Advances in Economic Analysis & Policy

Volume 4, *Issue* 2 2004 *Article* 8

THE POLLUTION HAVEN HYPOTHESIS

Unbundling the Pollution Haven Hypothesis

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Abstract

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KEYWORDS: trade, pollution haven hypothesis, environment

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One of the most important debates in trade policy concerns the environmental impact of trade liberalization. Should trade rules be altered to ensure international trade has a benign environmental impact? Should countries be allowed to countervail goods originating in countries with less strict controls on pollution? Should trade agreements and multilateral environmental agreements be linked, and if so how? Despite a flurry of both theoretical and empirical research over the last ten years, the debate surrounding these questions is far from over.

The debate started in the early 1990s when the North American Free Trade Agreement placed firms located in rich and tightly regulated countries (the U.S. and Canada) and firms located in a poor and laxly regulated country (Mexico) in direct competition for the North American market. Critics of the accord pointed to the obvious divergence in environmental control costs across countries, together with the already poor environmental record in the Maquiladora region to argue that NAFTA was sure to be an environmental disaster for Mexico, and a jobs disaster for the U.S. and Canada. Since then environmental issues have continued to play a major role in trade debates, while job issues have waned in importance. For example, the Doha Declaration lists several trade and environment issues for negotiation. Ongoing discussions are to clarify the relationship between WTO rules and trade obligations set out in Multilateral Environmental Agreements (MEAs); to establish procedures for regular information exchange between MEA secretariats and the relevant WTO Committees; and to reduce or eliminate tariff and non-tariff barriers on environmental goods and services. These negotiating objectives are additional to existing WTO discussions on the role fishery subsidies play in natural resource depletion, the benefits of accelerated liberalization in forest product trade, the usefulness of eco-labeling, and the role, if any, for the precautionary principle to play in determining allowable imports. Clearly the trade and environment debate is far from over.

It is then quite timely and very useful that *The B.E. Journals in Economic Analysis & Policy* has published a volume of studies examining the trade and environment link with special emphasis on the pollution haven hypothesis. The "Pollution Haven Hypothesis" (PHH) is one of the most contentious and hotly debated predictions in all of international economics. It is at the center of the trade and environment debate, since it makes a direct link between differences across countries in their environmental regulation and trade flows. Simply put, the hypothesis predicts liberalized trade in goods will lead to the relocation of pollution intensive production from high income and stringent environmental regulation countries, to low income and lax environmental regulation countries. In the NAFTA debate, it was used to support the prediction of both an environmental disaster in Mexico (because Mexico would specialize in pollution intensive goods) and a jobs disaster in partner countries (because jobs in pollution intensive industries would be destroyed by imports from Mexico). If the PHH is true, it can be used to argue for trade interventions such as green countervail on imported goods, or export bans on tropical timber. If false, the environmental impact of liberalized trade is likely to be far more benign. Providing evidence for or against the hypothesis should be a high priority for researchers in both international and environmental economics.

The purpose of this introduction is to set out the theory behind the Pollution Haven Hypothesis and to show how each of the contributions in this volume sheds light on one or another link in the logic of the pollution haven chain. By doing so, I hope to identify research questions requiring further scrutiny, while acknowledging the valuable contributions made in this volume. To organize my thoughts, I first restate the Pollution Haven Hypothesis as envisaged by Copeland and Taylor (1994) "North-South Trade and the Environment". I do so because CT (1994) was the first paper to link country income levels and the stringency of environmental regulation to predictions on pollution levels and trade patterns. It was in turn inspired by the ongoing NAFTA debate, and the seminal contribution of Gene Grossman and Alan Krueger (1993, 1995) on NAFTAs environmental consequences.

The CT (1994) analysis provides me with a springboard to organize my review. In what follows, I first state the assumptions underlying the Pollution Haven Hypothesis and then recount its predictions regarding trade flows and pollution levels. Following this, I unbundle the hypothesis into a series of logical steps from country characteristics to trade flows and interpret each contribution in the volume as shedding light on one or another of these links. Finally, I present a short conclusion with suggestions for future research.

1. The Pollution Haven Hypothesis

The original Copeland and Taylor analysis is an exercise in applied theory. It develops a two-country static general equilibrium model of international trade with a continuum of goods differentiated by their pollution intensity. The model has only one primary factor of production, and for the most part the authors assume countries only differ in their endowment of this factor (suggestively labelled human capital). Differences across countries in population density, assimilative capacity, and country size are considered in the penultimate section of the paper, but the focus is on how differences in human capital across countries affects their income, regulation, and resulting trade flows and pollution levels.

The production of any good in the economy creates pollution as a joint product. Pollution abatement is possible, but requires real resources. As the paper demonstrates, active abatement plus joint production leads to a final goods specification where pollution appears as if it was an input to production. Assumptions are adopted on abatement to allow for an unambiguous ranking across the continuum of industries according to their pollution intensity. The two countries are labelled North and South, with North having much greater human capital than South. Large differences in human capital across regions ensure that each country specializes in a set of either relatively clean or dirty goods in trade.[1] Pollution is assumed to be local in its effects, and the environment is a normal

[1] If countries differ only slightly in human capital levels, then factor prices will be equalized by trade and the commodity composition of trade becomes indeterminate. This complicates the analysis but does not alter the basic conclusions.

good. To make the policy process simple and transparent, a social planner in each country trades off increases in pollution, which generate higher real income, against the sum of marginal damage across the affected population.

The model is constructed to reflect three realities: one, the distribution of income is very unequal worldwide; two, industries differ greatly in their pollution intensity of production; and three, environmental quality is a normal good. It then provides predictions on trade patterns and pollution levels from these assumptions. When countries differ only in human capital levels, it generates the Pollution Haven Hypothesis: a movement from autarky to free international trade in goods leads to the relocation of dirty good production from the high-income, tight-environmental-regulation country to the low-income, lax-environmental-regulation country. It also provides two corollaries: one, pollution rises in the lax regulation country and falls in the tight regulation country; and two, overall world pollution rises with trade.

The intuition for these results is fairly clear. Trade alters the composition of output in both North and South because of differences in the stringency of their pollution regulation. Dirty goods are relatively expensive in the tight regulation North in autarky, and relatively cheap in the lax regulation South. Regulation levels are functions of the endogenous North-South income gap. Given the relative cost structure in autarky, a movement to free trade shifts dirty good production to the South and clean good production to the North. Pollution falls in the North because the composition of its industries becomes cleaner with trade. Pollution rises in the South because the composition of its industries becomes dirtier with trade. World pollution rises with trade because the world's dirtiest industries locate in the country with the lowest environmental standards.[2]

While the statement of the Pollution Haven Hypothesis is relatively simple, moving from a statement of the hypothesis to testing in the real world has proven difficult. The theory envisages an exogenous movement from autarky to completely free trade, but nowhere in the world is trade truly free, nor are trade liberalizations exogenous events. Any empirical testing of the hypothesis has to deal with data coming from marginal movements towards free trade and address the endogeneity of both trade and pollution policy. The theory was formulated in the context of industrial pollution, but testing has sometimes employed data on renewable resource use, consumption-generated pollution or transboundary pollution.[3] Finally, the theory generates the PHH as a prediction by eliminating all other motives for trade, leaving regulatory differences alone to determine trade patterns. While the original CT analysis allowed for differences in other country at-

[2]This is an oversimplification of the logic. Trade creates scale, composition and technique effects in both countries. Because of the model's construction, scale and technique effects largely cancel out, leaving the composition effect to determine whether pollution rises or falls with trade. See CT (1994) for further details.

[3]Copeland and Taylor (1995a) extend the analysis to transboundary pollution. Adding transboundary pollution does not alter the trade pattern or pollution-generation predictions of the pollution haven hypothesis. Copeland and Taylor (1995b) examine consumption-generated pollution but find an important reversal: tight regulation now leads to a comparative advantage (rather than disadvantage) in dirty goods.

tributes (population density, size, assimilative capacity) and showed how these additional factors also determined comparative advantage, the authors were satisfied in stating "In reality, of course, trade is influenced by many conflicting factors...To make inferences about the actual pattern of trade, one would have to weigh the influences derived from environmental policy against other determinants of trade" (p. 757). Unfortunately, the authors provided no guidance as to how empirical work should go about weighing these various influences.

It is not surprising then that subsequent empirical work on the PHH has sometimes confused two quite different concepts. The first concept is a "pollution haven effect". A pollution haven effect occurs if a tightening of environmental regulation deters exports (or stimulates imports) of dirty goods. The pollution haven effect relates changes in environmental policy to resulting changes in trade flows. Most conventional economic models exhibit a pollution haven effect. Typically, a tightening of regulation raises production costs and lowers exports (or raises imports). Empirical evidence for a pollution haven effect can come from many sources, but often authors establish a link between across-industry variation in the cost of meeting environmental regulations and across-industry variation in trade flows. Many of the studies in this volume provide evidence on the pollution haven effect.

The second concept is the "Pollution Haven Hypothesis".[4] The PHH is a prediction concerning trade patterns and the stringency of environmental regulation. It predicts that when trade barriers are reduced, pollution-intensive industries will shift from countries with stringent environmental regulation to countries with lax environmental regulation. Empirical evidence for the Pollution Haven Hypothesis can also come from many sources, but often researchers investigate whether countries that differ greatly in the stringency of their environmental regulation have a trade pattern matching the PHH prediction. Two studies in this volume investigate trade patterns for just this purpose.

The PHH and the pollution haven effect, although different, are related. Simply put, the trade pattern prediction of the PHH can only be true if we have a strong pollution haven effect. The existence of a pollution haven effect is necessary, but not sufficient, for the PHH to hold. Empirical researchers have used this necessity relationship to provide alternative tests of the PHH. For example, empirical work that finds a "small" impact of regulation on trade flows also provides evidence against the PHH. This is a reasonable conclusion since "small" measured pollution haven effects must surely be outweighed by other more conventional determinants of comparative advantage. Therefore, estimating the strength of pollution haven effects is of great value: failure to find them implies failure of the Pollution Haven Hypothesis; and finding only small effects is suggestive evidence against the hypothesis.

[4] In the body of CT (1994) differences in regulation are the only source of comparative advantage. The model exhibits pollution haven effects and generates the Pollution Haven Hypothesis. When the model is extended to include other determinants of comparative advantage (density, etc.) the model still exhibits a pollution haven effect, but the PHH may no longer hold. See CT (1994) section VIII and chapter 6 of Copeland and Taylor (2003).

It may also be useful at this point to distinguish the Pollution Haven Hypothesis from another commonly employed term: "environmental dumping." Environmental dumping refers to a situation where pollution regulation is less stringent than it would be in the absence of strategic interaction. Alternatively, it is a situation where equilibrium pollution levels in the non-cooperative Nash equilibrium exceed those in the cooperative equilibrium. Barrett (1994) and Rauscher (1991) are the earliest contributions to the environmental dumping literature. While environmental dumping and the strategic use of environmental policy may lead to a pattern of trade (or capital movements) satisfying the Pollution Haven Hypothesis, they are distinct phenomena. The definition of environmental dumping was constructed to focus attention on the difference between the level of policy instruments in a strategic setting and their first best levels. As such, environmental dumping often carries with it a negative welfare implication. The Pollution Haven Hypothesis is a positive prediction. Its focus is on the difference between policy instruments across countries and how this affects trade flows. It is silent on whether pollution haven driven trade is welfare enhancing or not. It is for this reason that the definition of the Pollution Haven Hypothesis was given in purely positive terms. It does not claim that the low income country loses from trade nor does it claim that world pollution is excessive in the trading equilibrium. The original CT (1994) analysis for example exhibits the PHH, has no environmental dumping, and trade is welfare improving.

2. Unbundling the Hypothesis

In the last ten years a flurry of work has addressed "pollution haven" questions using both empirical and theoretical methods. To a certain extent this literature questioned assumptions made in the original CT analysis or pushed into entirely new areas. The CT analysis makes a host of assumptions: differences in the regulation of pollution across countries is the sole determinant of location decisions, trade is completely free of tariffs, countries do not use environmental policy strategically, and all externalities are fully internalized leading to efficient outcomes in both autarky and trade. Not surprisingly, much of the new research examines how sensitive industry location decisions are to pollution policies, as this is a key ingredient in any pollution haven model. Others have asked how the location decision rests on the trade regime. Still others moved towards a more serious consideration of strategic issues by asking whether and when countries adopt weak environmental regulations to attract industry and jobs? Other contributions adopted a less sanguine view of government's ability to internalize all externalities, and examined the impact of pollution haven driven trade on welfare when pollution is local, regional, or global.

To clarify and classify my subsequent discussion, I present in Figure 1 a schematic representation of the logical skeleton supporting the PHH. The hypothesis takes as given country characteristics such as access to various production technologies, opportunities for abatement, and country-specific endowments of productive factors. These country

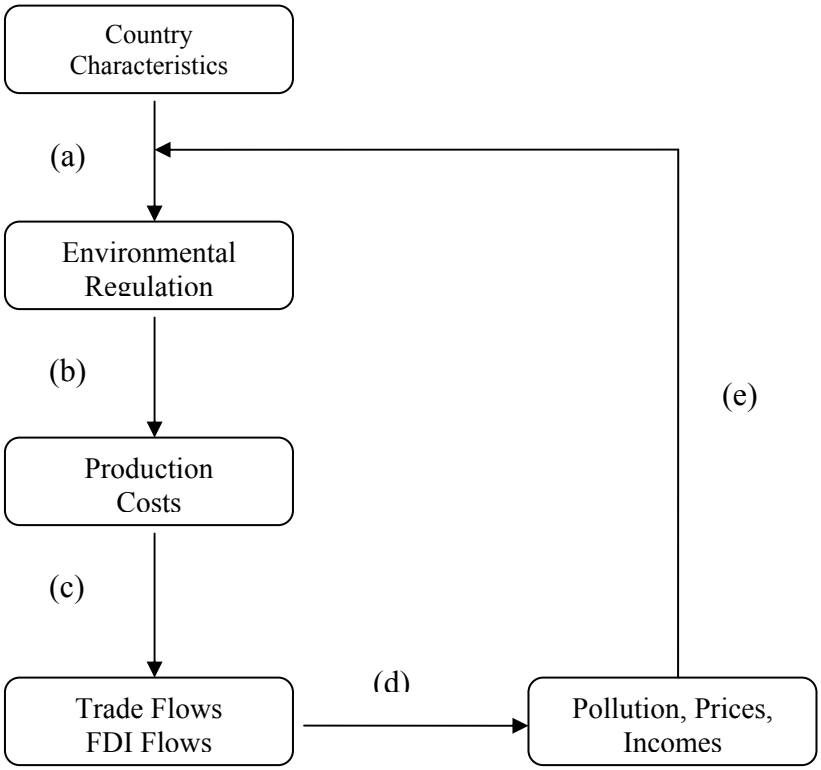

Figure 1: Unbundling the Pollution Haven Hypothesis

characteristics plus world prices determine national income, which in turn maps into the stringency of environmental regulation at step (a). In the canonical case the mapping is determined by a social planner who implements an efficient solution desired by the set of identical agents in the economy. The efficient solution is then implemented via a tax on pollution (or any other efficient instrument). This tax in turn affects the costs of goods production in the economy. Since some production technologies are more polluting than others, the impact of environmental regulation will vary across industries, and at channel (b) regulation will affect an economy's relative price structure. Relative prices define a nation's comparative advantage and determine trade flows at (c). Since the movement to trade alters production patterns, trade will also affect pollution, incomes and perhaps world prices at (d). These income and price changes feed back and modify the original mapping from country characteristics to regulation. They set in motion another round of adjustments, with the fixed point of this system being a general equilibrium where trade, pollution and regulatory stringency are all determined simultaneously.

Each of the contributions in this volume can be seen as unbundling or putting under scrutiny a piece of this logical chain. By doing so, the authors investigate either the logical inevitability of the pollution haven conclusions or the empirical significance of its predictions.

2.1 The Link from Country Characteristics to Environmental Regulation

In the simplest pollution haven model, a social planner determines optimal regulation that in turn affects a firm's abatement effort and its production costs. But even this simplest and most direct of cases is not that simple, as it begs the question about what is "optimal". For example, should the planner take into account the full general equilibrium consequences of their policy choice, including potential impacts on world markets? In CT (1994), each government chooses its pollution tax "optimally" under the assumption this choice will have no impact on world prices. Since pollution is local, this assumption rules out strategic interaction across governments in the setting of pollution policy, and ensures that the trading equilibrium is efficient. In addition, the social planner's problem is simplified by assuming identical agents. This assumption rules out income distribution affecting optimal policy and removes political economy motivations. Finally, agents are immobile across countries and the planner has complete information about abatement opportunities, technologies and marginal damage from pollution.

Five of the contributions in this volume extend, examine or criticize this simple link (a) between country characteristics and regulation. They do so by examining the relationship between regulatory stringency and factor mobility (Elbers and Withagen), information asymmetries (Wu), strategic adoption decisions (Regibeau and Gallegos), political economy motives (Fredriksson and Mani) and heterogeneity across agents (Becker).

Strategic interaction across governments is key to Elbers and Withagens' contribution "Environmental Policy, Population Dynamics and Agglomeration". These authors investigate the possibility of environmental dumping in a world where governments choose their pollution policy fully cognizant of its impact on world prices, industry location and labor migration. A commonly held view in the environment and trade literature is that factor mobility can only reinforce the tendency for polluting industries to shift towards lax regulation countries. The logic behind this view is simple. If factors are immobile, then the relocation of production is limited by the availability of productive factors in the low regulation country. If factors can chase low regulations, then this constraint is relaxed and the shift of industry reinforced. It is, however, unclear whether this is the whole story concerning factor mobility. Factors moving into the low regulation region may bring new technology or raise the host country's national income, and these changes may in turn create a tightening of standards. As Elbers and Withagen show, factor mobility may in some cases stop governments from enacting lax regulation, since skilled workers will flee a polluted country.

To generate this result, EW employ a standard two-sector model with a monopolistically competitive manufacturing sector producing under increasing returns and a perfectly

competitive agricultural sector producing under constant returns. The production of manufactures pollutes, cannot abate, and manufacturing employs only skilled workers. By making these assumptions the authors tie the production of manufactures, pollution and skilled labor tightly together, so that the number of active firms in a jurisdiction fully determines its pollution levels. Workers sort across countries in accordance with both real income and environmental concerns. The authors investigate the difference between the non-cooperative Nash equilibrium in pollution taxes and the cooperative solution. They define this difference to be the extent of environmental dumping.

Surprisingly, EW find that factor mobility can reduce the tendency to concentrate polluting activities in one country. While lax pollution regulation raises the return to skilled labor and works towards the agglomeration of manufacturing in one country, the concentration of industry also raises local pollution levels. Since workers also care about environmental quality, additional local pollution lowers the welfare of skilled workers and works against agglomeration. Whereas agglomeration of manufacturing in one location is a potential equilibrium (under some parameter values), the likelihood of agglomeration is lessened by the introduction of environmental concerns.

Elbers and Withagen's contribution is important in demonstrating how factor mobility is a two-way street: factors chasing high monetary rewards because of lax regulation can also flee excessive pollution created by lax regulation. Although the basic pollution haven model assumes factor immobility, Elbers and Withagen contribution shows that altering the degree of factor mobility does not necessarily imply a worsening of industrial flight and a magnified pollution haven effect.

Another contribution examining the mapping from country characteristics to environmental policy is Regibeau and Gallegos "Managed Trade, Liberalization and Local Pollution". In contrast to other contributions in this volume, RG this paper generates its pollution haven results via a purely strategic interaction. The paper contains two main results: a) countries may want to retain some flexibility in their tariff policy for environmental reasons; and b), we may find that countries with tight WTO commitments have relatively dirty production, while those with a great deal of discretion in trade policy have clean production.

RG develop a two-firm, two-country oligopoly model where only the Home country is policy active. Pollution is local and produced via production. The Home firm can choose between an existing dirty production technology or a costly new clean production technology. For most of the paper, the only policy instrument available to the Home government is a tariff on imports. The foreign government is inactive throughout.

The model is set up so that in the absence of a tariff on imports, the Home firm would never adopt the new technology. The new technology is costly and does not lower production costs. But since the Home government dislikes pollution, it would like the firm to adopt the new technology. As RG show, this implies that the government's optimal tariff on foreign imports is higher if the Home firm adopts the clean technology. Since the Home firm benefits from tariff protection, this generates an incentive for it to adopt. If the Home government committed to zero tariffs and free trade, then the Home firm would

never adopt the clean technology.

This is an interesting and thought-provoking paper. It is related to the literature on what I would call "tariff substitution" - that is, a literature where tariffs are employed to solve problems that other, more efficient instruments would typically be used to solve.[5] For example, the tariff in this case substitutes for both a direct tax on emissions and a subsidy to adoption. To be fair, the authors do consider other instruments and in the end argue that even if other instruments are available, tariffs still have a role in spurring adoption. Consequently, a commitment to free trade can be counterproductive. While the authors make a good case for their results, some remaining questions need to be answered. For example, only one country is policy active in their set up, and hence the Home country does not suffer from the Foreign country imposing trade restrictions on its own. When Foreign is inactive, it is easy to see how Home's commitment to free trade could be counterproductive. But in a setting with two policy active countries, a negotiated trade agreement between Home and Foreign may bring benefits to both countries by enlarging markets. Larger markets may spur rather than hinder adoption, and it will, in many models, also spur R&D activity. Therefore, trade liberalization in general may foster rather than deter the adoption of clean technologies.

Despite these quibbles, I think this paper is very useful. The authors demonstrate how technology adoption and strategic interaction produce a correlation between import volumes and the costs of environmental controls that are directly opposite to that expected. For example, a commitment to zero tariffs leads to dirty production, no environmental control costs, and large import volumes. Managed trade with positive tariffs leads to clean production, positive environmental control costs, and smaller import volumes. Therefore, import volumes are negatively correlated with control costs, which is opposite to the typical pollution haven prediction. This should tell us to beware simple correlations between, say, pollution abatement costs and trade flows, because tariffs, environmental protection and imports are jointly determined. Failing to account for this connection can lead us astray: any number of reasons may lead to an across-industry correlation between control costs and import volumes that has nothing to do with the competitiveness consequences of tighter regulations.

The PHH assumption of perfect information is relaxed in Wu's contribution "Pollution Havens and the Regulation of Multinationals with Asymmetric Information". This paper develops a common agency model where a continuum of multinational firms make production and location decisions. The two locations are the residence of the multinational called Home and the potential additional location denoted Foreign. The principals are the Home and Foreign governments that assign to each firm an output level and a corresponding transfer. The home and foreign country differ in two respects. Home residents exhibit a higher disutility of pollution than Foreign, and Home's government has perfect information regarding the pollution intensity of each firm, whereas the Foreign

[5] See Dixit (1985) for a discussion of the appropriate and inappropriate use of tariffs to substitute for other unavailable instruments.

government only knows the distribution of pollution intensity across firms.

The paper's main contribution is to show that the outcome of the noncooperative game between governments may produce an outcome opposite to that expected from the simple pollution haven hypothesis. The author first demonstrates that efficiency requires dirty output to be produced primarily in the country with the lower disutility for pollution. This efficient and cooperative outcome with information sharing across countries mimics a pollution haven division of output across countries. When we move to the noncooperative setting with no information sharing, the equilibrium division of dirty output across countries becomes more equal and hence less in line with the pollution haven prediction.

The logic behind Wu's results comes from the information extraction problem. Since the Foreign government doesn't know a firm's true type (its pollution intensity), any mechanism designed to extract this information will generate some informational rents for firms. However, the Home government knows all firms' pollution intensities. Home uses its superior information to improve it strategic interaction with Foreign, thereby transferring some of these informational rents to its own purse. Strikingly, in some cases, output will be higher in Home than in Foreign, which is of course directly opposite to the pollution haven prediction.

This is an interesting paper and one that identifies another area of research currently under-explored. The assumption that the Home government has superior information regarding the production and pollution process of its firms seems very natural, as does the policy game modeled across countries. It demonstrates that movements away from the perfect information set-up can produce motivations far different from those given by the pure pollution haven effect. Moreover, these offsetting forces can be large enough to reverse standard predictions.

Two remaining papers in this volume investigate the link between country characteristics and regulation using empirical methods. One of the key simplifications in the pollution haven model is that agents are identical. The motivation for this assumption is clear. By assuming away income distributional issues within countries, a researcher can focus on the country as the unit of analysis and develop a theory where income differences across countries play a key role. Alternatively, a researcher can introduce heterogeneity across agents. Countries can then be categorized by the fraction of their populous exhibiting a strong preference for protecting the environment. This division is a common one in research on the political economy determinants of regulation. However, relatively little empirical work has unbundled this mapping. As such, the contribution "Pollution Abatement Expenditure by U.S. Manufacturing Plants: Do Community Characteristics Matter?" by Randy Becker and the contribution "Trade Integration and Political Turbulence: Environmental Policy Consequences" by Fredriksson and Mani (FM) are very welcome indeed.

FM combine both theory and empirical work to investigate the interactions among government honesty, political stability, and trade liberalization. The authors develop a theory where a domestic lobby offers bribes to a regulator in exchange for less onerous

regulation. The regulator values both bribes and overall social welfare and must weigh the value of additional bribes against the loss in social welfare from lax regulation. FM show that when such a country undergoes a (exogenously imposed) trade liberalization, the political equilibrium is disturbed and regulation adjusts. Their main theoretical contribution is to show that when a trade liberalization shrinks output in the polluting industry, this lessens the dirty industry's incentive to offer bribes for more lenient regulation, and in equilibrium environmental standards rise.

In their empirical implementation, the authors construct a large, cross-country dataset including 26 OECD and 92 non-OECD countries. The authors explore the predictive power of their theory by explaining the cross-country variation in environmental stringency using proxies for political stability, openness, and government honesty. Overall, the authors find results in line with their theory. Environmental stringency is higher in open economies, and is higher still in economies that are both politically stable and open, as their theory predicts. These results demonstrate a potentially important role for political stability. In typical pollution haven models, political stability plays no role whatsoever, whereas it is center stage here. In fact, the authors find that income per capita has no direct role in raising environmental standards. This is true, for example, in all of the 2SLS results reported in the paper, where they have instrumented for the endogeneity of political stability and their two measures of government honesty. The authors do not interpret this empirical finding as a contradiction to the assumed link between stringency and income made in pollution haven models, because this is too hasty a conclusion. In all of the first stage regressions of political stability and honesty on instruments, income per capita is found to be the most significant variable. Therefore, finding an important role for political stability in setting regulation may instead reflect the tight connection that exists between country income levels, political stability and government honesty.

The contribution by Becker examines the link between characteristics of local U.S. county populations and the abatement behavior of firms in the same county. To do so, Becker employs data on plant-level air pollution abatement expenditures across the U.S. from 1979-1988. Plant-level pollution abatement costs are regressed on a set of plant characteristics, local community characteristics, time dummies, and proxies for the stringency of local, state and federal regulation. The dependent variable is an establishment-level measure of costs from the PACE surveys, while the characteristics of the establishment (size, productivity, etc.) are obtained from the Census of Manufactures.

The results are quite striking. After controlling for federal, state and county-specific regulation, Becker finds four county characteristics positively and consistently linked to the intensity of plant-level abatement. These are: income per capita in the community; the extent of home ownership; the percentage who voted Democrat; and whether the county is within a metropolitan statistical area. In addition, Becker finds one factor negatively linked to abatement: the percentage of employed civilian workers in manufacturing. The findings suggest that those with Green preferences or those with much to lose if environmental quality were to deteriorate, are successful in making their views known at the plant level. How their views are made known and why firms act on them is left unanswered,

but the natural inference is that community attributes are affecting the enforcement of existing regulations. Of the characteristics found to be important, income per capita is shown to have the strongest effect on abatement, although the various political economy variables also matter.

Together these contributions paint a much richer picture of the mapping from country characteristics to pollution policy than the one envisaged by the simple Pollution Haven Hypothesis. The theoretical contributions tell us this mapping may be importantly affected by the location decision of factors, the adoption decision of firms, and the lobbying behavior of politically active industry groups. Whether these additional determinants of policy turn out to be important empirically is not yet determined, but each contribution has pointed to additional and potentially important forces. The empirical contributions also suggest a richer picture of the policy process. Although income per capita is surely a determinant of policy, political economy factors are also important. The remaining empirical challenge is to determine which motive is paramount, or to give us a rough indication of their relative importance. Since many political economy measures are highly correlated with income per capita at the country level, this will prove difficult using country level data. Until this issue is resolved empirically, we can only rely on our judgement. It may be appropriate to take income per capita as the primary determinant of pollution policy in an aggregate analysis focussing on explaining cross-country variation in outcomes; alternatively, any study seeking to explain across-industry or across-county variation in outcomes would be well advised to account for elements of political economy.

2.2 The Link from Environmental Regulation to Production Costs

One of the least contentious links in the pollution haven chain of logic is the link between more stringent regulation and higher production costs at channel (b) in Figure 1. Economists are typically skeptical of free lunches that offer tighter regulation, improved environmental quality, and greater international competitiveness, although in some cases tighter regulation can indeed raise productivity levels and lower production costs - breaking the chain of logic supporting the PHH. The conditions for doing so rely on regulation playing an additional role in the economy. Two papers in this volume present theoretical arguments throwing into question the seemingly obvious link between stringent regulation and higher production costs. The first is McAusland's paper "Environmental Regulation as Export Promotion: Product Standards for Dirty Intermediate Goods" and the second is Golombek and Hoel's paper "Unilateral Emission Reductions and Cross-Country Technology Spillovers." In both papers, tighter regulation leads to productivity gains because regulation plays two roles in the model: on the one hand it raises costs and deters polluting activity; on the other hand it partially corrects an existing distortion that is reducing productivity. To break the direct regulation-to-cost link in the pollution haven chain, both authors adopt assumptions to ensure the second role outweighs the first.[6] In McAusland's

[6]It is also possible to generate the counter-intuitive result that tighter regulation lowers the relative price of dirty goods by judicious choice of assumptions in a multi-sector general equilibrium model.

paper, an intermediate input is produced with an increasing returns to scale technology. It is this pre-existing distortion that allows for her paradoxical results. In Golombek and Hoel's paper, R&D spills over across countries. Firms are not compensated for the knowledge spillovers, and we again have an existing distortion.

McAusland's paper sets out a partial equilibrium model of trade in both final and intermediate goods. The intermediate good is produced under increasing returns, and it is sold to Home and Foreign producers of the final good. The intermediate good can be produced using various emission intensities, but the dirtier the intermediate good the greater is its productivity in final goods production. Governments in the two countries set product standards limiting the emission intensity of the intermediate good used by its domestic final good producing firms. The main result of the paper is that a tightening of standards in the high standard Home country can raise the rents earned by Home firms, increase the use of intermediate goods by final goods producers, and raise the output of the final good as well. A further surprise is also offered: McAusland shows that pollution emissions may rise in the high standard country as it raises its standard.

These results follow from the interaction between market size and increasing returns. When the high standard Home country represents a large market for the intermediate good, a tightening of regulation in Home ensures that firms in the low standard Foreign country face a dilemma. On the one hand, foreign firms could comply with the less-stringent Foreign product standards and use a dirty and highly productive intermediate input. The problem with this option is that this intermediate will be relatively expensive to produce because Foreign demand is small. Alternatively, foreign firms could use the same intermediate input as the Home firms. This input is clean but less productive in final good production. The only benefit to using the clean intermediate is that it will be relatively cheap, since Home demand is large, and production is subject to increasing returns. McAusland shows that as long as the high standard country has a sufficiently large market share, then the least cost solution for Foreign firms is to use the clean input.

To generate a comparative advantage for firms in the Home country, McAusland assumes Foreign productivity falls quite quickly with increasingly clean intermediate inputs. As a consequence, a tightening of Home's standards raises Foreign production costs relatively more than Home's. Even though foreign firms "voluntarily" use the clean intermediate, they suffer disproportionately. With this assumption in place, tighter standards at Home shift world demand towards its firms and enhance its exports. If the shift is large enough, overall pollution rises in the high standard country even though its regulation tightens.

This paper is a very clever piece of applied theory. It generates two results that are counter to conventional wisdom in a setting that is not obviously strained. The results provide a theoretical argument for what some have called the "California effect." The "California effect" is the assertion that by virtue of its large market size, California has been able to export its higher product standards elsewhere, and this may have produced competitive benefits for (local) firms who are best able to meet these standards.

In "Unilateral Emission Reductions and Cross-Country Technology Spillovers" GH

employ another mechanism to provide surprising results from tightened regulation. Two active countries choose both abatement and R&D expenditures to minimize the sum of environmental damage and conventional costs. Pollution is global. Abatement expenditures lower emissions directly, while R&D expenditures make abatement less costly. The authors' main result is that a shock leading to an increase in Home country abatement may lead to a complementary increase in Foreign country abatement. In a typical public goods framework with increasing marginal damages, an increase in abatement by Home should be met with a decrease in abatement by Foreign. Working against this free riding motive is the impact of R&D spillovers, which increase Foreign's incentive to abate. Given two potentially offsetting effects, it is now a horse race: whether abatement rises or falls depends on model-specific features. The main contribution of GH is to specify when the typical free-rider motive can be overwhelmed.[7]

This paper makes several contributions by examining a potentially important link between regulation and abatement costs. The Pollution Haven Hypothesis is predicated on an asymmetry in regulation and hence environmental control costs across countries. If technological knowledge concerning abatement spills across countries, as GH assume, then differences in stringency will lead to smaller differences in control costs than standard theory predicts. It also demonstrates how additional channels of adjustment - in this case enhanced R&D and technological spillovers - may undo the seemingly obvious and direct free riding effect. The free riding motive is a partial effect arising from the fall in Home emissions, lowering marginal damage. A similar logic is at work in several contributions in this volume, where the seemingly obvious and direct pollution haven effect can be overwhelmed by other motivations for trade.

At a broad level, both the McAusland and GH paper owe their surprising results to increasing returns. This is obvious in the McAusland paper, but is also true in the GH paper. Knowledge spillovers can only occur if knowledge is nonrival. Nonrivaly implies increasing returns. While it is often true that adding increasing returns to a model will produce different and sometimes paradoxical results, increasing returns may be an important feature of many polluting industries. It is well known that the distribution of pollution emissions across U.S. industries is highly concentrated: a handful of very dirty industries produce the lion's share of emissions. I would conjecture that these same heavy industries are also very concentrated, R&D intensive, and employ increasing returns to scale technologies. If this conjecture is true, then the results of these authors suggest we re-examine some of the basic pollution haven linkages within an increasing returns setting.

2.3 The Link from Production Costs to Trade or Investment Flows

This volume contains several papers presenting evidence on the importance of regulatory costs in determining either foreign direct investment or trade flows. While the costs

[7] Heal (1994) and Copeland and Taylor (2005) also demonstrate how the free rider effect can be overwhelmed by other forces.

of meeting regulation are surely important, it has long been recognized that any empirical test of the PHH must also account for other determinants of comparative advantage. The existing empirical literature linking production costs to trade flows is both large and heterogenous in terms of its results. A key early finding was that measures of environmental control costs had either no effect or often a paradoxical positive effect on a country's net exports.[8] In many cases, the small and sometimes perversely signed coefficient estimates were taken as evidence of the irrelevance of regulation in determining costs. These early studies failed to find a "pollution haven" effect, and then they employed the necessity of a pollution haven effect to argue against acceptance of the PHH.

In the late 1990's, a series of empirical studies started to overturn these results by taking explicit account of the endogeneity of regulation.[9] Since then the literature has employed a series of new estimators (such as fixed effects, instrumental variable estimators or matching estimators) and now consistently finds a negative relationship between many measures of industry health such as plant births, production and exports and measures of environmental control costs. Therefore, we now have ample evidence for a "pollution haven effect", but still little direct evidence for or against the PHH. Antweiler et al. (2001) presented evidence on the PHH, but this evidence comes from an inference linking trade liberalization to changes in pollution concentrations and not from a direct observation on trade flows. In contrast, the contribution by Ederington, Levinson and Minier (ELM) "Trade Liberalization and Pollution Havens" directly addresses the PHH by employing trade data.

ELM examine U.S. manufacturing data over the 1972-1994 period to investigate the extent to which large tariff reductions undertaken over this period have impacted production and trade flows in a manner consistent with the PHH. The paper argues that finding a negative impact of regulation on trade flows does not, in and of itself, provide support for the PHH. Instead, ELM argue that evidence for the PHH has to come from an observation that trade liberalization led the US to produce cleaner goods while replacing its dirty good production with imports from other countries. That is, the U.S. must have a demonstrated comparative advantage in clean goods for the hypothesis to hold. This is in effect the argument of Antweiler et al. (2001), although the data and methods used by ELM are very different. ELM's major contribution is to use trade data directly to investigate the PHH.

ELM examine the pollution intensity of U.S. imports, exports and production over the 1972-1994 period. To do so, they employ pollution intensity coefficients developed by the World Bank to calculate the implied pollution emissions created by U.S. production, imports and exports in manufacturing industries at the 4-digit level. The results are striking. ELM first document how U.S. manufacturing production has become cleaner over time. While overall manufactures grew by 57% over the period, the emissions of

[8] For reviews of the empirical literature, see Dean (1992), Levinson (1996), and Copeland and Taylor (2004).

[9] Becker and Henderson (2000) is perhaps the most well known of these studies.

various pollutants grew by much less. At first blush this appears to support the PHH, since the authors find US production is moving towards cleaner industries as the PHH would predict. When the authors examine import and export flows, however, they find evidence against the hypothesis. While import volumes surged over the period, growing on the order of 344%, the composition of these imports shifted towards cleaner industries as well. The pollution content of imports grew by amounts typically less than 1/3 of the change in the value of imports. If the PHH held, U.S. imports should be getting dirtier and not cleaner over time as U.S. trade was liberalized. When ELM examine U.S. exports, they find that while exports became cleaner over time, the implied pollution emissions of U.S. exports fell relatively little over this period. While U.S. exports grew by 268% over the period, the pollution content of exports also grew by over 200% for most pollutants. In total, ELM find the underlying trend is towards cleaner industries over time in U.S. production, imports and exports. This trend is greatest in U.S. imports and least in U.S. exports. ELM suggest that U.S. comparative advantage lies not in clean industries, but instead in dirty ones, and hence other determinants of comparative advantage have proven to be more important determinants of trade flows than the relatively stringent U.S. regulation.

These inferences and evidence come from simple graphs and tables documenting the pollution content of production and trade flows. To go further, the authors employ a regression framework explaining U.S. gross imports in manufacturing as a function of industry attributes, pollution abatement costs, and tariffs. The authors argue that a finding in favor of the PHH requires that imports rise most in industries with above average pollution control costs when the U.S. undergoes a trade liberalization. Recall this is the composition effect that played such a large role in the results of CT (1994). The results from the ELM regression analysis supports their earlier inferences: they find no evidence that trade liberalization has led to large impacts on dirty industries - in fact, their results are just the opposite.

A more aggregate approach to testing the PHH is given by Kahn and Yoshino's (KY) contribution "Testing for Pollution Havens Inside and Outside of Regional Trading Blocs". The authors start with a very clever way to test the PHH. Since the PHH is a statement relating trade flows to country characteristics, the authors employ variation across countries in their membership to regional trade agreements to proxy for a measure of openness to trade. In theory, countries in trading agreements have lower tariffs, all else equal, and hence this variation in their exposure to world markets coupled with knowledge of country characteristics may allow us to estimate the strength of pollution haven motives for trade.

While using this source of variation is ingenious, the authors face several obstacles in their implementation. The most important obstacle may be that membership in a trade agreement is not exogenous and instead is linked with country characteristics that also determine environmental policy. While the authors find that the pollution intensity of trade flows does vary across countries according to their trade agreement membership, these differences are not uniform across country type and escape easy explanation.

The next two studies test the PHH by examining the strength of pollution haven effects, and in particular how their strength varies across industries. In "Environmental Regulation and International Trade: Empirical Results for Germany, the Netherlands and the US, 1977-1992", the authors Mulatu, Florax and Withagen (MFW) take a slightly different approach to testing the PHH. They start by noting that the standard linear regression model of net exports against industry characteristics and pollution costs does not allow the impact of regulatory costs to vary across industries differentiated by either their pollution or natural resource intensity. Recall that regulation must in fact have a differential effect at channel (b) in Figure 1 in order for it to affect relative prices, comparative advantage, and trade flows. The magnitude of the pollution haven effect should vary across industries.

The authors argue that the impact of tighter regulation on trade flows may be greater in polluting industries that are footloose, labor intensive, and located in countries that are scarce in low skill labor. Alternatively, the impact of regulation may be less severe in industries tied to their current location because of their natural resource intensity. To test this thesis, MFW employ a new dataset on 2-digit industry trade flows from the US, Germany and the Netherlands. The authors amend the typical linear regression model of net exports on factor shares to allow the impact of regulation to vary across both industry group and reliance on natural resources. Their empirical results are somewhat mixed. On the plus side, the authors find ample evidence that the impact of regulation varies across industries. Less satisfactory is their finding that the estimated coefficients on control costs often have paradoxical signs. Overall their results suggest empirical work should take serious account of how regulatory effects differ across industries, although finding consistent and meaningful differences appears to be a difficult task.

Cross-industry differences in regulatory impact also play a large role in Javorcik and Wei's (JW) contribution "Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth". The authors examine the determinants of foreign direct investment into 25 transition economies in Eastern Europe and the former Soviet Union, and similar to MFW look for a differential effect of regulation across industries that vary in their pollution intensity. The study is novel in a number of ways. The authors obtain firm-level data from 143 firms who invested or had planned investments as of 1995. This rich data set allows JW to control for firm-specific attributes that may have a bearing on their propensity to invest. The empirical specification is a probit model with the dependent variable taking on a value of one if the firm had planned or undertaken investments in the region. The controls include firm-specific attributes such as size, experience in the region and R&D intensity, and host country controls such as openness, democracy, and tax rates. To investigate how sensitive FDI is to host country regulations, the authors construct two pollution haven variables. One is an indicator variable proxying for the stringency of host country regulation, and the other is an interaction of this first stringency variable with a variable proxying for the pollution intensity of the industry.

The authors find that many of the firm and country-specific variables enter significantly in all (or almost all) specifications, but the sign and significance level of the two

pollution haven variables varies across specifications. In many specifications, the indicator variable for the host country's overall environmental stringency enters negatively and significantly, suggesting that FDI is deterred by tight environmental standards. In contrast, in most specifications, the interaction of this term with the industry's pollution intensity is neither significant nor uniformly signed. However, one result is robust: foreign direct investment appears to be attracted to relatively clean industries in their sample. The authors argue that they find little evidence in favor of the pollution haven hypothesis.

While I agree with the authors' conclusions, my interpretation of their results is slightly different. Tests on the sign and significance of the regulation co-variates are tests for a pollution haven effect and not a test of the PHH *per se*. The tests are akin to those conducted using trade data (as with ELM and MFW discussed above), where researchers are looking for a responsiveness of trade flows to variation in regulation. Here the variation is in FDI flows, but the logic is the same. The authors find significant deterrent effects from overall stringency, and this is evidence for a pollution haven effect. In theory it could be argued that the authors' failure to find a consistent and meaningful differential impact of regulation across industries is a rejection of the PHH, although this seems a bit extreme. For many reasons we may not be able to pick up the differential impact of regulation across industries. It may therefore have proven useful to include other industry-specific controls in their specification, to ensure that the failure to find a strong cross-industry impact is not due to other confounding factors.

Putting these three studies together, it is clear that we still have some way to go before we fully understand the determinants of trade in dirty goods. The studies by JW and MFW find empirical support for a pollution haven effect, although neither is completely successful in demonstrating that the impact of regulation varies across industries. While this is partial evidence against the PHH, it may of course reflect our inability to identify these cross-industry effects using current methods and data. At present, I would argue that failure to find a strong across-industry effect is not sufficient reason to reject the PHH. The evidence presented by both KY and ELM are directly relevant to testing the PHH, but both leave some questions unanswered. ELM is based solely on US trade flows, and underlying concerns are the endogeneity of the US trade liberalization under study and the possibility that other processes (such as growth or industrial restructuring) are responsible for their results. The work of KY is broad in cross-country coverage, but its conclusions are tentative and sometimes defy easy explanation. Here too an issue regarding endogeneity is created by the country's choice to join a free trade agreement.

While these studies represent real progress, endogeneity issues remain a concern. Testing the pollution haven hypothesis is an exercise in policy evaluation. We are trying to compare what we observe in the world regarding trade flows or pollution levels under one set of trade and pollution policies, with the unobserved counterfactual created when these policies are different. The key empirical problem is that we do not observe the counterfactual. Instead, we observe trade or investment flows under a certain state of the world X (with free trade or lower tariffs), but then wish to make statements about what would have occurred in another state Y (autarky, or higher tariffs, etc.). This observation

and many others are made in the valuable contribution by List, Millimet and McHone (LMM) entitled "The Unintended Disincentive of the Clean Air Act".

The paper sets out a problem in policy evaluation. In the U.S., the Clean Air Act requires existing plants undergoing modifications comply with the New Source Review Requirements (NSR). These requirements offer very asymmetric and strange incentives for plant owners. If a modification to the plant is undertaken, not only must the new modification meet tighter environmental standards but so too must all of the remaining plant that was not modified. This all-or-nothing flavor to the regulation provides a disincentive for plants to undergo any modification or to delay closure, but measuring the size of the disincentive is not easy.

The empirical problem is to determine how the rate of plant modification was altered by NSR - that is, we would like to know what would have happened to plant modifications had NSR not been in place. To solve this problem, the authors employ a matching estimator drawn from the statistics literature. The estimator in essence constructs the counterfactual by matching each plant in a region where meeting NSR is very expensive with a set of plants in regions where meeting NSR is far less expensive. This across-region variation is then used to identify the impact of NSR on the rate of plant modifications. The regions are non-attainment counties and attainment counties in New York State.

The match across plants is made on a wide set of observable plant characteristics, but it leaves open the question of whether plants matched on observables are truly equivalent. To account for the possible impact of unobservables that may be affecting the rate of modification, the authors use another source of variation in their data: the variation across dirty and clean industries in plant modifications and closures. The idea here is simply that if the matching estimator finds a treatment effect by matching dirty plants in region (or time period) X and Y, some of this treatment effect may arise from region - or time - specific unobservables driving modifications in region (or time period) X. The authors surmount this problem by redoing the matching exercise using only plants from clean industries. Since the rate of modification in clean plants should be unaffected by NSR, any treatment effect we find across region (or time period) X and Y for clean industries can now be attributed to the impact of unobservables. If we difference out this unobservable effect, we obtain a true estimate of the treatment effect.

The paper very convincingly estimates an impact of tighter regulation on plant modification rates. As such it provides further confirmation that regulation is not irrelevant to economic activity, whether it be plant modifications, plant closures, or FDI. I take this as very strong evidence of a pollution haven effect. As well, the estimated impact of regulation is quite large, which suggests we cannot reject the PHH out of hand. Using their matching estimator, the authors find on average that three plants per non-attainment county forego modification because of NSR. Since an average county has one modification per year, this is a sizeable deterrent effect. This suggests that regulatory differences can create large impacts on behavior, although we should be careful in extending this within-country finding to an across-country setting too quickly.

2.4 Feedback Effects from Pollution, Prices and Incomes

Most general equilibrium models of pollution and trade contain an immediate and obvious feedback from trade flows to policy making. This can occur through many channels. In CT (1994) for example, the Samuelson rule makes the optimal provision of "pollution" a function of relative prices and incomes, and both of these change in the movement from autarky to trade. In other cases, trade may bring new information about trading partners or enlarge the set of issues that countries negotiate, and this may affect equilibrium pollution levels. Finally, international trade affects the incentive to accumulate capital, knowledge, or new technology, and these decisions will in turn affect policy choices even if in the distant future. This volume contains three papers where feedback effects play a major role.

In Di Maria and Smulders' (DS) contribution "Trade Pessimists vs. Technology Optimists: Induced Technical Change and Pollution Havens", the authors focus on the impact trade has on innovation and pollution levels. DS build a North-South model with trade in the two intermediate goods. The intermediates are produced from a set of differentiated capital goods (machines) and a primary factor. All innovation occurs in the North, while a fraction of innovations diffuse to the South. The authors focus on the balanced growth path throughout.

These authors show that international trade has two effects on pollution levels. The usual pollution haven effect is created when the Southern country specializes in production of the dirty intermediate, but a second effect is created when trade alters the allocation of R&D across industries and thereby alters abatement costs. The authors refer to this second effect as the technology effect.

When the authors combine these two potentially offsetting forces, they find pollution may not rise in the South even when it specializes in dirty goods. The authors are quite successful in linking this result to just two features of their framework: the initial determinants of comparative advantage and the substitutability of Northern and Southern products. Surprisingly, and in contrast to most models with feedback effects, the potential long run impact of trade on pollution is not just to dampen the short run response but to change it qualitatively.

This paper is important because it reminds us that by ignoring the impact of trade on long run accumulation processes - like innovation - we can be missing important possibilities. But it also warns us against hailing new technologies as a fix for all environmental problems, as progress in their model is not always environmentally friendly. Overall, the paper suggests we take a closer look at how the PHH is affected by the dynamic processes driving trade, innovation, and pollution levels.

Hilary Sigman's contribution "Does Trade Promote Environmental Coordination: Pollution in International Rivers" also examines a feedback effect from trade to environmental policy, but this time the goal is to estimate its magnitude. Sigman's analysis uses data on national and international river quality to ask whether greater trade contacts lead to environmental cooperation. The possibility of greater coordination and cooperation

because of trading ties is a potential benefit that is rarely incorporated into theoretical analyses. While theorists could think of many reasons why "multi-market" contact may be beneficial, the empirical challenge in this paper is to identify a possible positive impact on rivers crossing country borders. Sigman's empirical work is supportive of a positive link between greater trade and improved river quality. For example, she finds that greater trade intensity between countries leads to lower levels of biological oxygen demand (BOD) measures on their international river.

This paper is novel in arguing for a link between contact in the trade sphere and cooperation over environmental issues. While the empirical results are supportive of such a link, it is difficult to pin down the causal mechanism. Is it because numerous bilateral contacts reduce the transaction costs in other negotiations over river quality? Or is it because countries have other bilateral frictions that can be traded off in these negotiations?

Finally, in "Cross-Country Policy Harmonization with Rent-Seeking", Patrik Hultberg and Edward Barbier (HB) examine an extreme form of feedback from trade flows to policy making. The authors focus on the growing sentiment in the policy community that trade and environment policy should be linked and perhaps harmonized. Harmonization of policies is often put forward as a defense against a pollution-haven-driven pattern of trade. The authors' contribution is to show that harmonization may in some cases be Pareto improving. They develop a two-country, two-firm reciprocal markets model to investigate the impact of harmonization in emission taxes. The countries differ in their disutility of pollution and in the extent to which firms can lobby the government to relax regulation. Harmonization upwards to the high-standard country necessarily benefits the high-standard country as it puts foreign firms at a competitive disadvantage in goods markets. The low-standard country can also gain (when corruption exists) because harmonization acts as a credible commitment not to bow to the pressure of lobbies.

This is an interesting paper on an important policy issue directly related to the PHH. Calls for harmonization are almost always based on the fear of industrial flight and on an acceptance of the PHH. Since many of the studies in this volume have shown that evidence for the PHH is difficult to find, calls for harmonization across very heterogenous countries cannot be based on evidence for the PHH.

3. Summary and Conclusion

The debate over trade liberalization and the environment will be going on for some time. As the world's population grows, and trade expands, future trade and environment conflicts will arise. This is, in some sense, natural. As economists, we recognize that trade-offs are involved in any decision, and that the decision to enter into a trading arrangement will require adjustment and change in many industries. Some of these changes will bring environmental consequences, and some of these consequences will be negative. No amount of research on the Pollution Haven Hypothesis will remove this conclusion,

but research - such as that produced in this volume - can identify the trade-offs involved and help us estimate the magnitude of costs and benefits.

In total, the contributions in this volume contain three important messages. The first message is that environmental regulation matters to production and trade flows. Several studies produced empirical evidence of a "pollution haven effect" on both trade and investment flows. Since the existence of a pollution haven effect is a necessary condition for the PHH, this evidence rules out a quick rejection of the PHH. Some researchers have gone further, to argue that the PHH also requires the impact of regulation to differ across industries. Going one step further, they conclude that failure to find important or consistent differences across industries should be taken as evidence against the PHH. In theory this is correct: the PHH is built on the supposition that regulation affects industries differently. This is necessary for regulation to affect comparative advantage and trade flows (recall channel (b) in Figure 1). However, failure to find important differences across industries could come from many sources, and it is premature to reject the PHH on these grounds. This is especially true given the magnitude of regulatory effects found in several of the contributions. Regulatory effects are not only present, they are quite large. Therefore, work remains to be done in testing the PHH.

The second message is related to the first. Regulatory effects are important, but trade in dirty goods is also affected by a host of other factors: capital abundance, industry factor intensities, the quality of governance as measured by corruption, and other political economy determinants. Since many factors jointly determine trade flows, this finding demonstrates how important it is to distinguish between the finding of a "pollution haven effect" and a finding in support of the PHH. Given the evidence presented in this volume for pollution haven effects, future work will now need to focus on weighing the relative strength of different motives for trade in dirty goods. Antweiler et al. (2001) provides one method for doing so, but in this volume, ELM provide another more direct approach.

This type of weighing exercise is important, because even if we find that regulation has a large impact on plant-level investment (such as in LMM), we cannot conclude that trade between a tightly regulated country like the U.S. and a poorly regulated country like Mexico will generate a pollution haven pattern of trade. While it is reasonable to assume that skilled labor and capital are fairly mobile across US counties and US states, so that large differences in regulations across U.S. states may translate into large shifts in the location of production, we should not extend this conclusion to shifts of production across countries differentiated far more starkly in endowments, technologies, and resources. While studies based on U.S. data provide us with some of the most convincing evidence for a regulatory impact on economic activity - i.e., a pollution haven effect - convincing evidence for or against the PHH must employ international data.

Unfortunately, weighing all of the many relevant factors is not easy. In fact, no study in the literature provides a compelling many-country test of the PHH, and I know of no theory paper that details what such a test would look like. Future theoretical work in this area should provide such a test. But even when theorists do provide us with the necessary guidance, empirical work will remain hobbled by data constraints.

While I cannot judge exactly what data a formal multicountry test may require (since it does not yet exist!), I suspect that a fully convincing test of the hypothesis requires data on both home and partner country factor endowments and regulations (to weigh various motives for trade), trade flows, aggregate information on rest-of-world policy, and factor endowment variables (to ensure third country effects are accounted for), together with a source of exogenous variation in trade policy. The challenge for theorists is to show how these many factors interact to determine the pollution intensity of trade flows; the challenge for empiricists is to develop clever methods that eliminate the need for at least some of the data listed above. It is a cruel feature of the world that those countries where we may find the strongest evidence for the PHH typically have data of the poorest quality.

The third message I take from this volume is that the relationship between trade, technology and the environment is not well understood but potentially very important. Four contributions in this volume delivered surprising results from "technology effects." In two contributions, trade liberalization created changes in the set of technologies employed while increasing openness to international markets. In both cases, the induced technology effects produced results opposite to those expected in a pollution haven model (recall RG and DS). In two other contributions, increasing returns technologies interacted with other market features to produce another set of surprising results again at odds with conventional wisdom. Perhaps we have placed too much emphasis on the relative price component of trade liberalization, and too little on how openness to world markets affects knowledge accumulation and technology choice. At present we have very little empirical evidence linking openness to markets, pollution levels, and technology choice. This is surprising, because it is widely believed that technology transfer to poor developing countries will help them limit their pollution regardless of the stringency of their pollution policy or their income levels. If the diffusion of clean technologies is accelerating as a result of globalization, this indirect impact of trade may well become the most important for environments in the developing world.

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