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Globalization and Dirty Industries: Do Pollution Havens Matter?

Jean-Marie Grether and Jaime de Melo

5.1 Introduction

In the debate on globalization and the environment, there is concern that the erasing of national borders through reduced barriers to trade will lead to competition for investment and jobs, resulting in a worldwide degradation of environmental standards (the "race-to-the-bottom" effect) and/or in a delocalization of heavily polluting industries in countries with lower standards (the "pollution-havens" effect). Moreover, environmentalists and ecologically oriented academics argue that the political economy of decision making is stacked up against the environment. In the North, Organization for Economic Cooperation and Development (OECD) interest groups that support protectionist measures for other reasons continue to invoke the race-to-the-bottom model, relying on the perception that the regulatory gap automatically implies a race to the bottom, even though some have argued that countries may circumvent international agreements on tariffs by choosing strategic levels of domestic regulation. Because avoidance of a race to the bottom would call for the enforcement of uniform environmental standards in all countries, which cannot be created, they argue for trade restrictions until the regulatory gap is closed. In the

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South, corruption is likely to result in poor enforcement of the regulatory framework. Finally, at the international level, environmental activists fear that the dispute settlement mechanism of the World Trade Organization (WTO) favors trade interests over environmental protection.

To sum up, the arguments raised above, as well as empirical evidence reviewed below, suggest that trade liberalization and globalization (in the form of reduced transaction costs) could lead to a global increase in environmental pollution as well as to an increase in resource depletion as natural resource–exploiting industries, from forest-logging companies to mining companies, relocate to places with less strict standards or use the threat of relocation to prevent the imposition of stricter standards. These effects are likely to be more important the further environmental policy is from the optimum and the less well-defined property rights are (as is the case for the so-called global commons). It is therefore not surprising that, even if trade liberalization and globalization more generally can lead both to an overall increase in welfare (especially if environmental policy is not too far from the optimum) and to a deterioration in environmental quality, a fundamental clash will persist between free-trade proponents and environmentalists.

This paper addresses the relation between globalization and the environment by reexamining evidence of a North-South delocalization of heavily polluting industries.[1] Section 5.2 reviews the evidence on pollution havens,[2] arguing that it is either too detailed (firm-specific or emission-specific evidence) or too fragmentary (case studies) to give a broad appreciation of the extent of delocalization over the past twenty years. The subsequent sections then turn to new evidence based on worldwide production and trade data (fifty-two countries) at a reasonable level of disaggregation (three-digit international standard industrial classification [ISIC]) and over a sufficiently long time period, 1981–1998.[3] In section 5.3, we report on the worldwide evolution of heavy polluters (the so-called dirty industries) and on the evolution of North-South revealed comparative advantage indexes. Section 5.4 then estimates a gravity trade model to examine bilateral patterns of trade in polluting products. Estimates reveal that transport costs may have acted as a brake on North-South relocation, and fail to detect a regulatory-gap effect.

1. The causes of any detected relocation will not be identified because we are dealing with fairly aggregate data.

2. In the public debate, the "pollution-havens" effect refers either to an output reduction of polluting industries (and an increase in imports) in developed countries or to the relocation of industries abroad via foreign direct investment in response to a reduction in import protection or a regulatory gap.

3. The main database has been elaborated by Nicita and Olarreaga (2001). The appendix to this chapter describes data manipulation and the representativity of the sample in terms of global trade and production in polluting activities.

5.2 Pollution Havens or Pollution Halos?

We review first the evidence on trade liberalization and patterns of trade in polluting industries based on multicountry studies that try to detect evidence of North-South delocalization. We then summarize results from single-country (often firm-level) studies that use more reliable environmental variables and are also generally better able to control for unobservable heterogeneity bias. We conclude with lessons from case studies and political-economy considerations.

5.2.1 Evidence on Production and Trade in Dirty Products

Evidence from aggregate production and trade data is based on a comparison between "clean" and "dirty" industries, the classification relying invariably on U.S. data, either on expenditure abatement costs or on emissions of pollutants.[4]

Table 5.1 summarizes the results from these studies. Overall, the studies, which for the most part use the same definition of dirty industries as we do,[5] usually find mild support for the pollution-havens hypothesis.

The large number of countries and the industrial-level approach gives breadth of scope to the studies described in table 5.1, but at a cost. First, changing patterns of production and trade could be due to omitted variables and unobserved heterogeneity that cannot be easily controlled-for in large samples where aggregated data say very little about industry choices which would shed light on firms or production stages (Zarsky 1999, 66). For example, as pointed out by Mani and Wheeler (1999) in their case study of Japan, changes in local factor costs (price of energy, price of land) and changes in policies other than the stringency of environmental regulations could account for observed changes in trade patterns. Second, these studies give no evidence on investment patterns and on how these might react to changes in environmental regulation, which is at the heart of the pollution-havens debate.[6] It is therefore not totally surprising that the papers

4. Most work on the United States is based on pollution-abatement capital expenditures or on pollution-abatement costs (see, e.g., Levinson and Taylor 2002, table 1). It turns out that the alternative classification based on emissions (see Hettige et al. 1995) produces a similar ranking for the cleanest and dirtiest industries (five of the top six pollution industries are the same in both classifications).

5. As in this paper, polluting industries were classified on the basis of the comprehensive index of emissions per unit of output described in Hettige et al. (1995). That index includes conventional air, water, and heavy metals pollutants. As to the applicability of that index based on U.S. data to developing countries, Hettige et al. conclude that, even though pollution intensity is likely to be higher, "the pattern of sectoral rankings may be similar" (1995, 2).

6. Smarzynska and Wei (2001) cite the following extract from "A Fair Trade Bill of Rights" proposed by the Sierra Club: "In our global economy, corporations move operations freely around the world, escaping tough control laws, labor standards, and even the taxes that pay for social and environmental needs."

Table 5.1 Multicountry Studies on the Pollution Havens Hypothesis

Paper	Dependent Variable	Environmental Measure	No. of Countries	Years	Main Findings
Low and Yeats (1992)	RCAs for polluting industries	PACE	109	1965–88	RCAs increased in polluting industries for LDCs. RCAs decreased in polluting industries in DCs.
Hettige, Lucas, and Wheeler (1992)	TRI per unit of output	Toxic release based on UE EPA TRI	88	1960–88	Toxic intensity increased in DCs in 1960s (decreased in 1970s and 1980s) Toxic intensity increased in LDCs in 1970s and 1980s. Higher toxic intensity in economies closed to trade.
Tobey (1990)	Net exports (of PACE-based industries)	Ordinal index 1–7	23	1977	Net exports not determined by environmental stringency.
Grether and de Melo (1996)	RCAs for polluting industries	PACE	53	1965–90	RCAs increased in polluting industries for LDCs, stable for DCs.
Van Beers and Van den Bergh (1997)	Bilateral trade in 1992	Composite index compiled from OECD data	30	1992	Coefficient on environmental index no larger for polluting industries than on average.
Mani and Wheeler (1999)	Factor intensities, production and consumption ratios	IPPS OECD	92	1965–92	Pollution intensive output fell steadily in OECD.

Notes: DCs = developed countries; LDCs = developing countries; RCA = revealed comparative advantage; TRI = toxic release index; PACE = pollution abatement expenditures (U.S. data); and IPPS = industrial pollution projection system (Hettige et al. 1995). Composite emission index (see text).

surveyed in Dean (1992) and Zarsky (1999), by and large, fail to detect a significant correlation between the location decisions of multinationals and the environmental standards of host countries. This suggests that, after all, when one goes beyond aggregate industry data, the pollution-havens hypothesis may be a popular myth.

Recent studies respond to the criticism that the evidence so far does not address the research needs because of excessive aggregation. However, this recent evidence, summarized below, is still very partial, and heavily focused on the United States.

5.2.2 Evidence on the Location of Dirty Industries

Levinson and Taylor (2002) revisit the single-equation model of Grossman and Krueger (1993), using panel data for U.S. imports in a two-equation model in which abatement costs are a function of exogenous industry characteristics while imports are a function of abatement costs. Contrary to previous estimates, they find support for the pollution-havens hypothesis: Industries whose abatement costs increased the most saw the largest relative increase in imports from Mexico, Canada, Latin America, and the rest of the world.[7]

Drawing on environmental costs across the United States that are more comparable than the rough indexes that must be used in cross-country work, Keller and Levinson (2002) analyze inward foreign direct investment (FDI) into the United States over the period 1977–1994. They find robust evidence that relative (across states) abatement costs had moderate deterrent effects on foreign investment.

Others have analyzed outward FDI to developing countries. Eskeland and Harrison (2003) examine inward FDI in Mexico, Morocco, Venezuela, and Côte d'Ivoire at the four-digit level using U.S. abatement-cost data controlling for country-specific factors. They find weak evidence of some FDI being attracted to sectors with high levels of air pollution, but no evidence of FDI to avoid abatement costs. They also find that foreign firms are more fuel-efficient in that they use lower amounts of "dirty fuels." This evidence supports the pollution-halo hypothesis: superior technology and management, coupled with demands by "green" consumers in the OECD, lift industry standards overall.[8]

Smarzynska and Wei (2001) estimate a probit of FDI of 534 multinationals in twenty-four transition economies during the period 1989–1994 as a function of host-country characteristics. These include a transformed (to avoid outlier dominance) U.S.-based index of dirtiness of the firm at the

7. Ederington and Minier (2003) also revisit the Grossman and Krueger study, assuming that pollution regulation is endogenous, but determined by political-economy motives. They also find support for the pollution-havens hypothesis, this time because inefficient industries seek protection via environmental legislation.

8. The mixed evidence on the pollution-halo hypothesis is reviewed in Zarsky (1999).

four-digit level, an index of the laxity of the host country's environmental standards captured by a corruption index, and several measures of environmental standards (participation in international treaties, quality of air and water standards, observed reductions in various pollutants). In spite of this careful attempt at unveiling a pollution-haven effect, they conclude that host-country environmental standards (after controlling for other country characteristics, including corruption) had very little impact on FDI inflows.

5.2.3 Case Studies and Political-Economy Considerations

Reviewing recently available data, Wheeler (2001) shows that suspended particulate matter release (the most dangerous form of air pollution) has been declining rapidly in Brazil, China, and Mexico, fast-growing countries in the era of globalization and big recipients of FDI. Organic water pollution is also found to fall drastically as income per capita rises (poorest countries have approximately tenfold differential pollution intensity).[9] In addition to the standard explanations (pollution control is not a critical cost factor for firms; large multinationals adhere to OECD standards), Wheeler also points out that case studies show that low-income communities often penalize dangerous polluters even when formal regulation is absent or weak. Wheeler concludes that the "bottom" rises with economic growth.

This result is reinforced by recent evidence based on a political-economy approach that endogenizes corruption in the decision-making process. Assuming that governments accept bribes in formulation of their regulatory policies, Damia, Fredriksson, and List (2000) find support in panel data for thirty countries over the period 1982–1992 that the level of environmental stringency is negatively correlated with an index of corruption and positively with an index of trade openness. Given that corruption is typically higher in low-income countries, this corroborates the earlier finding mentioned above, that environmental stringency increases rapidly with income.

5.3 Shifting Patterns of Production and Comparative Advantage in Polluting Industries

Direct approaches to the measurement of pollution emission (e.g., Grossman and Krueger 1993; Dean 2002; Antweiler, Copeland, and Taylor 2001; and several of the studies mentioned above) use emission estimates at geographical sites of pollutant particles (sulfur dioxide is a fa-

9. These results accord with independent estimates of environmental performance constructed by Dasgupta et al. (1996) from responses to a detailed questionnaire administered to 145 countries (they find a correlation of about 0.8 between their measure of environment performance or environment policy and income per capita).

vorite) or the release of pollutants into several media (e.g., air, water, etc.). That approach has several advantages: Emissions are directly measured at each site, and it is not assumed that pollutant intensity is the same across countries. On the other hand, activity (e.g., production levels) is not measured directly. Arguably, this is a shortcoming if one is interested in the pollution-havens hypothesis. Indeed, emissions could be high for other reasons than the relocation of firms to countries with low standards (China's use of coal as an energy source is largely independent of the existence of pollution havens).

The alternative chosen here is to use an approach in which emission intensity is not measured directly. We adopt the approach in the studies summarized in table 5.1, where dirty industries are classified according to an index of emission intensity in the air, water, and heavy metals in the United States described in footnote 4. We selected the same five most polluting industries in the United States in 1987 selected by Mani and Wheeler (1999; three-digit ISIC code in parenthesis): iron and steel (371), nonferrous metals (372), industrial chemicals (351), nonmetallic mineral products (369), and pulp and paper (341).[10] According to Mani and Wheeler, compared to the five cleanest U.S. manufacturing activities—textiles, (321), nonelectric machinery (382), electric machinery (383), transport equipment (384), and instruments (385)—the dirtiest have the following characteristics: 40 percent less labor-intensive; capital-output ratio twice as high; and energy-intensity ratio three times as high.

5.3.1 Shifting Patterns of Production

We start with examination of the broad data for our sample of fifty-two countries over the period 1981–1998. The sample (years and countries) is the largest for which we could obtain production data matching trade data at the three-digit ISIC level. Compared to the earlier studies mentioned in table 5.1, this sample has production data for a larger group of countries, though at a cost because comprehensive data—only available since 1981—implies that we are missing some of the early years of environmental regulation in OECD countries in the seventies.

Because there is a close correlation between the stringency of environmental regulation and income per capita, we start with histograms of indexes of pollution intensity ranked by income per capita quintile (the data are three-year averages at the beginning and end of period). Given our sample size, each quintile has ten or eleven observations.

Figure 5.1 reveals a slight change in the middle of the distribution of production and consumption of dirty industries, as the second-richest quintile sees a reduction in production and consumption shares in favor of the

10. Mani and Wheeler (1999, table 1) describe the intensity of pollutant emissions in water, air, and heavy metals.

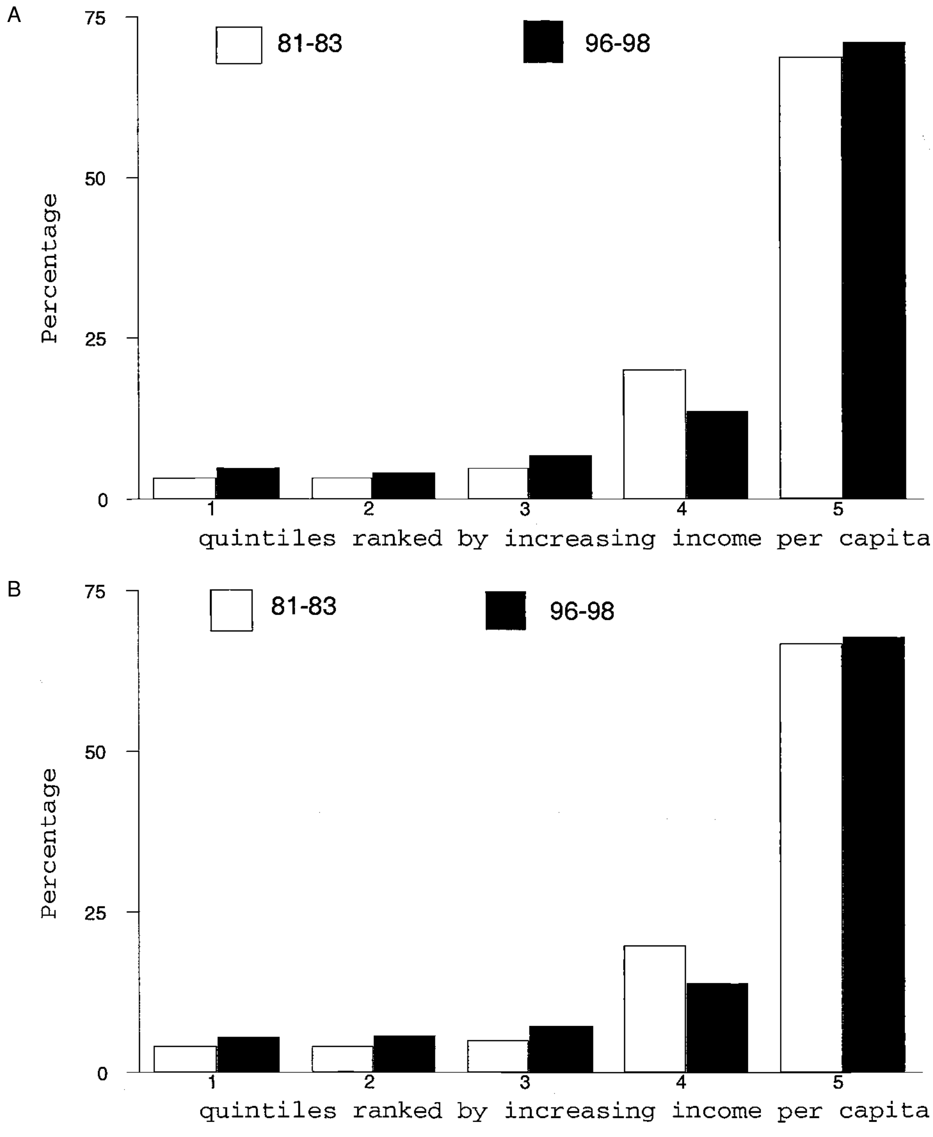


Fig. 5.1 Histograms of output and consumption shares of polluting products: *A*, Output; *B*, Consumption

highest and lowest quintiles. Turning to export and import shares (fig. 5.2), one notices a reduction in both trade shares of the highest quintile in favor of the remaining quintiles.

These aggregate figures mask compositional shifts apparent from inspection of the histograms at the industry level (see appendix fig. 5A.1).

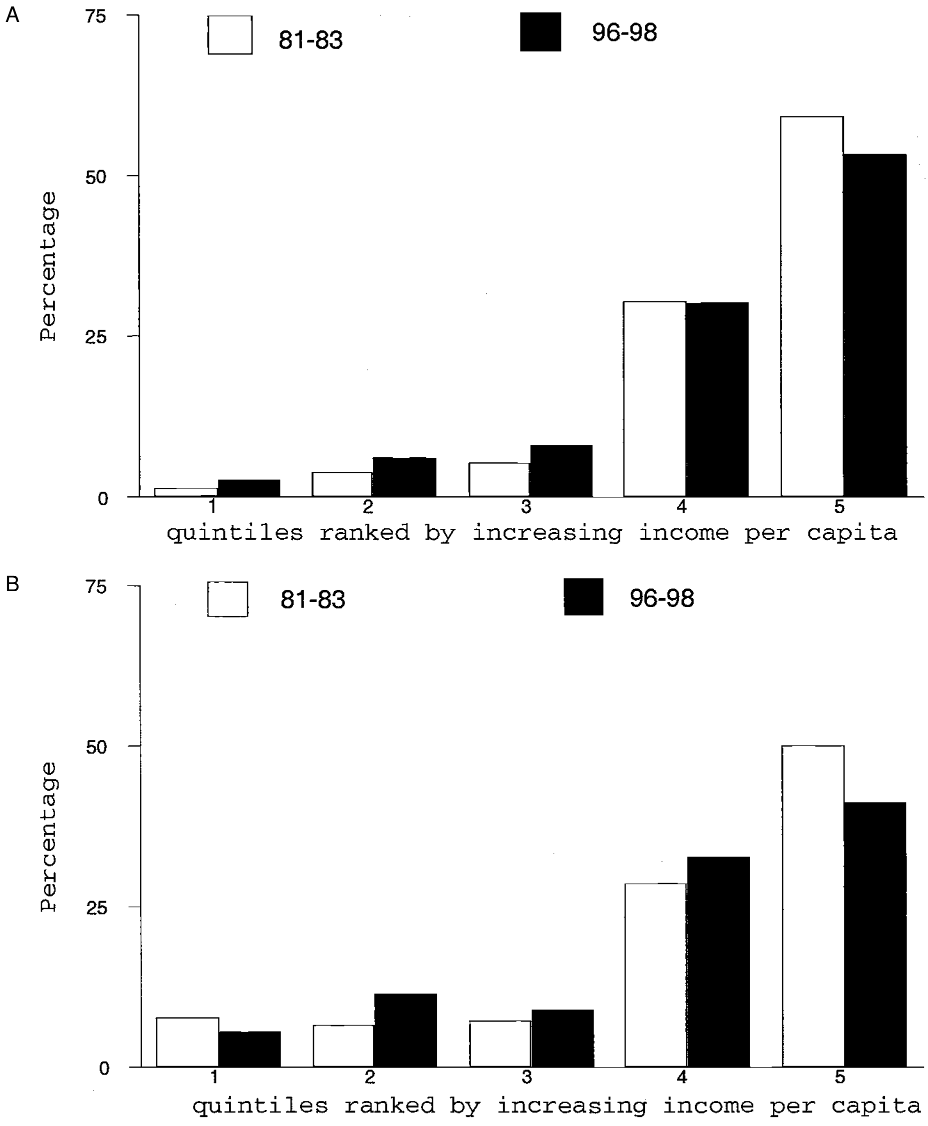


Fig. 5.2 Histograms of exports and imports shares of polluting products: *A*, Exports; *B*, Imports

For the second-richest quintile, the output share is always decreasing, but changes in the export share vary a lot across sectors. For the richest quintile, the output share is decreasing except for paper and products (ISIC 341) and other nonmetallic mineral products (369), while the export share is always decreasing, except for nonferrous metals (372).

In sum, these broad figures suggest some delocalization of pollution industries to poorer economies. However, aggregate effects are weak, partly because of opposite patterns at the sector level.

5.3.2 Shifting Patterns of Revealed Comparative Advantage

We look next for further evidence of changes in trade patterns in dirty industries. We report on revealed comparative advantage (RCA) indexes computed at the beginning or at the end of the sample period; RCA indexes are not measures of comparative advantage, since they also incorporate the effects of changes in the policy environment (trade policy, regulatory environment, etc).

The RCA index for country i and product p is given by

$$\text{(1)} \qquad \text{RCA}_i^p = \frac{S_{wp}^{ip}}{S_{wa}^{ia}} = \frac{S_{ia}^{ip}}{S_{wa}^{wp}}$$

where $S_{wp}^{ip}(S_{wa}^{ia})$ is country i's share in world exports of polluting products (of all products) and $S_{ia}^{ip}(S_{wa}^{wp})$ is the share of polluting products in total exports of country i (of the world).

Countries are split into two income groups (see appendix table 5A.1) that replicate the distinction between the three poorest and two richest quintiles of the previous section: twenty-two high-income countries (1991 gross national product [GNP] per capita larger than U.S.$7,910 according to the World Bank) and thirty low- and middle-income countries. Hereafter, the former group is designed by developed countries (DCs) or "North," and the latter by less-developed countries (LDCs) or "South."

A first glimpse at the aggregate figures (see table 5.2) confirms that LDCs' share in world trade of polluting products is on the rise. But the average annual rate of growth is lower for polluting products than for exports in general. As a result, LDCs as a whole exhibit a decreasing RCA (and an increasing revealed comparative disadvantage) in polluting products (see last columns of table 5.2).

However, inspection at the industry level (see appendix table 5A.5) re-

Table 5.2 Developing Countries' World Trade Shares (percentages except for RCA, RCD)

	Polluting Products		All Products		Revealed Comparative Indexes	
	Exports (1)	Imports (2)	Exports (3)	Imports (4)	Advantage (RCA) (1)/(3)	Disadvantage (RCD) (2)/(4)
1981–83	9.08	18.87	9.40	15.73	0.97	1.20
1996–98	14.46	22.98	15.93	18.67	0.91	1.23
Average annual growth rate	3.15	1.32	3.58	1.15		

Note: Blank cells indicate not calculated.

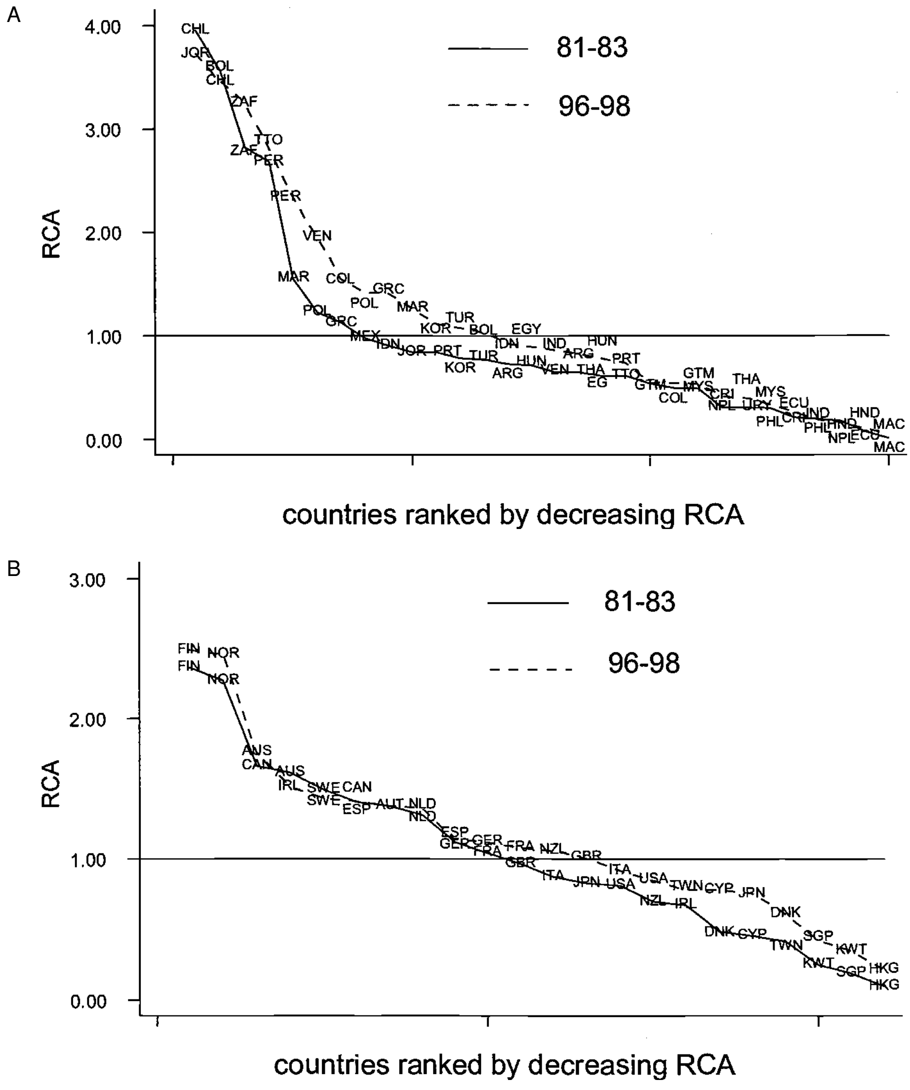


Fig. 5.3 Revealed comparative advantage indexes in polluting products: *A*, Developing countries; *B*, Developed countries (countries ranked by decreasing RCA)

veals that this reverse-delocalization outcome is due to the dominating effect of nonferrous metals (ISIC 372). All four of the other industries present some ingredient of delocalization, with a particularly strong increase in RCA for industrial chemicals (351). Interestingly, nonferrous metals represented more than 40 percent of LDCs exports at the beginning and less than 25 percent at the end of the period, while the pattern is exactly opposite for industrial chemicals.

To unveil cross-country variations, figure 5.3 ranks countries by decreasing order of RCAs for both income groups. In each case, the dashed line represents the end-of-period pattern, with countries ranked by decreasing order of comparative advantage so that all observations above (below) unity correspond to countries with a revealed comparative advantage (disadvantage). A shift to the right (left) implies increasing (decreasing) RCA, and a flattening of the curve, a less-pronounced pattern of specialization.

Overall, LDCs' pattern of RCAs is characterized by higher upper values of RCAs and a steeper curve than for high-income countries. Over time, both curves appear to shift right[11] and to become somewhat flatter. The increase in RCAs seems larger in LDCs, where it is concentrated in the middle of the distribution, while it basically affects the end of the distribution in the other income group. At the industry level (see appendix figure 5A.2) results for LDCs are quite similar, except for nonferrous metals, where the RCA curve shifts in.[12]

Still, the above pattern does not say anything about the changing pattern of RCAs between the North and the South, which is what the delocalization hypothesis is about. To measure this effect, we introduce a new decomposition that isolates the impact of geography on the RCA index. From equation (1), note that the RCA of country i in product p (RCA_i^p) can be decomposed into

$$\mathrm{RCA}_i^p = \sum_{j=1}^{N} \mathrm{RCA}_{ij}^p S_{iwa}^{ija}, \tag{2}$$

where the bilateral RCA (RCA_{ij}^p) is defined as the ratio between the share of product p in all exports of country i to country j (S_{ija}^{ijp}) and the share of product p in total world exports (S_{wa}^{wp}). This share is weighted by the share of country j in total exports of country i to the world (S_{iwa}^{ija}).

Now let the world be divided in two groups of countries: n_S in the South and n_N in the North ($n_S + n_N = N$). Then equation (2) can be rewritten as

$$\mathrm{RCA}_i^p = S_i^p + N_i^p \equiv \sum_{j=1}^{n_S} \mathrm{RCA}_{ij}^p S_{iwa}^{ija} + \sum_{j=1}^{n_N} \mathrm{RCA}_{ij}^p S_{iwa}^{ija}, \tag{3}$$

where S_i^p is the South's contribution and N_i^p the North's contribution to RCA_i^p. Thus, in terms of variation between the end (1996–1998) and the beginning (1981–1983) of the sample period, one obtains

11. This result may seem puzzling, but the contradiction is only apparent: the weighted sum of RCAs is indeed equal to 1.0, but the weights can vary. Thus, a simultaneous increase in all RCA indexes may well happen, provided a larger weight is put on smaller values.

12. Note that the pattern illustrated by figure 5.3 reflects only a "structural" effect, i.e., the change of individual RCAs. The evolution of the aggregate RCA for LDCs as a group is also governed by a "composition" effect, namely the impact of changes in countries' shares keeping RCA indexes constant. Straightforward calculations reveal that for LDCs the composition effect (–0.19) has been stronger than the structural effect (0.13), leading to a net decrease of the aggregate RCA reported in table 5.2 (for results at the industry level, see table 5A.6).

Table 5.3 **North-South Bilateral RCAs for Polluting Products**

Sector	ΔRCA	Δ*N*	Δ*S*
Pulp and paper (341)	0.23	0.10	0.13
Industrial chemicals (351)	0.41	0.21	0.20
Nonmetallic minerals (369)	0.38	0.61	–0.22
Iron and steel (371)	0.66	0.39	0.27
Nonferrous metals (372)	–0.57	–0.79	0.22

Note: Computed from equation (4).

(4) $$\Delta \mathrm{RCA}_i^p = \Delta S_i^p + \Delta N_i^p$$

Results from applying this decomposition to the two groups of countries are reported in table 5.3. For each polluting sector, we report the (unweighted) average of both sides of equation (4) over the LDCs' group. It appears that in all cases but one, the North's contribution to the change in LDCs' RCA is positive. This result is consistent with the pollution-havens effect. Again, the only exception is nonferrous metal, where North-South trade has negatively contributed to the RCA of the South.

In sum, the RCA-based evidence on delocalization of polluting activities toward the South is rather mixed. As a group, developing countries exhibit a surprising reverse-delocalization pattern of increasing revealed comparative disadvantage in polluting products. However, as shown above, this reflects both the pattern of one particular industry (nonferrous metals) and a composition effect: within the group of developing countries, those less prone to export polluting products have gained ground. In fact, most developing countries have actually experienced an increase in their RCA in polluting products. Moreover, after controlling for geography, it turns out that for all but for one case (nonferrous metals), North-South trade has had a positive impact on LDCs' comparative advantage in these products.

5.4 Bilateral Trade Patterns in Polluting Products

Dirty industries are typically weight-reducing industries. They are also intermediate-goods-producing industries. As a result, if they move to the South, then transport costs must be incurred if the final (consumer goods) products are still produced in the North—as would be the case, for example, in the newspaper-printing industry. Hence the reduction in transport costs and protection that has occurred with globalization may not have had much effect on the location of these industries.

Our third piece of evidence consists of checking if, indeed, polluting industries are not likely to relocate so easily because of relatively high transport costs. To check whether this may be the case, we estimate a standard bilateral trade gravity model for polluting products, and compare the coefficients with those obtained for nonpolluting manufactures.

Take the simplest justification for the gravity model. Trade is balanced (in this case at the industry level, which some would find unrealistic), and each country consumes its output, and that of other countries according to its share, S_i, in world GNP, Y^W. Then (see Rauch 1999) bilateral trade between i and j will be given by $M_{ij} = (2Y_iY_j)/Y^W = f(\mathbf{W}_{ij})$. The standard "generalized" gravity equation (which can be obtained from a variety of theories) can be written as $M_{ij} = f(\mathbf{W}_{ij})(\theta_{ij})^{-\sigma}$ where θ_{ij} is an index of barriers to trade between i and j. $\mathbf{W}_{ij}$ is a vector of other intervening variables that includes the bilateral exchange rate, e_{ij}, and prices, and σ is an estimate of the ease of substitution across suppliers.

In the standard estimation of the gravity model, θ_{ij} is captured either by distance between partners, or if one is careful, by relative distance to an average distance among partners in the sample, $\overline{\text{DIST}}$ (i.e., by $\text{DT}_{ij} = \text{DIST}_{ij}/\overline{\text{DIST}}$). Dummy variables that control for characteristics that are specific to bilateral trade between i and j (e.g., a common border, BOR_{ij}, landlockedness in either country, $\text{LL}_i[\text{LL}_j]$) are also introduced to capture the effects of barriers to trade.[13] Here, we go beyond the standard formulation by also including an index of the quality of infrastructure in each country in period t, $\text{INF}_{it}(\text{INF}_{jt})$, higher values of the index corresponding to better quality of infrastructure.[14] Finally, because we estimate the model in panel, we include the bilateral exchange rate, RER_{ijt}, defined so that an increase in its value implies a real depreciation of i's currency.

The above considerations lead us to estimate in panel the following model (expected signs in parenthesis):

$$(5)\quad \ln M_{ijt} = \alpha_0 + \alpha_t + \alpha_{ij} + \alpha_1 \ln Y_{it} + \alpha_2 \ln Y_{jt} + \alpha_3 \ln \text{INF}_{it} + \alpha_4 \ln \text{INF}_{jt} + \alpha_5 \ln \text{RER}_{ijt} + \alpha_6\text{BOR}_{ij} + \alpha_7\text{LL}_i + \alpha_8\text{LL}_j + [\alpha_9 \ln \text{DY}_{ijt}] + \beta_1 \ln \text{DT}_{ij} + \eta_{ijt}$$

$$(\alpha_1 > 0, \alpha_2 > 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_5 < 0, \alpha_6 > 0, \alpha_7 < 0, \alpha_8 < 0, \beta_1 < 0)$$

In equation (5), α_0 is an effect common to all years and pairs of countries (constant term), α_t an effect specific to year t but common to all countries (e.g., changes in the price of oil), α_{ij} an effect specific to each pair of countries but common to all years, and η_{ijt} the error term.

In a second specification we introduce the difference in GNP per capita

13. Brun et al. (2002) argue that the standard barriers-to-trade function is misspecified and propose a more general formulation that captures both variables that include country-specific characteristics and variables that capture time-dependent costs (e.g., the price of oil). Since here we are interested only in country-specific characteristics, time-dependent shocks are captured by time dummies.

14. The index is itself a weighted sum of four indexes computed each year: road density, paved roads, railway, and the number of telephone lines per capita.

$DY_{ij} = [(Y_i/N_i) - (Y_j/N_j)]$ in the equation, this additional variable presumably capturing the effects of the regulatory gap across countries. If the regulatory-gap effect is important, one would expect a positive sign for α_9.[15]

For estimation purposes, equation (5) can be rewritten as

$$\text{(6)} \qquad \ln M_{ijt} = \mathbf{X}_{ijt}\phi + \mathbf{Z}_{ij}\delta + u_{ijt} \text{ with } u_{ijt} = \mu_{ij} + \nu_{ijt},$$

where **X**(**Z**) represents the vector of variables that vary over time (are time invariant) and a random error-component is used because the within-transformation in a fixed-effects model removes the variables that are cross-sectional time invariant. To deal with the possibility of correlation between the explanatory variables and the specific effects, we use the instrument variable estimator proposed by Hausman and Taylor (1981). However, we also report fixed-effects estimates which correspond to the correct specification under the maintained hypothesis (columns [1] and [2] of table 5.4).

Because the null hypothesis of correlation between explanatory variables and the error term cannot be rejected, we reestimated the random-effects model treating the gross domestic product (GDP) variables as endogenous. The results are reported in columns (3) through (6) of table 5.4. Coefficient estimates are robust and, after instrumentation, the coefficient estimates are quite close in value to those obtained under the fixed-effects estimates.

First note that all coefficients have the expected signs and, as usual in gravity models with large samples, are robust to changes in specification.[16] Notably, the dummy variables for infrastructure have the expected signs and are highly significant. So is the real exchange rate variable, which captures, at least partly, some of the effects of trade liberalization that would not have already been captured in the time dummy variables (not reported here). Income variables are also, as expected, highly significant. Overall then, except for the landlocked variables, which are at times insignificant, all coefficient estimates have expected signs and plausible values.

Compare now the results between the panel estimates for all manufactures—except polluting products—(column [5]) with those for the five polluting industries (column [6]). Note first that the estimated coefficient for distance is one-third higher for the group of polluting industries compared to the rest of manufacturing.[17] Second, note that the proxy for the regulatory gap captured by the log difference of per capita GDPs is negative for

15. In a full-fledged model with endogenous determination of environmental policy, Antweiler, Copeland, and Taylor (2001) obtain a reduced form in which the technique effect (change in environmental policy) is captured by changes in income per capita.

16. We also experimented with other variants (not reported here) by including population variables and obtained virtually identical estimates for the included variables.

17. One could note that the coefficient estimates on infrastructure are much higher for these weight-reducing activities, which is also a plausible result signifying another brake on North-South delocalization.

Table 5.4 Gravity Equation: Panel Estimates for Polluting (POL) and Nonpolluting (NPOL) Products

		Fixed Effects		Random Effects I[a]		Random Effects II[b]	
	Independent Variable	NPOL (1)	POL (2)	NPOL (3)	POL (4)	NPOL (5)	POL (6)
Coefficient in equation (5)							
α_1	$\ln(Y_{it})$	1.84**	1.60**	1.81**	1.50**	1.81**	1.50**
		(30.0)	(21.5)	(25.9)	(19.4)	(25.9)	(19.4)
α_2	$\ln(Y_{jt})$	1.23**	0.99**	1.28**	0.92**	1.27**	0.92**
		(20.3)	(13.2)	(17.5)	(10.9)	(17.5)	(10.9)
α_9	$\ln(Y_{it}/N_{it}) - \ln(Y_{it}/N_{jt})$	–0.06**	0.003	n.a.	n.a.	–0.06**	0.007
		(2.6)	(0.1)	n.a.	n.a.	(3.0)	(0.3)
β_1	$\ln \text{DIST}_{ij}$	n.a.	n.a.	–0.83**	–1.12**	–0.82**	–1.12**
				(16.8)	(17.6)	(16.6)	(17.7)
α_6	BOR_{ij}	n.a.	n.a.	1.28**	1.30**	1.27**	1.30**
				(6.7)	(5.5)	(6.6)	(5.5)
α_7	LL_i	n.a.	n.a.	–0.89**	0.50	–0.92**	0.49
				(3.7)	(1.7)	(3.74)	(1.66)
α_8	LL_j	n.a.	n.a.	–0.43	–0.42	–0.42	–0.42**
				(1.78)	(1.21)	(1.74)	(1.22)
α_3	$\ln \text{INF}_{it}$	0.15*	0.003	0.37**	0.46**	0.36**	0.46**
		(2.2)	(0.04)	(5.8)	(6.4)	(5.7)	(6.43)

α_4	ln INF_{jt}		0.38**	0.70**	0.37**	0.64*	0.39**	0.64**
			(5.1)	(7.7)	(5.8)	(7.7)	(6.0)	(7.7)
α_5	ln RER_{ijt}		–0.34**	–0.46**	–0.32**	–0.40**	–0.32**	–0.40**
			(15.5)	(17.5)	(13.4)	(14.3)	(13.4)	(–14.3)
No. of observations (*NT*)		34,563	30,345	34,563	30,345	34,563	30,345	
No. of bilateral (*N*)		2,371	2,300	2,371	2,300	2,371	2,300	
R-squared[c]		0.54	0.47	0.46	0.49	0.52	0.52	
Bilateral fixed effect		34.2**	31.0**					
		$F(2,370; 32,171)$	$F(2,299; 28,024)$					
Hausman test W versus GLS		265.3**	161.3**	n.a.		n.a.		
Chi-2 (*Kw*)		Chi-2(21)	Chi-2(21)					
Hausman test HT versus GLS				496.6**	758.9**	413.1**	614.7**	
Chi-2(*K*)				Chi-2(24)	Chi-2(24)	Chi-2(25)	Chi-2(25)	

Notes: Dependent variable = ln M_{ijt}. T-student in parentheses. Time dummies and constant term not reported. n.a. = not applicable.

[a]Hausman-Taylor (HT) estimator, with endogenous variables Y_i, Y_j.

[b]HT estimator, with endogenous variables Y_i, Y_j, $(Y_i/N_i - Y_j/N_j)$.

[c]Calculated, for HT, from 1 – (Sum of Square Residuals)/(Total Sum of Squares) on the transformed model. Note that the impact of random specific effects are not in the R^2 but are part of residuals.

**Significant at the 99 percent level.

*Significant at the 95 percent level.

nonpolluting manufactures (as one would expect from the trade-theory literature under imperfect competition where trade flows are an increasing function of the similarity in income per capita) while it is insignificant (though positive) for polluting industries. Now, if indeed the regulatory gap can be approximated by differences in per capita GDPs across partners, the presence of pollution havens would be reflected in a significant positive coefficient for this variable.

Compositional effects for the coefficients of interest are shown in table 5.5. Nonferrous metals (and, to a lesser extent, iron and steel) stand out with low elasticity estimates for distance. If one were to take seriously cross-sector differences in magnitude, one would argue that the South-North "reverse" (in the sense of the pollution-havens hypothesis) delocalization of nonferrous metals according to comparative advantage in response to the reduction in protection would have occurred because of fewer natural barriers to trade. Of course, there are other factors as well to explain the developments in these sectors, including the heavy protection of these industries in the North.

The sectoral pattern of estimates for α_9 indicates that the regulatory gap would have had an effect on bilateral trade patterns for two sectors: nonmetallic minerals and iron and steel, and marginally for the pulp and paper industry. Again, nonferrous metals stands out, suggesting no effect of differences in the regulatory environment once other intervening factors are controlled for.

In sum, the pattern of trade elasticities to transport costs obtained here makes sense. Most heavily polluting sectors are intermediate goods, so proximity to users should enter into location decisions more heavily than

Table 5.5 Panel Estimates, by Industry

	Equation (5)	
Industry	β_1	α_9
Nonpolluting industries	–0.82**	–0.06**
All polluting industries	–1.12**	0.007
Pulp and paper (341)[a]	–1.40**	0.08*
Industrial chemicals (351)	–1.23**	0.03
Nonmetallic minerals (369)	–1.21**	0.12**
Iron and steel (371)	–1.12**	0.11**
Nonferrous metals (372)[a]	–0.95**	–0.04

[a]An estimate of –1.40 [–0.95] implies that if trade flows are normalized to 1 for a distance of 1,000 km, a doubling of distance to 2,000 km would reduce bilateral trade volume to 0.38 [0.52].

**Significant at the 99 percent level.

*Significant at the 95 percent level.

customs goods that are typically high-value, low-weight industries that can be shipped by air freight. Interestingly, after controlling for a number of factors that influence the volume of bilateral trade, we find little evidence of the presence of a regulatory gap, thus broadly supporting (indirectly) the pollution-halo hypothesis.

5.5 Conclusions

Concerns that polluting industries would "go south" was first raised in the late eighties, at a time when labor-intensive activities like the garment industries were moving south in response to falling barriers to trade worldwide. Such delocalization could be characterized as a continuous search for "low-wage havens" by apparel manufacturers in an industry that has remained labor intensive. Fears about pollution havens were already expressed at the time, notably because of the possible impact of the regulatory gap between OECD economies where polluters paying more would lead them to search for "pollution havens" analogous to low-wage havens. Later, with the globalization debate, the hypothesis gained new momentum by those who have read into globalization a breakdown of national borders, making it difficult to control location choices by multinationals.

This paper started with a review of the now-substantial evidence surrounding this debate, which can be classified in three rather distinct families. First, aggregate comparisons of output and trade trends based on a classification of pollution industries based on U.S. emissions revealed very marginal delocalization to the South. Second, firm-level estimates of FDI location choices by and large found at best marginal evidence either of location choice in the United States in response to cross-state differences in environmental regulations, or of location choices by multinational firms across developing countries in response to differences in environmental regulations. Reasons for this lack of response to the so-called regulatory gap were found in the third piece of evidence largely assembled from developing-country case studies. Taking into account political-economy determinants of multinational behavior in host countries and the internal trade-offs between leveling up emission standards (to avoid dealing with multiple technologies) and cutting abatement expenditures, overall this literature finds no evidence of havens, but rather of "halos."

Turning to new evidence, this paper drew on a large sample of countries accounting for the bulk of worldwide production and trade in polluting products over the period 1980–1998. Globally, we found that RCA in polluting products by LDCs fell as one would expect if the environment is indeed a normal good in consumption. At the same time, however, the decomposition indicates that the period witnessed a trend toward relocation of all (but one) polluting industries to the South. The exception was the reverse delocalization detected for nonferrous metals. We argued that this reverse delocalization was as one would expect, according to a comparative-advantage-driven response to trade liberalization in a sector where barriers to trade turn out to be relatively small. Finally, in the aggregate, RCA decompositions revealed no evidence of trade flows' being significantly driven by the regulatory gap, again with the exception of some positive evidence for the nonmetallic and the iron and steel sectors.

Estimates from a panel gravity model fitted to the same industries showed that, in comparison with other industries, polluting industries had higher barriers to trade in the form of larger elasticities of bilateral trade with respect to transport costs. These results confirm the intuition that most heavy polluters are both weight-reducing industries and intermediates for which proximity to users should enter location decisions more heavily than for customs goods (i.e., differentiated products) that are typically high-value products. Finally, after controlling for several factors that influence the volume of bilateral trade, we find little evidence of the presence of a regulatory gap.

In sum, the paper provided some support for the pollution-havens hypothesis, a result in line with several earlier studies reviewed here. Beyond this result, the paper contributed to the debate by identifying a new explanation for the less-than-expected delocalization that had been neither identified nor quantified in the literature: relatively high natural barriers to trade in the typical heavily polluting industries.

In concluding, one should however keep in mind two important caveats with respect to the pollution-havens debate. First, like the rest of the literature reviewed in the paper, we only examined manufactures. This implies that we did not take into account resource-extracting industries that may have successively sought pollution havens. Second, even within the narrow confines of trade-pattern quantification, a fuller evaluation of the debate on trade, globalization, and the environment would also have to examine the direct and indirect energy content of trade.

Appendix

This appendix describes the data, transformations, and sample representativity; gives sectoral tables corresponding to the aggregate results for all polluting products given in tables 5.2 and 5.4 in the text; and does the same for figures 5.1 to 5.3 in the text.

Table 5A.1 Categories of Polluting Products

ISIC Code	Description[a]
341	Paper and products (6)
351	Industrial chemicals (3)
369	Other nonmetallic mineral products (5)
371	Iron and steel (1)
372	Nonferrous metals (2)

Notes: Ranks in parentheses.

[a]Mani and Wheeler (1999, table 8.1). As in Mani and Wheeler, we have excluded petroleum refineries (ISIC = 353) from the sample.

Data Sources and Sample Representativity

The database is extracted from the Trade and Production Web site of the World Bank (www1.worldbank.org/wbiep/trade/data/TradeandProduction.html) and covers the period 1976–1999 for sixty-seven countries. It includes ISIC three-digit data on imports, exports and mirror exports. For the first five years and for the last year of the open-sample period, many countries reported missing values. Moreover, mirror exports are only available since 1980. Therefore, a closed sample was defined over the years 1981 to 1998, with fifty-two countries (five low-income countries, twenty-five middle-income countries, twenty-two high-income countries) reporting nonmissing values for the three-digit trade data over this period. Categories of polluting products are presented in table 5A.1, and closed-sample countries[18] are listed in table 5A.2.

Sample Representativity

Open and Closed Samples

With respect to the open sample, and using the average trade shares for 1995–1996 (the years with the maximum amount of nonmissing values), the closed sample represents about 95 percent of the open-sample trade.

Regarding the representativity of the open sample itself, this was estimated using world trade data reported by the World Bank (2001). Results are shown in table 5A.3. These figures may appear quite low. However, it should be kept in mind that world trade figures used in these calculations are, themselves, estimated. As a result, even in the original World Bank

18. Income groups were defined on the basis of 1991 GNP per capita figures. Following the World Bank cut-off levels, the sample was split into three income groups: low- (income lower than U.S.$635), middle- (between U.S.$635 and U.S.$7,910), and high- (larger than U.S.$7,910) income countries.

Table 5A.2 Countries of the Closed Sample (1981–1998)

Low-Income		Middle-Income		High-Income	
EGY	Egypt	ARG	Argentina	AUS	Australia
HND	Honduras	BOL	Bolivia	AUT	Austria
IDN	Indonesia	CHL	Chile	CAN	Canada
IND	India	COL	Colombia	CYP	Cyprus
NPL	Nepal	CRI	Costa Rica	DNK	Denmark
		ECU	Ecuador	ESP	Spain
		GRC	Greece	FIN	Finland
		GTM	Guatemala	FRA	France
		HUN	Hungary	GBR	The United Kingdom
		JOR	Jordan	GER	Germany
		KOR	Korea, Republic of	HKG	Hong Kong
		MAC	Macau	IRL	Ireland
		MAR	Morocco	ITA	Italy
		MEX	Mexico	JPN	Japan
		MYS	Malaysia	KWT	Kuwait
		PER	Peru	NLD	The Netherlands
		PHL	The Philippines	NOR	Norway
		POL	Poland	NZL	New Zealand
		PRT	Portugal	SGP	Singapore
		THA	Thailand	SWE	Sweden
		TTO	Trinidad and Tobago	TWN	Taiwan
		TUR	Turkey	USA	The United States
		URY	Uruguay		
		VEN	Venezuela		
		ZAF	South Africa		

Table 5A.3 Representativity of the Open and Closed Samples (%, using reported world totals by the World Bank)

	Open Sample		Closed Sample		Original Source[a]	
	Exports	Imports	Exports	Imports	Exports	Imports
1981	48.8	44.3	48.7	43.7	81.5	81.3
1990	58.9	59.5	57.3	57.9	86.4	86.2
1998	63.6	66.3	60.5	63.6	94.5	94.5

Sources: Sample data and World Bank (2001).
[a]Sum over the 207 countries reported in the World Bank database.

data, the sum of exports and imports over 207 countries represent less than 100 percent of world totals (see last two columns of table 5A.3).

Income Groups

Similar world totals were not available for income groups. In this case, world totals were estimated by the sum of exports or imports over all the

Table 5A.4 **Representativity of the Open and Closed Samples by Income Groups (%, 1998)**

	Open Sample		Closed Sample	
	Exports	Imports	Exports	Imports
Low-income countries	64.6	61.4	52.1	46.8
Middle-income countries	74.9	72.2	56.4	56.1
High-income countries	92.8	92.9	92.8	92.9
All	88.3	87.5	84.1	83.7

Sources: Sample data and World Bank (2001).

Notes: Using calculated world totals (sum over the 207 countries reported in the World Bank database).

Table 5A.5 **Imports-over-Exports Ratios**

	Polluting Products (1)	All Products (2)	(1)/(2)
1981	0.96	0.92	1.04
1990	1.11	1.03	1.08
1998	1.14	1.03	1.10

countries available in the World Bank source. To account for a maximum number of nonmissing reporters, these calculations, whose results appear in table 5A.4, are limited to year 1998.[19]

Generally speaking, representativity is larger for high-income countries (and of course for the open sample). However, even for low- and middle-income countries in the closed sample, the coverage of world trade is larger than 50 percent (except for low-income countries' imports).

Polluting Products

Similar calculations were not possible for polluting products, as world trade data were not available at this level of disaggregation. However, a very crude indicator of the representativity of the sample for these products is simply the ratio of imports over exports, which should be equal to 1.0 in case of complete coverage. These figures, along with their standardized value obtained by dividing them by the import/export ratio for all products in the sample, are reported in table 5A.5.

Overall, the ratio is reasonably close to 1.0, which suggests an acceptable level of representativity for polluting products. The sectoral results appear in tables 5A.6–5A.8, and in figures 5A.1 and 5A.2.

19. Accordingly, it is a more recent classification of countries by income groups (based on 1999 GNP figures) that is applied in this particular table.

Table 5A.6 **Shares of Developing Countries in World Trade**

	Polluting Products		All Products		Revealed Comparative Advantage	Revealed Comparative Disadvantage
	Exports (1)	Imports (2)	Exports (3)	Imports (4)	(1)/(3)	(2)/(4)
	Paper and Products (ISIC = 341)					
1981–83	3.70	12.70	9.40	15.73	0.39	0.81
1996–98	9.55	19.92	15.93	18.67	0.60	1.07
Rate of growth	6.53	3.05	3.58	1.15		
	Industrial Chemicals (ISIC =351)					
1981–83	5.11	21.55	9.40	15.73	0.54	1.37
1996–98	12.12	24.33	15.93	18.67	0.76	1.30
Rate of growth	5.92	0.82	3.58	1.15		
	Other Nonmetallic Mineral Products (ISIC = 369)					
1981–83	11.42	22.33	9.40	15.73	1.22	1.42
1996–98	16.28	19.16	15.93	18.67	1.02	1.03
Rate of growth	2.39	–1.02	3.58	1.15		
	Iron and Steel (ISIC = 371)					
1981–83	9.09	23.63	9.40	15.73	0.97	1.50
1996–98	18.38	26.85	15.93	18.67	1.15	1.44
Rate of growth	4.81	0.86	3.58	1.15		
	Nonferrous Metals (ISIC = 372)					
1981–83	24.01	10.31	9.40	15.73	2.56	0.66
1996–98	22.91	17.88	15.93	18.67	1.44	0.96
Rate of growth	–0.31	3.73	3.58	1.15		

Table 5A.7 **Decomposition of Aggregate Change in Revealed Comparative Advantage (RCA) for Developing Countries**

ISIC Code	Total Change in RCA	Composition Effect	Structural Effect
341	0.206	–0.060	0.266
351	0.216	–0.087	0.303
369	–0.193	–0.301	0.108
371	0.186	–0.260	0.446
372	–1.118	–0.529	–0.589

Table 5A.8 Gravity Equation: Hausman-Taylor Estimates

	M_{ijt}					
Independent Variable	POL-HT	341	351	369	371	372
$\ln(Y_{it})$	1.50**	1.26**	1.27**	1.69**	1.82**	1.91**
	(19.4)	(12.6)	(16.39)	(15.4)	(16.5)	(17.8)
$\ln(Y_{jt})$	0.92**	0.58	1.86**	–0.58**	–0.32*	–0.16
	(10.9)	(5.0)	(21.8)	(5.0)	(2.5)	(1.3)
$\ln(Y_{it}/N_{it}) - \ln(Y_{jt}/N_{jt})$	0.007	0.08*	0.03	0.12**	0.11**	–0.04
	(0.3)	(2.0)	(1.1)	(3.5)	(2.7)	(1.1)
ln $DIST_{ij}$	–1.12**	–1.40**	–1.23**	–1.21**	–1.12**	–0.95**
	(17.7)	(14.4)	(19.1)	(12.9)	(7.9)	(6.8)
BOR_{ij}	1.30**	1.68**	1.15**	1.70**	0.96**	0.87
	(5.5)	(4.01)	(4.6)	(4.2)	(2.8)	(1.6)
LL_i	0.49	0.52	–0.28	1.76**	2.79**	2.26**
	(1.66)	(1.0)	(0.9)	(3.4)	(4.23)	(3.3)
LL_j	–0.42**	–2.48**	–1.99**	–4.39**	–3.79**	–2.48**
	(1.22)	(3.8)	(5.4)	(6.9)	(4.25)	(3.3)
ln INF_{it}	0.46**	0.48**	0.43**	0.98**	0.51**	0.55**
	(6.43)	(5.1)	(6.1)	(9.3)	(4.4)	(4.9)
ln INF_{jt}	0.64**	1.19**	0.26**	2.22**	1.43**	0.15
	(7.7)	(9.9)	(3.0)	(18.6)	(9.9)	(1.2)
ln RER_{ijt}	–0.40*	–0.57**	–0.35**	–0.66**	–0.71**	–0.19**
	(14.3)	(14.3)	(12.6)	(16.3)	(16.6)	(5.1)
No. of observations (NT)	30,345	21,831	28,087	20,907	21,122	21,591
No. of bilateral (N)	2,300	2,017	2,240	1,970	1,938	1,956
R^2	0.52	0.51	0.52	0.44	0.51	0.35
Hausman test HT vs. Chi-2(K)	614.7** Chi-2(25)	413.1** Chi-2(25)	589.6** Chi-2(25)	13.7** Chi-2(25)	97.9** Chi-2(25)	182.5** Chi-2(25)

Notes: Dependent variable: M_{ijt} (imports of i from j in period t). T-student in parentheses. Time dummy variables and constant term not reported. Random effect estimates (endogenous variables: Y_i and Y_j and $[Y_i/N_i] - [Y_j/N_j]$).

**Significant at the 99 percent level.

*Significant at the 95 percent level.

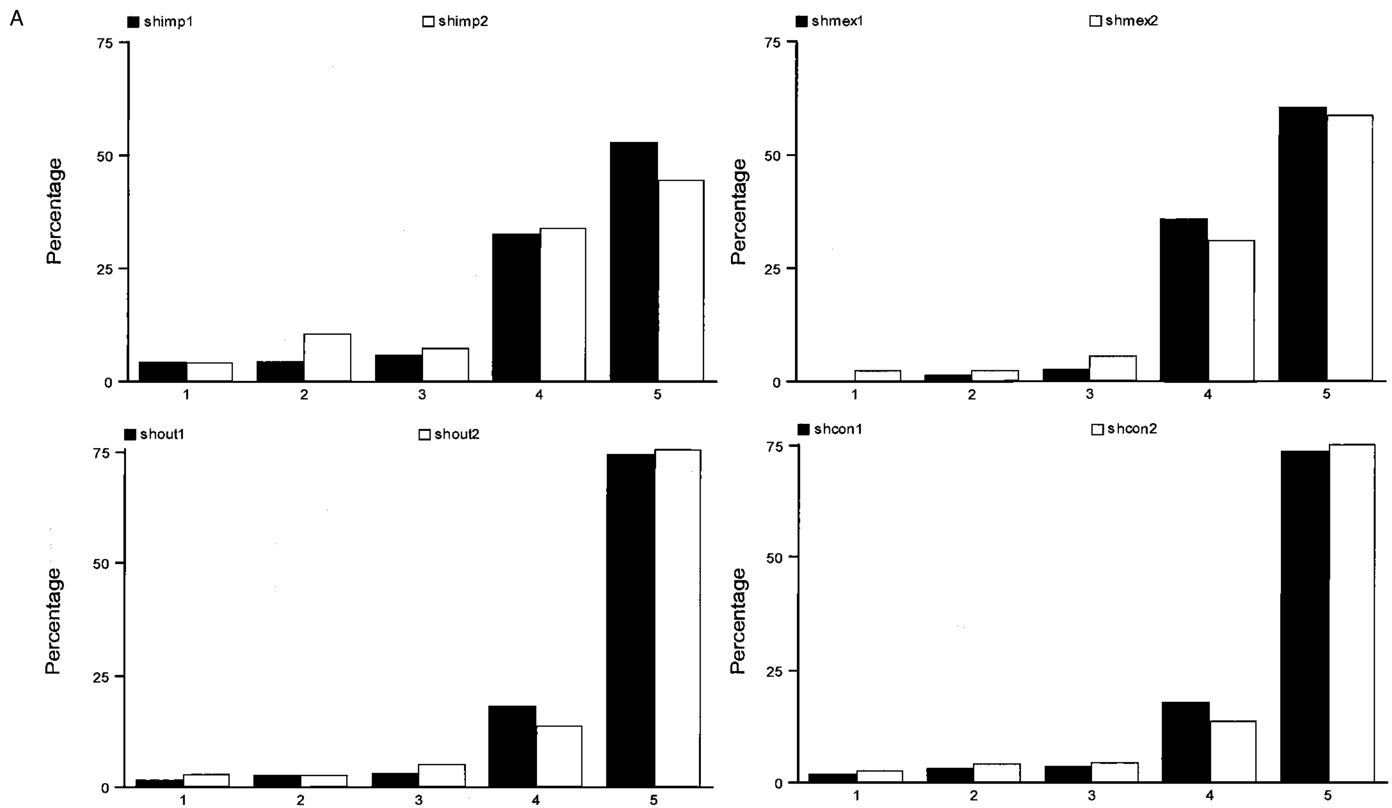


Fig. 5A.1 Histograms for output (shout), consumption (shcon), exports (shmex), and imports (shimp): *A*, ISIC = 341; *B*, ISIC = 351; *C*, ISIC = 369; *D*, ISIC = 371; *E*, ISIC = 372

Notes: 1: beginning of period; 2: end of period.

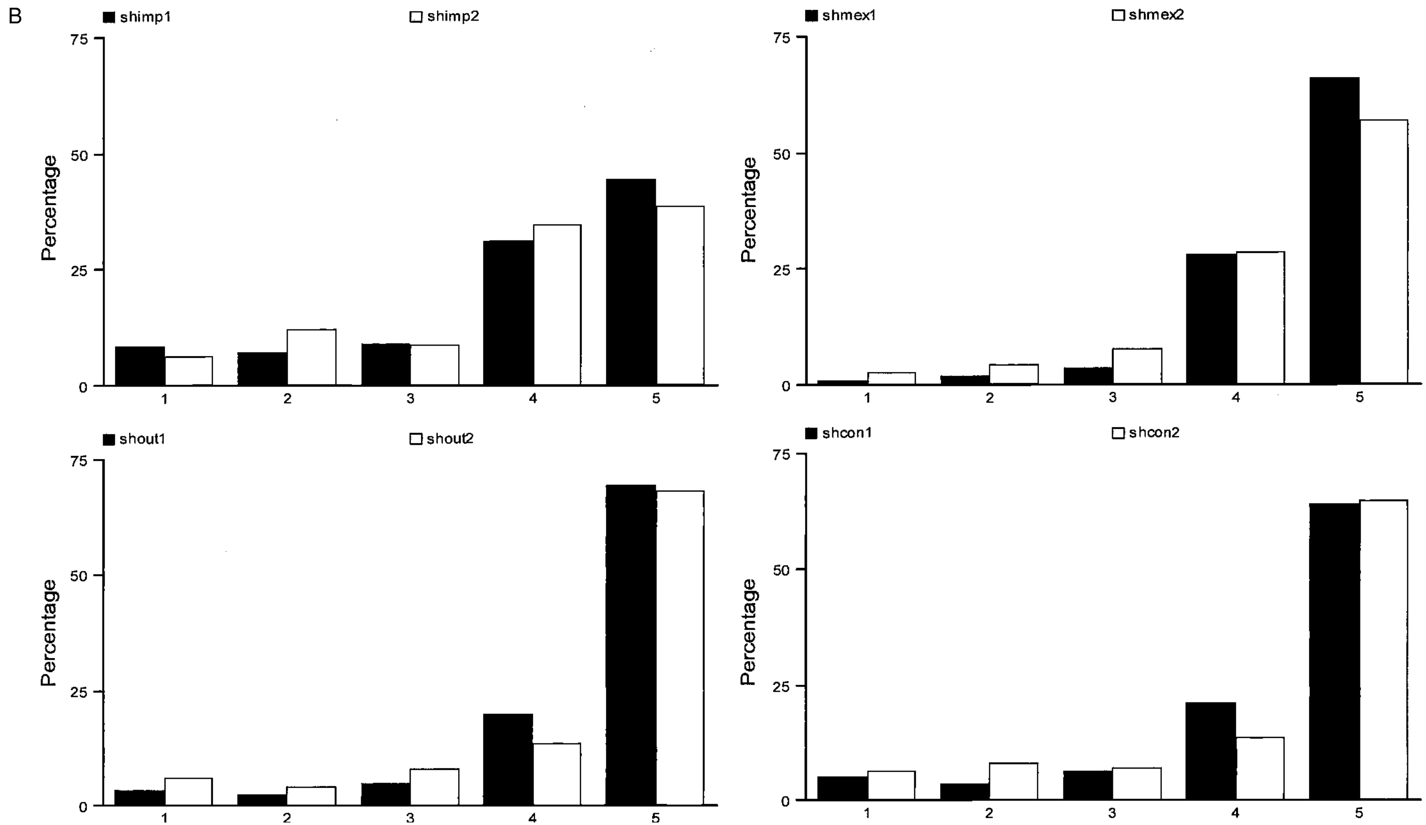

B
shimp1
shimp2
shmex1
shmex2
shout1
shout2
shcon1
shcon2
Percentage
0
25
50
75
1
2
3
4
5

Fig. 5A.1 (cont.)

C

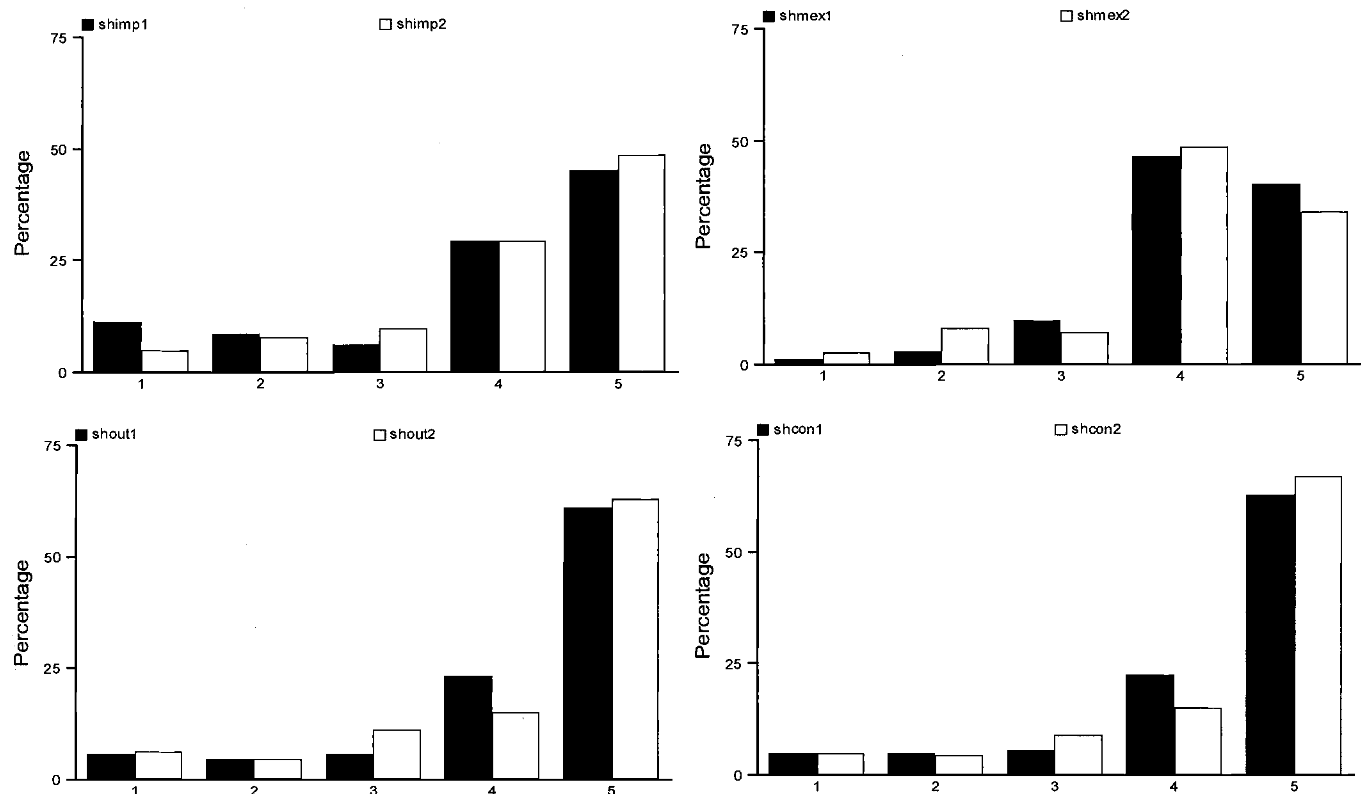
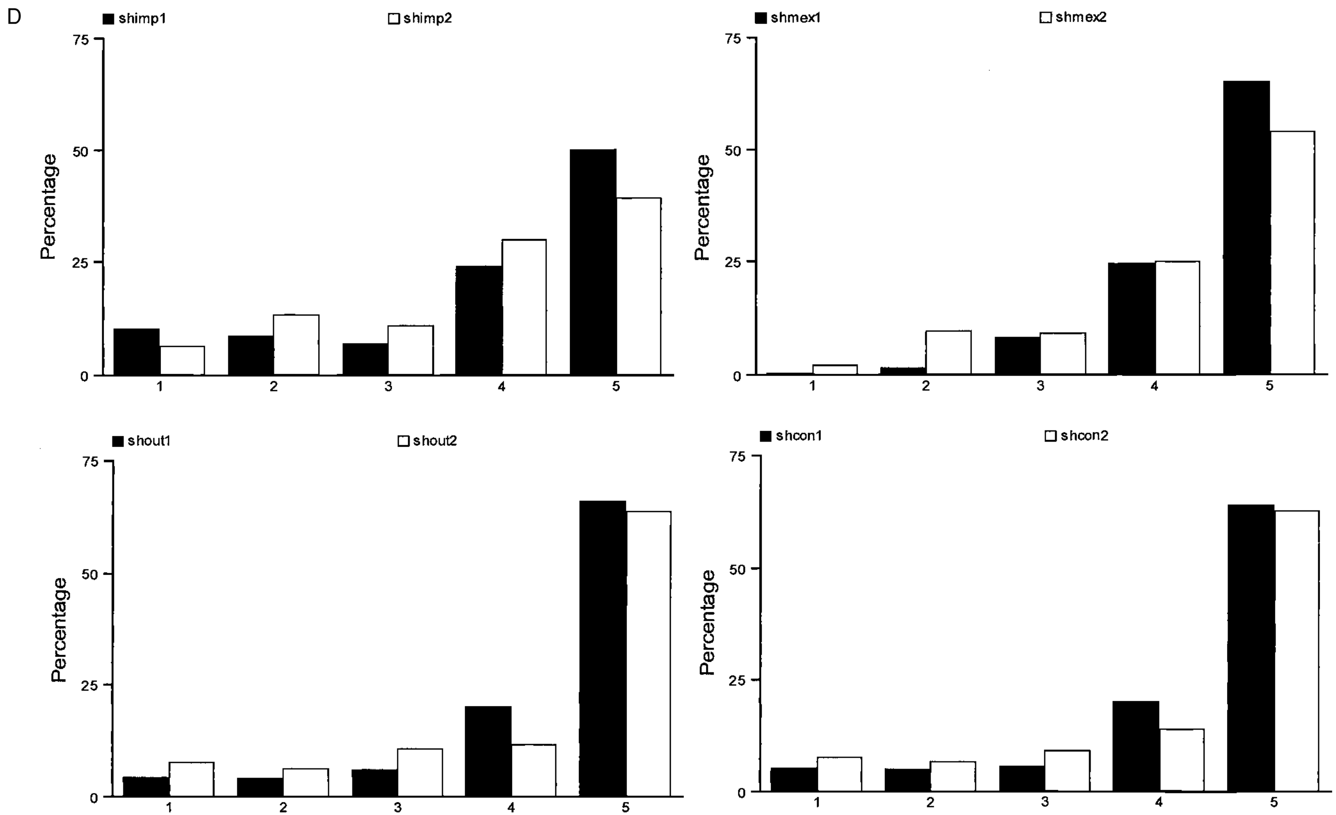


Fig. 5A.1 (cont.) Histograms for output (shout), consumption (shcon), exports (shmex), and imports (shimp): *A*, ISIC = 341; *B*, ISIC = 351; *C*, ISIC = 369; *D*, ISIC = 371; *E*, ISIC = 372

Notes: 1: beginning of period; 2: end of period.


D
shimp1
shimp2
shmex1
shmex2
shout1
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Percentage
0
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Fig. 5A.1 (cont.)

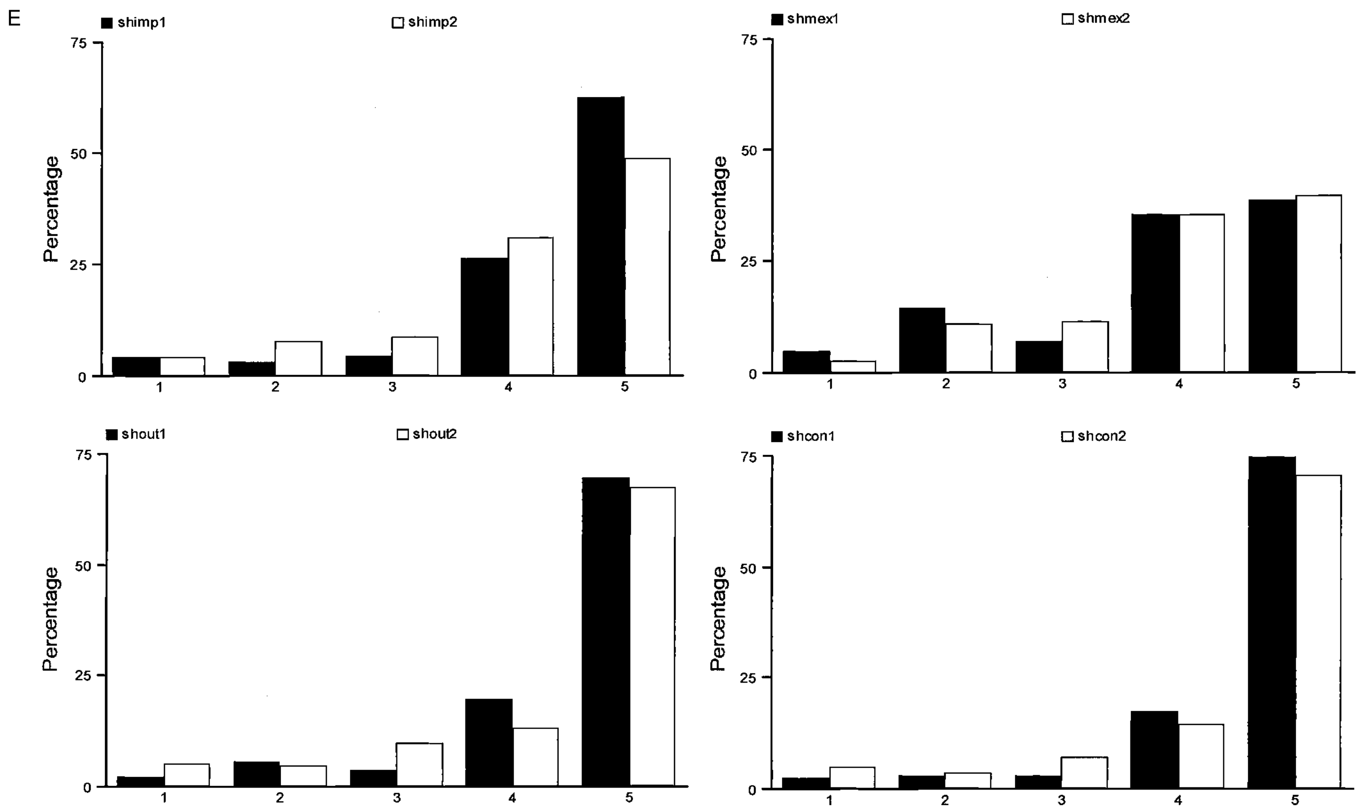
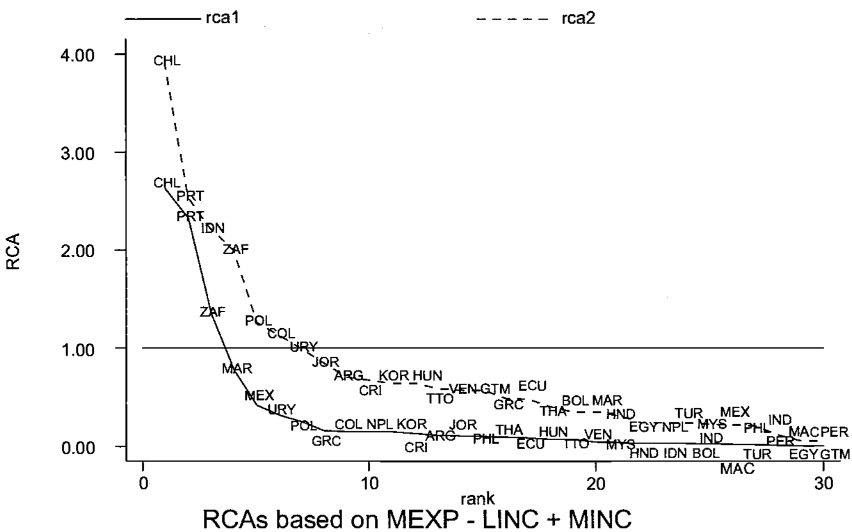


Fig. 5A.1 **(cont.) Histograms for output (shout), consumption (shcon), exports (shmex), and imports (shimp):** ***A,*** **ISIC = 341;** ***B,*** **ISIC = 351;** ***C,*** **ISIC = 369;** ***D,*** **ISIC = 371;** ***E,*** **ISIC = 372**

Notes: 1: beginning of period; 2: end of period.

A



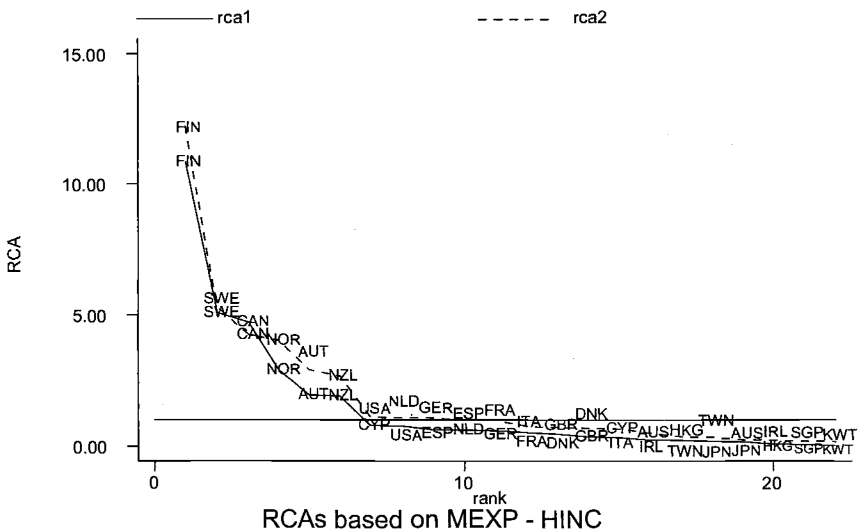
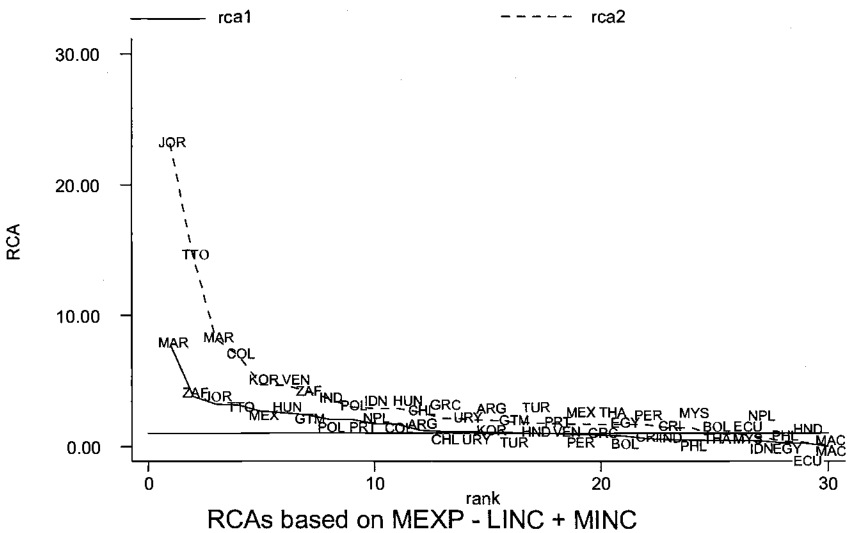


Fig. 5A.2 Beginning-of-period (1) and end-of-period (2) RCAs, by country group: ***A,*** **ISIC = 341;** ***B,*** **ISIC = 351;** ***C,*** **ISIC = 369;** ***D,*** **ISIC = 371;** ***E,*** **ISIC = 372**

B



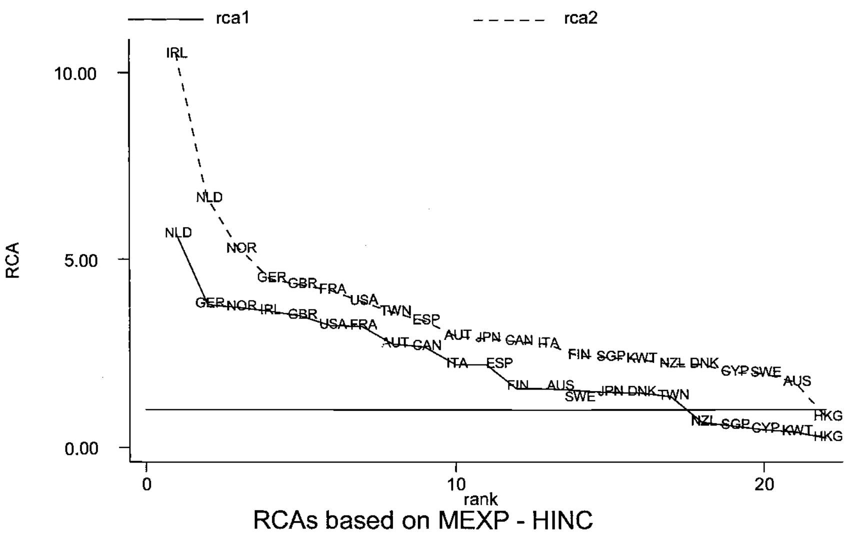
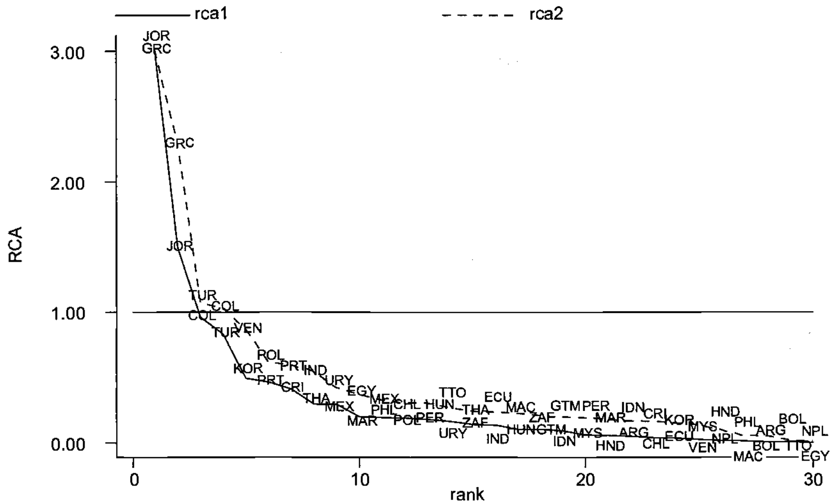
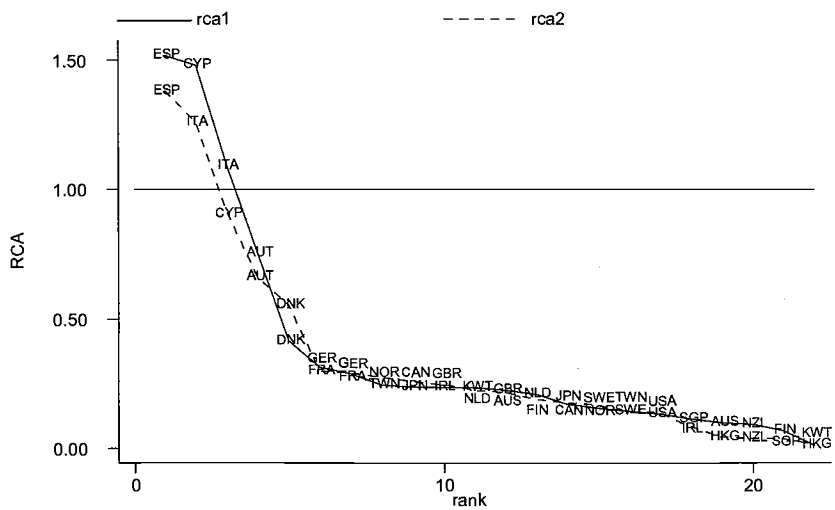


Fig. 5A.2 (cont.) Beginning-of-period (1) and end-of-period (2) RCAs, by country group: *A,* ISIC = 341; *B,* ISIC = 351; *C,* ISIC = 369; *D,* ISIC = 371; *E,* ISIC = 372

C



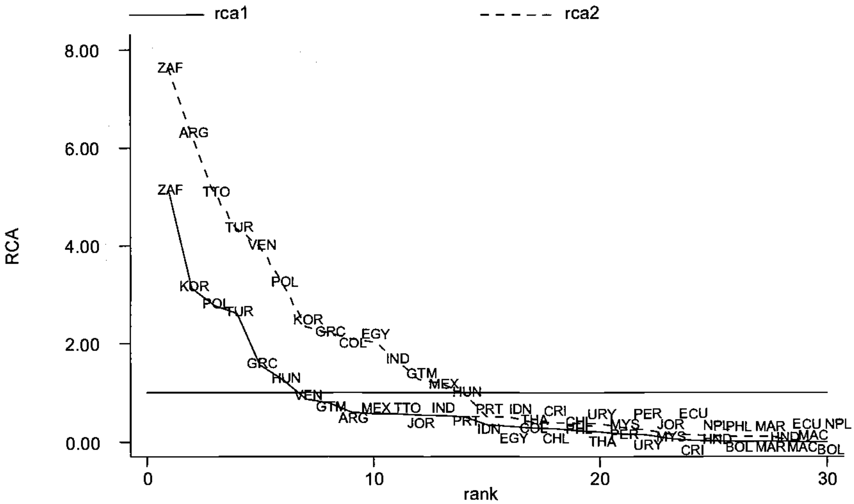
RCAs based on MEXP - LINC + MINC



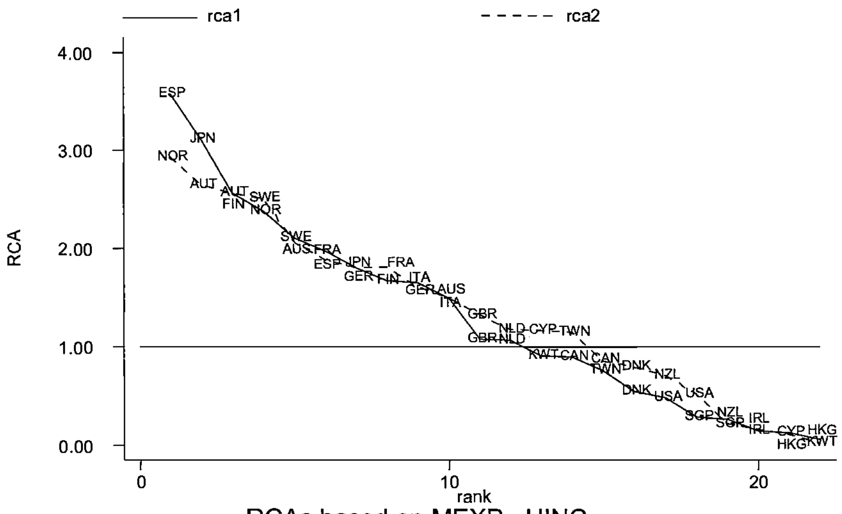
RCAs based on MEXP - HINC

Fig. 5A.2 (cont.)

D



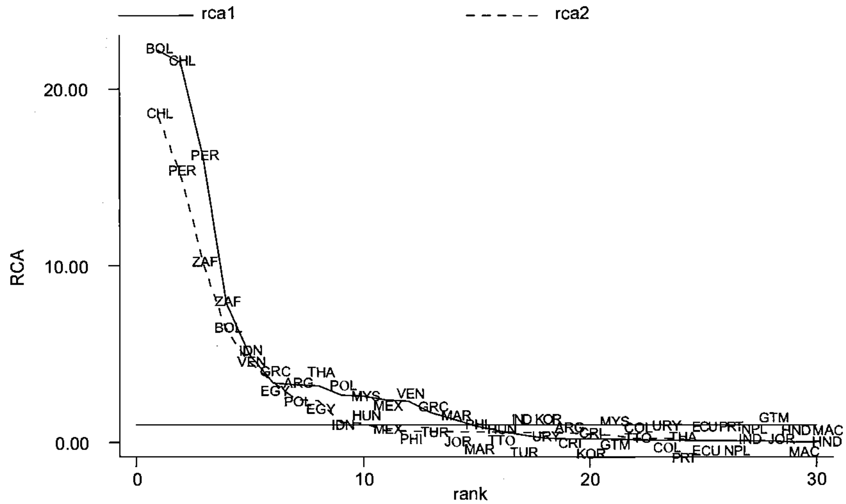
RCAs based on MEXP - LINC + MINC



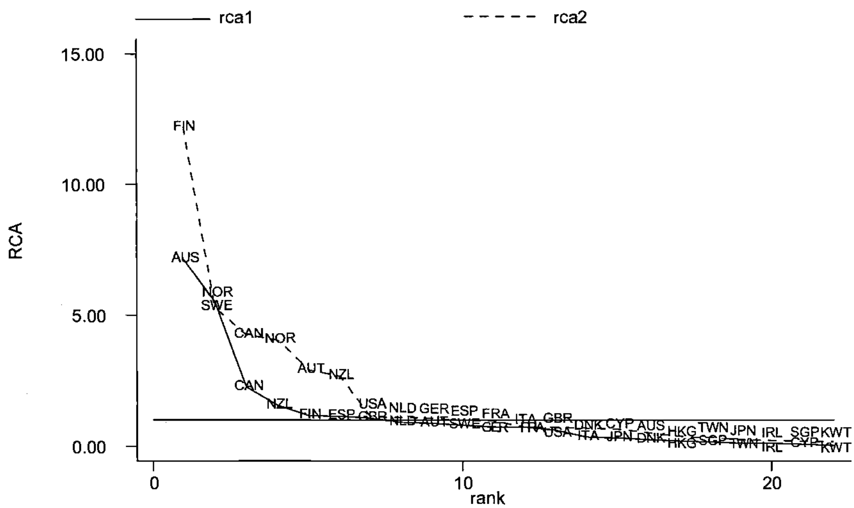
RCAs based on MEXP - HINC

Fig. 5A.2 (cont.) Beginning-of-period (1) and end-of-period (2) RCAs, by country group: *A,* ISIC = 341; *B,* ISIC = 351; *C,* ISIC = 369; *D,* ISIC = 371; *E,* ISIC = 372

E



RCAs based on MEXP - LINC + MINC



RCAs based on MEXP - HINC

Fig. 5A.2 (cont.)

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Comment Simon J. Evenett

Although much commentary on the consequences of the latest wave of international market integration has focused on economic matters, a vocal and important element of the policymaking community has been concerned with the environmental effects of globalization. With an eye to journalistic and policymaking audiences, environmental critics of trade, investment, and other reforms quickly coined two terms that have subsequently gained widespread currency, specifically the "pollution havens" hypothesis and the "race to the bottom" hypothesis. These seemingly plausible conjectures about how firms and governments behave in the global economy have now been subject to considerable scrutiny by researchers, as the balanced and methodical paper by Grether and de Melo ably demonstrates. It turns out that neither hypothesis is an accurate general characterization of firm or government behavior; yet certain circumstances can be identified where these hypotheses might not be at odds with observed behavior. This conclusion probably confirms what cautious observers from all camps have known all along, and serves the useful purpose of taking some of the wind out of the sails of the more partisan commentators.

In this comment I shall focus on the fourth section of Grether and de Melo's chapter, which attempts to quantify the effects of regulatory gaps on

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international trade flows in selected nonpolluting and polluting industries. One of the goals of their analysis is to examine whether higher international transportation costs in polluting industries would—for a given regulatory gap—diminish the incentives for firms to relocate production from the industrialized economies to the developing countries. The logic, apparently, is that relocation would require shipping products from a production location in a new, developing country to customers in industrialized countries and that high international transportation costs would erode (if not entirely offset) any cost advantage of shifting production to a jurisdiction with less-stringent environmental regulations. Consistent with this thesis, Grether and de Melo found that, in a traditional gravity equation framework, the (absolute value) of the estimated distance elasticities were larger for five goods that are known to involve greater pollution during production than a composite of other goods that are thought to involve less pollution. In interpreting this finding, much turns on how convinced one is that the estimated distance parameters are really picking up international transportation costs and not some other distance-related cost of conducting international trade, such as the cost of acquiring information at potential sales opportunities. Indeed, one might ask what the evidence is that the latter costs are greater for products made in polluting industries. In this regard, it is also worth noting Grossman's (1998) skepticism about the plausibility of the magnitude of estimated distance elasticities in gravity equation studies.

In my view, the weakest aspect of Grether and de Melo's analysis concerns the construction and interpretation of the variable proxying for the regulatory gap. Grether and de Melo use bilateral differences in per capita national income to proxy for national differences in the stringency of environmental regulation, an assumption that they justify by making reference to a prediction of a theoretical model in Antweiler, Copeland, and Taylor (2001). They then go on to examine whether the estimated parameter for this proxy variable is a statistically significant determinant of bilateral trade flows. In only two of the five polluting industries (nonmetallic minerals, and iron and steel) is the estimated proxy positive and statistically significant (see the parameter estimates for α_9 in table 5.5). Moreover, these positive elasticities are remarkably small when compared to the size of the estimated elasticities of the traditional gravity variables, such as national income. Taking a unitary elasticity for national income (which is in line with the relevant parameter estimates reported in table 5.4), in the case of nonmetallic minerals the estimated elasticity on the regulatory gap term implies that a 1 percent increase in this gap would have an effect on trade flows equal to an eighth of the size of a 1 percent change in gross domestic product of either trading partner. It would seem, then, in terms of the impact on trade flows, that national differences in environmental regulation have little economically significant effect on trade flows.

Or do they? The interpretational problem arises from the fact, as Grether and de Melo note, that in many trade models differences in per capita national incomes are an independent determinant of international trade flows—that is, independent of environmental regulation. Unfortunately, the authors do not draw out the implications of this observation for the interpretation of the estimated parameters. Essentially, the estimated parameter on differences in per capita national incomes conflates the effect on trade flows created by national differences in environmental regulations with another independent determinant of trade flows. Worse, in the approach taken in this chapter, there appears to be no way to separate out these two influences. This implies that the estimated parameter for per capita income differences of –0.06 for nonpolluting manufacturing industries could include a small component that is due to regulatory gaps (say, +0.02). Or the latter could be large (say, +0.7). The point is that we just cannot tell how large the effects of the regulatory gap are. Consequently, this chapter does not accomplish one of its own objectives, namely, to estimate the effect of national differences in environmental regulation on international trade flows. It would appear, then, that another proxy for those national differences is called for if this hurdle is to be overcome in future research.

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