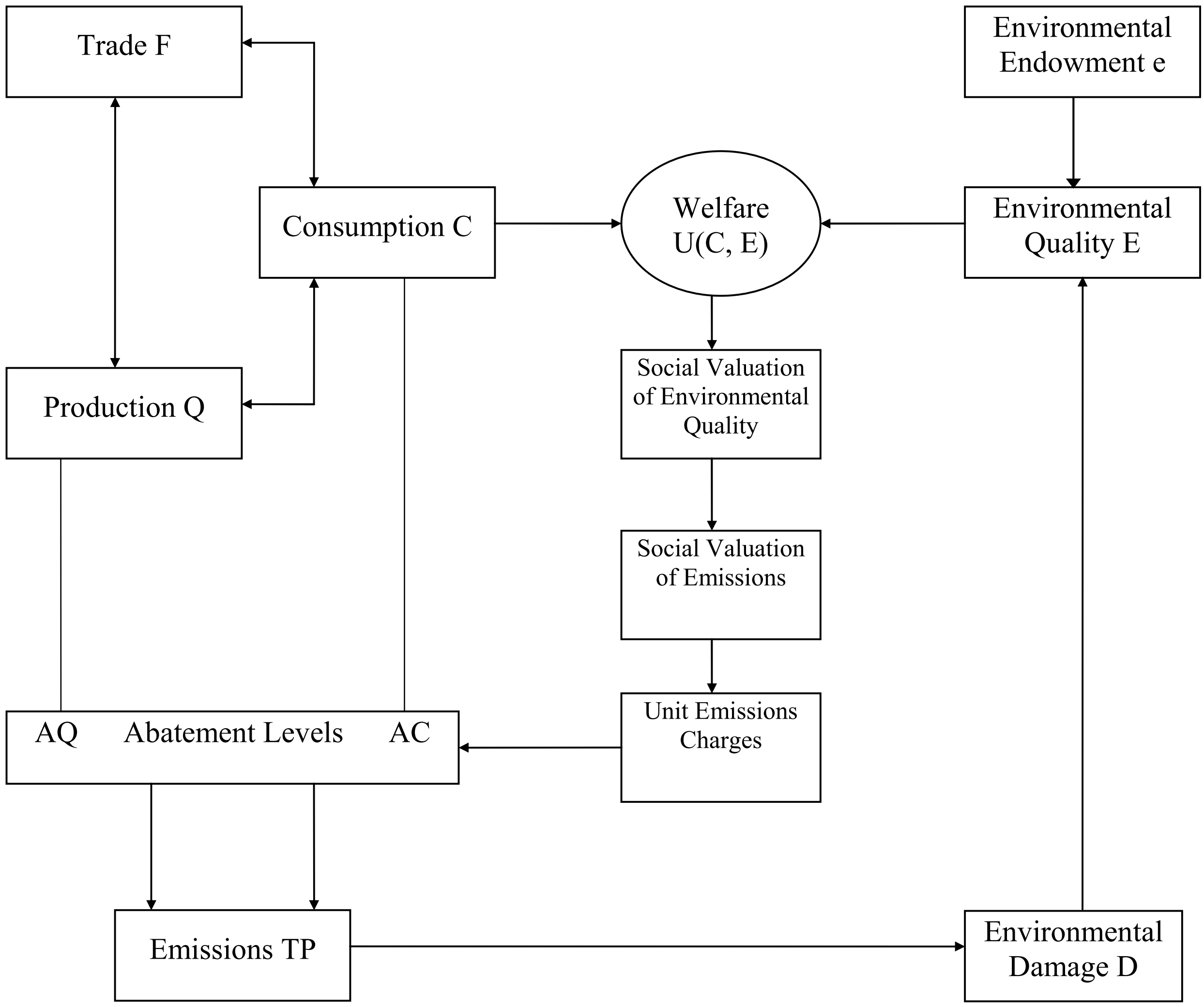
[13] Starting with Leontief (1970) most environmental CGE models have mostly been single-country approaches. For example, Bergman (1991) simulates of a policy requirement to reduce atmospheric emissions for the Swedish economy. Hazilla and Kopp (1990) attempt to estimate the social costs of the Clean Air and Clean Water acts in the United States. In addition to policy changes, Dufournaud et al. (1988) look at the net effects of technological improvements on pollution in a single country model. Anderson and Strutt (1998) model the environmental impact of trade liberalization for Indonesia, Beghin et al. (1995) for Mexico. Addressing APEC and the environment is the approach by Lee and Roland-Holst (1993). However, they keep the pollution coefficients of economic activities fixed across countries and thus do not endogenize environmental policy changes.

[14] Limiting the analysis in the basic model to local effects of pollution can be justified as follows. To start with, regulation of transboundary pollution is not well developed, not to mention that its enforcement in most cases still is only debated in theory (e.g. greenhouse gas emissions related to global warming). Therefore it does not appear to be an aspect of environmental regulation that differs across countries. The simulations in this paper, however, primarily aim to look at the interplay of differences in regulation and freer trade. Moreover, data on global pollution and its effects is even harder to find than that on local pollution.

abatement level is fixed. Under a pollution tax, however, the agents will choose an optimal abatement level at which the marginal cost of abatement equals the marginal benefit from saving pollution charges. This assumption requires one to specify an abatement cost function for each sector of production and consumption.

In order to assess the welfare effects of pollution, the environmental-damage has to be evaluated. Total pollution, which is the sum of net emissions by all sectors, enters a convex environmental damage function with a constant elasticity of damage with respect to pollution. The function's parameters may vary across countries to reflect differences in assimilative capacity. Environmental quality and per capita aggregate consumption then enter a Cobb-Douglas utility function to assess overall welfare. The share parameter of environmental quality in this function is assumed to be identical across all countries; preferences are identical and homothetic. From this one gets a social valuation of environmental quality and thus of emissions. This may differ across countries because of differing environmental damage parameters or per capita incomes. Note however, that it cannot differ because of preferences, since the share parameter on environmental quality is the same across all countries. Finally, the internalization rate of environmental externalities, assumed to be the same across all countries, determines the fraction of social emission costs which consumers and producers are forced to pay as emission charges. Thus it controls indirectly the abatement levels chosen in production and consumption. The mechanics of the environmental sub-model are illustrated in figure 1. The model is closed by the assumption of balanced trade for all model regions, which is implied by the macroeconomic assumption that income equals expenditure.

Figure 1: Environmental sub-model and multi-country trade model



Data on production, demand and trade is obtained from the GTAP database, Version 3. The Global Trade Analysis Project (GTAP) provides a fully documented, publicly available, global database for 1992. Its main advantage for the purpose of this research is that it creates consistent bilateral trade, transport and protection data and combines it with individual country input-output data. Each model region (UCAN, ANZ, JAP, NIC4, SEA4, CHINA, ROW) combines countries which are assumed to be at a similar stage of their economic development and therefore can be expected to apply similarly stringent environmental regulation. There are nine economic sectors in the model, which could be classified as representing “dirty”, “somewhat dirty”, and “relatively clean” industries. The two main data sources for the environmental sub-model are Low (1992) on estimates of industrial pollution and abatement cost functions, and the World Resource Institute (several issues) on environmental damage functions. Most of the environmental parameters, however, stem from the calibration of the environmental sub-model and thus are subject to initial calibration conditions or assumptions.[15]

3.2 Simulation Results

The first environmental policy regime chosen for the simulations is fixed command-and-control abatement levels. This may be considered the most realistic scenario. As O’Connor (1994) shows, the command-and-control approach to environmental management is predominant not only in the countries of his survey (Japan, South Korea, Taiwan, Thailand and Indonesia) but also in virtually all countries with an environmental management system. Furthermore, the most commonly used regulation in the case of industrial pollution takes the form of discharge standards, which imply a minimum fraction of pollution to be abated.[16]

Two different trade-policy simulations have been run. The first represents a 50% reduction or complete elimination of tariff and non-tariff trade barriers between the APEC member regions (but excluding ROW) on the three most pollution-intensive goods.

[15] For details of the calibration procedure pertaining to environmental standards refer to Unteroberdoerster (1998; ch. 4). The calibrated standards for the benchmark differ markedly across countries and mainly reflect the differences in per capita income.

The second is a 50% or 100% increase of trade barriers between the same set of regions on the same group of goods. The rationale for focusing on pollution-intensive sectors is as follows: (i) changes in production patterns of these industries have the largest impact on pollution. And (ii) production-cost differences due to differences in environmental regulation are most significant for these goods, which is why some industrial lobbyists have called for trade restrictions to protect these industries in tightly regulated countries.

The effects on pollution and welfare are given in tables 1 and 2, and they appear to be fairly modest. Even when all tariffs and non-tariff barriers are eliminated or increased by 100% resulting changes in pollution remain below 2% in most of the regions. The effects on welfare (from the change in trade policy *and* the change in pollution) remain below 1% for all but one region and are even below 0.5% in many regions.[17]

Table 1: Welfare and pollution effects (in % with respect to benchmark) of partial trade liberalization (command-and-control)

reduction of trade barriers	50%				100%			
	emissions			welfare	emissions			welfare
	total	production	consumption		total	production	consumption	
UCAN	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.04
ANZ	0.00	0.00	0.00	-0.05	0.00	0.00	0.00	-0.13
JAP	0.24	0.28	0.00	0.01	0.47	0.55	0.00	0.03
NIC4	0.32	0.36	0.00	-0.12	0.97	0.73	0.00	-0.27
SEA4	-0.79	-0.93	0.00	-0.30	-1.57	-1.85	0.00	-0.78
CHINA	-0.69	-1.63	0.00	-0.43	-2.08	-2.44	0.00	-1.14
ROW	-0.10	-0.09	0.17	0.08	-0.17	-0.20	0.17	0.18

Table 2: Welfare and pollution effects (in % with respect to benchmark) of partial trade restriction (command-and-control)

increase in	50%	100%

[16] Even though specific abatement levels may not be the most efficient environmental regulation, it appears that the rationale for their use has been the relative certainty of their effectiveness.

[17] The numbers are relative changes in the representative agents' utility index. Since the model is based on linear homogeneous utility functions, these percentage changes can be easily interpreted as compensating variation (when multiplied with the ex-post income levels) and equivalent variation (when multiplied with the ex-ante income levels). See Shoven and Whalley (1984), p. 1014.

trade barriers								
		emissions		welfare		emissions		welfare
	total	production	consumption		total	production	consumption	
UCAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANZ	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.06
JAP	-0.24	-0.28	0.00	-0.01	-0.24	-0.55	0.00	-0.01
NIC4	0.00	-0.36	0.00	0.09	-0.32	-0.36	0.00	0.16
SEA4	0.79	0.00	0.00	0.15	0.79	0.93	0.00	0.22
CHINA	0.69	0.00	0.00	0.14	0.69	0.81	0.00	0.14
ROW	0.05	0.09	0.00	-0.04	0.10	0.17	0.00	-0.08

Interestingly, there is no specific pattern that distinguishes countries with high abatement levels from those with low ones. Even in some developing areas, trade liberalization results in a small reduction of pollution levels. When trade barriers are increased, the pollution effects become almost insignificant for the tightly regulated developed countries, whereas the increases in pollution levels in some developing areas are somewhat greater. In sum, radical changes in trade policy pertaining to dirty goods yield only small deteriorations or improvements of environmental quality while at the same time the direction of these changes remains ambiguous with respect to the tightness of environmental regulation. The results also suggest that the effects are dampened by the relative stability of pollution from consumption. Changes in pollution from consumption are negligible in the above scenarios and they tend to be smaller than changes on the production side throughout all of the following simulations. Trade may induce specialization in production, but consumption is likely to remain much more diversified. However, pollution also stems from consumption, which is often overlooked in the trade-and-environment debate. Hence, the model helps to emphasize the role of consumption in explaining why the effects of trade on the environment are very limited.

When trade barriers on all goods are changed among APEC regions the effects are somewhat magnified. This highlights the importance of input-output linkages between economic sectors. Trade-policy changes on relatively clean goods may have adverse environmental effects because of increased demand for pollution-intensive intermediate goods. However, the overall changes in emissions and welfare remain fairly limited even for the most radical trade policy scenarios, so that the conclusions drawn above remain valid.

A fixed-emission-charge scenario tends to produce somewhat stronger effects on pollution and welfare than the command-and-control scenario. This variation stems mostly from changes in abatement levels as agents adjust these optimally to the fixed emissions charge. Apart from the magnitude of the effects, the conclusions of the previous section also apply to this one. Welfare gains (losses) from reduced (increased) pollution are offset by larger (smaller) distortions from the change in trade policy. Moreover, lax environmental regulation in developing areas does not necessarily imply an increase in their pollution once trade is liberalized. Resulting changes in pollution from consumption tend to be much smaller than those caused on the production side.

Compared to the previous scenarios, the effects of trade liberalization on pollution and welfare tend to be smaller under the flexible pollution tax scenario. This is because any first-round increases in pollution yield higher emission charges - environmental quality becomes relatively more scarce and thus its social value increases - which in turn result in higher abatement levels chosen by firms and consumers, offsetting the first round increases in pollution. Thus the policy regime has a stabilizing effect on pollution levels.

All previous scenarios suggest that trade policy is not an effective, or an efficient, tool to mitigate environmental problems. This becomes even more obvious when it is compared to changes in environmental policy. Table 3 below summarizes the results of an increase in the internalization rate (for the social valuation of emissions), first from 33% to 40%, then to 50% in all regions of the model.

Table 3: Effects of increased internalization rate (in % with respect to benchmark)

internalization rate	40%			50%		
	pollution	abatement	welfare	pollution	abatement	welfare
UCAN	-26.58	18.54	0.20	-58.42	40.82	0.38
ANZ	-36.67	16.00	0.23	-80.00	34.29	0.43
JAP	-31.72	9.82	0.17	-63.06	19.50	0.29
NIC4	-3.74	51.52	0.04	-9.86	133.33	0.10
SEA4	-3.23	69.05	0.00	-8.87	200.00	0.04
CHINA	-2.11	75.00	0.00	-5.63	229.17	0.00
ROW	-4.40	61.54	0.06	-12.00	170.77	0.12

First, it is obvious that such a policy measure, which reduces the gap between social and private cost of pollution without distorting other parts of the economy, can only increase economic welfare (if enforcement cost is ignored). Note that an increase in the emission charge is more efficient than an imposed increase in abatement levels in this respect. This is because in the former situation firms and consumers optimally adjust their abatement levels to the increase in the charge, whereas in the latter situation the imposed abatement levels are not necessarily cost-efficient. Second, the results show that even a relatively modest tightening of environmental regulation causes more reduction in pollution than any dramatic or even radical change in trade barriers. This reduction is achieved mainly through an increase in abatement levels resulting from the rise in the private cost of emissions. Notice, too, that the effect on pollution and welfare is more pronounced in the developed world. Here the absolute gap to be narrowed between social and private cost is higher because of a higher valuation of environmental quality. Also these economies reduce pollution from much higher abatement levels in the benchmark.

So far, the simulations have produced four main results. First, under the most realistic scenario of command-and-control environmental regulation, even dramatic changes in trade policy have only small effects on pollution. Also, welfare gains that may arise from a subsequent improvement in environmental quality are offset by economic distortions produced elsewhere. This holds true in particular when trade restrictions are used to reduce pollution. Second, the level of environmental standards does not exclusively determine changes in pollution. Liberalized trade can reduce pollution in developing areas with relatively lax environmental standards. In other words, low environmental standards do not give rise, on average, to comparative advantage in pollution-intensive industries. Third, pollution from consumption has a stabilizing effect on overall pollution levels. Fourth, trade policy is not only inefficient as a means to protect the environment, but it is also less effective than addressing environmental problems directly via stricter regulation. This holds true for multilateral and unilateral policies (not shown here). Interestingly, even a one-sided increase in environmental standards by the US-Canada region has no significant repercussions on pollution and welfare in other model regions, regardless of their degree of openness.

4. Concluding Remarks

The empirical results from both estimation and simulation approaches suggest that in many cases the environmental effects of trade liberalization are very small. Moreover, they may even be opposite in direction to what is widely believed (e.g. trade may reduce pollution where it is expected to increase). Is this lack of evidence of a clear linkage between trade and pollution a disappointing result? On the contrary, by eliminating international trade from the list of usual suspects or at least shortening its bill of indictments, the focus of attention can shift to more important environmental issues (e.g. domestic regulation of emissions). Moreover, by showing that trade restrictions for the sake of the environment are not generally justifiable, the paper carries a hopeful message: The benefits (economic and other) from international trade need not be sacrificed in order to solve environmental problems.

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