Policy Endogeneity and the Effects of Trade on the Environment

Brian R. Copeland

This paper reviews recent work on the implications of endogenous policy for the effects of trade on the environment and the sustainability of renewable resource stocks. A recognition that pollution policy is endogenous has had a major impact on the trade and environment literature and has reversed some of the previously established empirical findings. Work on pollution has proceeded faster than work on renewable resources. I suggest some directions for future work in this area.

Key Words: pollution, international trade and the environment, renewable resources, globalization

The central question underlying much of the recent work on trade and the environment is how globalization affects environmental quality and the sustainability of renewable resources. The work that attempts to answer this question can be divided into two very broad categories. One approach is to give answers contingent on the policy regime. For example, if agriculture is intensive in the use of pesticides, and if regulations restrict the amount of pesticide use per hectare of land, then if environmental policy is left unchanged, we might predict that trade liberalization that leads to an expansion of agriculture will increase water pollution because of increased pesticide use. Another approach is to treat the policy regime as endogenous. That is, the policy regime is treated as responsive to economic factors such as income and relative prices. Whether or not an expansion of agricultural output increased pollution would then depend on whether or not environmental regulations were tightened up in response to increased pressure on the environment.

While predictions contingent on the policy regime are useful and are crucial inputs in domestic policy analysis, there are many cases where ignoring the potential effects of globalization on the policy regime may be very misleading. For example, many common property resources in poorer countries are managed using traditional norms and mechanisms based on a stable social structure. If globalization disrupts these practices, then the management regime may collapse, leading to much more adverse environmental consequences than might have been predicted based on the pre-trade management regime. In the context of transboundary or global pollution, attention to endogenous policy responses is critical because of concerns about leakage: the benefits of emission reductions by one group of countries may be undermined if other countries increase their emissions in response. Endogeneity is also important in the empirical literature. If policy is endogenous, then empirical work investigating the effects of environmental policy on trade and investment flows will give biased results if policy is treated as exogenous. Finally, and perhaps most obviously, concerns that trade liberalization may lead to a "race to the bottom" in environmental policy can be addressed only in a framework where policy is endogenous.

This paper reviews some recent work that explores the implications of endogenous policy responses for the effects of trade on the environment. The literature on endogenous policy responses in the context of pollution is much more extensive than that for renewable resources. I therefore begin by reviewing some of the recent work on pollution. I briefly discuss several ways

Brian R. Copeland is Professor, Department of Economics, University of British Columbia, Vancouver.

This paper was presented as an invited paper at the International Trade and the Environment Workshop sponsored by the Northeastern Agricultural and Resource Economics Association and the U.S. Environmental Protection Agency, National Center for Environmental Economics, in Halifax, Nova Scotia, on June 23, 2004. The views expressed in this paper are those of the author's and do not necessarily represent those of the U.S. Environmental Protection Agency.

in which a focus on endogenous policy has led to new insights. Part of my objective here is to suggest that the payoff to focusing on endogenous policy is high. I then look at some of the recent work on renewable resources, where there has to date been very little work on models with endogenous policy. As this work is still very much in its formative stages, I focus in some depth on three different approaches to modeling endogenous management regimes, and suggest some directions for future work in this area.

Trade and Pollution

A central theme underlying both policy debates and analytical work on trade and the environment has been the role of income effects in affecting both the demand for environmental quality and policy outcomes.

The pollution haven hypothesis proposes that trade liberalization will shift pollution-intensive production to low income countries because of their relatively weaker environmental policy. In the first wave of work on this issue, it simply was assumed that poor countries had weaker environmental policy than rich countries (see for example Pethig 1976 and Chichilnisky 1994); however, subsequent work (Copeland and Taylor 1994, 2003) studied models in which pollution haven effects emerged in models with endogenous policy—in these models, environmental managers in poorer countries choose relatively weaker environmental regulations than do those in rich countries.

Income effects are also central to analysis of the environmental Kuznets curve—the relation between pollution and per capita income. One of the leading explanations for the improvement in environmental quality in rich countries is that environmental quality is a normal good, and so governments who are responsive to consumers regulate pollution more intensively in higher income countries.

There is some evidence to support income effects. Dasgupta et al. (1995) develop an index of environmental policy and performance based on a survey of governments prepared for the United Nations Conference on Environment and Development. Their index is highly correlated with income, with high income countries having more effective policy. In a study of a specific pollutant—lead content in gasoline—Hilton and Levinson (1998) found that the lead content was strongly inversely correlated with national per capita income, a result that they interpret as a reflection of policy differences across countries. Pargal and Wheeler (1996) in their study of Indonesia find that the effectiveness of informal approaches in influencing environmental quality (such as community pressure) are positively correlated with income. This suggests that the income effect need not rely on a formal government regulatory agency to be effective. Finally, there are a variety of micro-level studies, albeit mostly from high income countries, that suggest that the willingness to pay for environmental amenities is positively correlated with income (see for example Kriström and Riera 1996 and Hokby and Soderqvist 2003).

Income effects are important in the study of the effects of trade on the environment because the motivation for trade liberalization is usually to increase real income in a country. However, where there are income effects, there are typically substitution effects as well. And since trade liberalization changes relative prices, we should expect both income and substitution effects to play an important role in determining the responsiveness of environmental policy to trade liberalization. Consequently, a model is needed to keep track of these different effects.

Two types of models of endogenous environmental policy have dominated the literature on pollution and trade: representative agent models, and political economy models. These two approaches share a common thread, since in most political economy models, governments must weigh the general public interest against interest groups. Consequently, in both types of models, if environmental quality is a normal good, higher average per capita income typically leads to more stringent environmental policy. However, in political economy models, distribution and interest group effects may work against this effect.

Income Effects and the Effect of Trade on the Environment

To illustrate briefly how income effects influence the predicted effects of trade and the environment, consider a country that exports pollution-intensive goods. Figure 1 illustrates the supply and demand for emissions. Emissions are on the

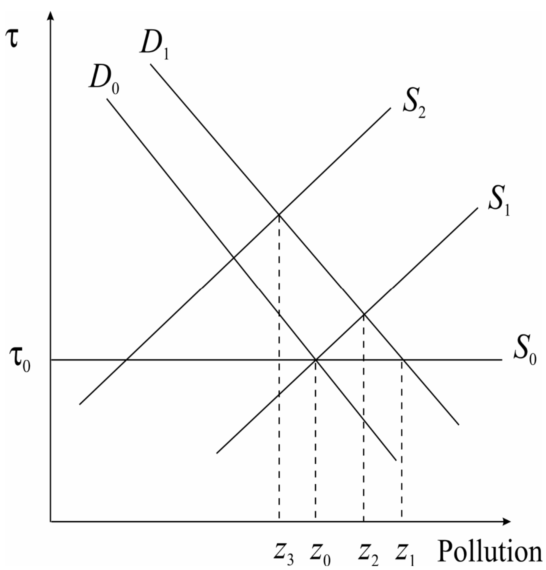

Figure 1. Effect of Trade on Pollution for an Exporter of Pollution-Intensive Goods

horizontal axis, and for simplicity I use a pollution tax on the vertical axis as a proxy for the stringency of environmental policy. The initial demand for emissions is D_0. This is a derived demand, reflecting emission of pollution as a side effect of production. With a lower pollution tax (or implicit cost of emitting), the economy emits more pollution. The pollution supply curve captures the country's willingness to allow emissions as reflected by the policy regime. Several supply curves are illustrated, corresponding to different policy regimes.

First, suppose there is a fixed pollution tax (similar results are obtained with a fixed emission intensity). The supply curve is then S_0. Trade liberalization will stimulate the export sector, and since it is pollution-intensive, this shifts out the demand for emissions. With a fixed emissions tax, emissions rise to z_1. With fixed emissions taxes (or fixed emission intensities), the effects of trade on the environment can be estimated by predicting the effects of trade on outputs.

Next, suppose that the pollution supply curve is given by S_1. In this case, the government tightens up policy as more pressure is placed on the environment. A trade-induced outward shift of pollution demand will still raise pollution to z_2, but the endogenous policy response dampens the increase.

Finally, suppose that the pollution supply curve is income-responsive. Since environmental quality is a normal good, we expect the demand for environmental quality to rise with income. Since trade liberalization will typically increase per capita income, this suggests that the pollution supply curve will shift back and to the left if the policymaker is responsive to consumer preferences. The amount by which the supply curve shifts back depends on income and substitution effects. With a sufficiently strong income effect, the new supply curve will be S_2, leading to a *fall* in pollution from trade liberalization despite the country having a comparative advantage in the dirty goods.

What is a strong income effect? In a simple model, Copeland and Taylor (2003) show that if the income elasticity of marginal damage is less than or equal to one, then the income effect is not strong enough to offset the increased demand for the right to pollute. Intuitively, if the income elasticity of marginal damage is one, the policy response exactly offsets the scale effects of economic growth. That is, in this case neutral growth has no effect on pollution. However, trade liberalization is not neutral—it also changes the composition of a country's production. For an exporter of pollution-intensive goods, the composition effect tends to increase pollution. This additional composition effect over and above the increase in the scale of production of the economy tends to increase pollution unless the income elasticity of marginal damage is sufficiently large.

Overall, we see that both the quantitative and qualitative effect of trade liberalization on environmental quality depend on the policy response. To determine the effects of trade on the environment we need to know not just the shift in pollution demand, but both the slope and shift in the pollution supply curve.

Political Economy, Dampening Effects, and Tariff Substitution

Suppose now that the government is responsive to interest group pressure. Then pollution policy will depend on factors such as how corrupt the government is, and how strong different interest groups are in the economy. One of the key questions that has been investigated with such models is how pollution policy responds to trade liberalization.

One way to think about this is to consider that weak pollution policy is similar to a production subsidy. Consequently, if an import-competing sector loses trade protection, it will ask the government for other forms of protection; and a weakening of environmental policy is one way to achieve this. Bommer and Schulze (1999) use a political economy model to show that pollution policy becomes weaker when trade is liberalized if the import-competing sector is pollution-intensive. This result is an example of *tariff substitution.* The idea is that trade agreements create incentives for governments to use domestic policy instruments to act as substitutes for trade barriers. Another implication of this line of work is that endogenous policy responses will dampen the effects of trade liberalization on both pollution and production patterns.

However, there is another possibility, as shown by Damania, Fredriksson, and List (2003). They use a Grossman-Helpman (1994) framework in which a corrupt government elicits bribes from producers to provide favorable policy. In their model, tariffs are exogenous, so polluting industry bribes the government to provide weak environmental policy. When trade is liberalized, the industry contracts and becomes less profitable. It is therefore less able to afford bribes, and so the government tightens up pollution policy. The predictions of this model are opposite those of the previous model. The difference is that trade policy is endogenous in the former and exogenous in the latter model. When trade policy is endogenous, governments prefer to protect polluters with tariffs than with weak pollution policy because it imposes less cost on consumers (see Schleich 1999 for a nice exposition of this point). Consequently, a trade agreement that removes tariffs as a potential instrument from governments results in tariff substitution. However, if tariffs are exogenous, the only instrument available to governments both before and after trade liberalization is the pollution policy (these models are restricted to two instruments), and so tariff substitution does not arise.

These are two competing hypotheses that could be tested empirically. So far there is very little evidence available, and that which we have is conflicting. Eliste and Fredriksson (2002) use data on trade liberalization in U.S. agriculture and find evidence of tariff substitution. Ederington and Minier (2003) use panel data on U.S. imports and find that industries with higher import levels are likely to have weaker environmental policy, a result which suggests that environmental policy is sensitive to foreign competition. However, Damania, Fredriksson, and List (2003) use a panel of data on the lead content of gasoline for 48 countries and find that openness tends to lead to more stringent environmental policy in more corrupt countries. This can be interpreted as evidence against tariff substitution. Given the conflicting results in this literature and its relevance to the debate on whether or not trade liberalization leads to a "race to the bottom" in environmental policy, there is potential to do much more research in this area.

Income Effects and Comparative Advantage

Income effects lead naturally to a theory of pollution havens. Consider two countries, North and South. Let X be a good that pollutes when it is produced, and Y be a clean good. The countries differ only in income—North is equiproportionately more productive in both goods. Assume preferences over goods are identical and homothetic, and separable from environmental quality. In Figure 2, I have drawn the relative demand for X. Because of homotheticity, the relative demand curve is the same for both countries. If there is no pollution policy, the relative supply curve is also the same for both countries. This is because the countries are identical except for neutral productivity differences—there is no comparative advantage by assumption.

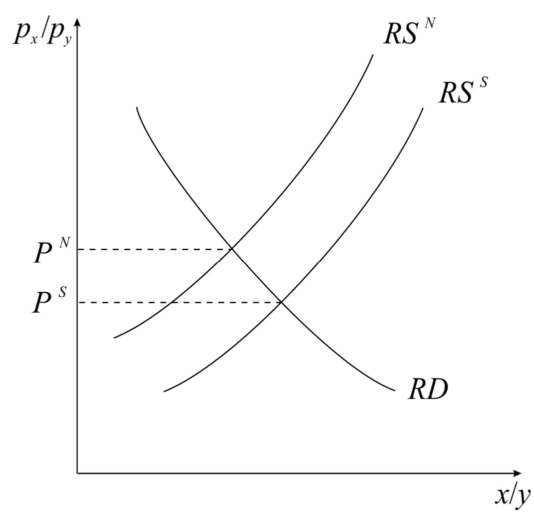

Figure 2. Pollution Haven with Endogenous Policy

Now suppose there is endogenous pollution policy. Then, since North is richer than South because of its superior productivity, North will choose more stringent environmental policy than South. This raises relative costs in the polluting industry and implies that North's relative supply curve will be up and to the left of South's, as illustrated. In the absence of trade, North's relative price of X will be higher than South's, implying that when trade is liberalized, North will have a comparative advantage in the clean good. South becomes a pollution haven—its weak environmental policy attracts dirty good production away from North.

Consider the simple case where the income elasticity of marginal damage is equal to one. This case is of interest, because it implies that neutral economic growth has no effect on pollution. In this case, Copeland and Taylor (1994) show that trade leads to an increase in pollution in South and a fall in pollution in North. That is, trade alters the incidence of pollution, shifting it towards poor countries. Moreover, note that trade shifts pollution-intensive production towards the country with the weakest environmental policy. One can show that this implies that trade can increase world pollution, despite the fact that each country is fully internalizing externalities, and that there is no international externality. What is particularly striking about this example is that neutral economic growth has no effect on global pollution, but trade raises world pollution.

One can, however, turn this example around, by noting that trade is driven by more than just environmental policy. If the polluting good is also capital-intensive, and North is capital-abundant, then it is possible that North may export the polluting good if its capital abundance is more important for production costs than is its more stringent environmental policy. In this case, trade would shift the polluting good towards North, and lower world pollution. There have been relatively few attempts to carefully test these alternative hypotheses. Antweiler, Copeland, and Taylor (2001) indirectly test this using data on sulfur dioxide pollution, and find that the evidence is consistent with the latter hypothesis—trade seems to reduce pollution because the richer countries appear to have a comparative advantage in sulfur-dioxide–intensive production. However, there is no reason to expect that this result will be robust across other pollutants, and so more work needs to be done.

Trade and the Convergence of Environmental Policy

Another implication of endogenous environmental policy is that the forces causing trade may not be picked up by empirical work using equilibrium environmental policies.

To illustrate, consider our simple North-South model. Suppose that North's income is higher than South's, but that the difference is not extreme. Suppose that income is the only difference between countries and that initially trade barriers are high. Figure 3 illustrates the pollution supply and demand in each country. The initial pollution demands are D_0 and D^*_0. North initially has a higher pollution tax than South ($\tau_0 > \tau^*_0$); this gives South a comparative advantage in the dirty good. When trade is liberalized, North imports the dirty good, causing its pollution demand curve to shift down to D_1, lowering North's pollution tax. South exports the clean good, shifting out its pollution demand curve and raising its pollution tax.[1] Notice that by taking pressure off North's environment and increasing pressure on South's, trade creates a tendency for pollution regulation to converge. This is the standard factor price equalization result from international trade. Copeland and Taylor (1995) consider a North-South model in which trade leads to complete equalization of the intensity of pollution regulation across countries, even though the only motive for trade in the model is differences in pollution regulation!

This result has important implications for empirical work. In the example above, trade is driven by pollution haven effects, but in equilibrium, the data will not exhibit significant differences in environmental policy. Consequently, differences in environmental regulation may appear not to be a significant variable in affecting trade flows (even though they are in fact the only cause of trade flows in this example). The trade literature on the effects of factor supply differentials on the pattern of trade deals with this issue by not using factor prices as the explanatory variable for trade flows. Instead, measures of relative factor supplies are used. That is, to test the hypothesis that labor-abundant countries export

[1] For simplicity, I have not drawn the shift in supply curves—both are likely to shift up because of the increase in real income induced by trade.

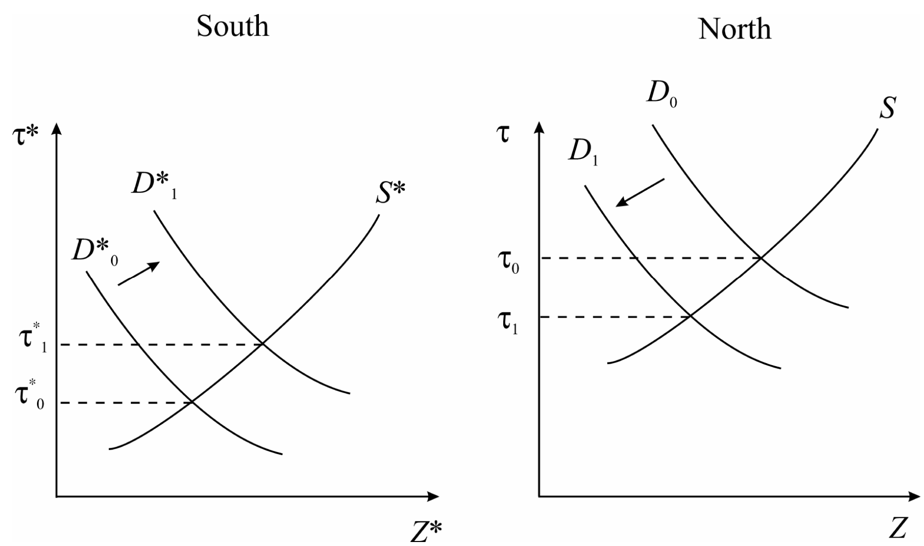

Figure 3. Trade Leads to Convergence of Pollution Policy

labor-intensive goods, data on relative supplies of labor is used rather than data on wage differentials because it is understood that trade will alter these wage differentials. This is problematic for environmental economics, since there it is difficult to find an analogue to relative factor supplies—it is the income differential that makes environmental services an expensive factor in the North. To date, there has been no empirical work that addresses this problem.

Effects of Environmental Policy on Trade Flows

The endogeneity of environmental policy can be critically important in interpreting the effects of environmental policy on trade and investment flows for other reasons as well. To illustrate, suppose that whether a country exports or imports polluting goods depends on an agglomeration effect (which we index by A) that affects productivity. High A means that, all else equal, the country is more productive in the polluting good.

Refer to Figure 4, which is based on Copeland and Taylor (2004a). Let two countries share a common supply curve S, but let country M be an importer of pollution-intensive goods (a low-A country) and let country E be an exporter (a high-A country). The demands for emissions are illustrated, with country E's demand to the right of country M's.

Now consider the effects of pollution policy on trade flows. First note that for any given country, an exogenous increase in the pollution tax will cause firms to move up along their pollution demand curves and reduce emissions. This raises production costs and lowers net exports (or raises imports). That is, our model predicts that an increase in pollution taxes will reduce net exports (and it would also predict that the country is a less attractive place for foreign investment in pollution-intensive industries).

However, when we compare countries, notice that the pollution tax is higher in country E than M. That is, in a simple naive regression, we would find that higher pollution taxes are correlated with higher exports of pollution-intensive goods. The pollution tax in country E is high because there is high pressure on the environment. Success in exporting is causing stringent environmental regulations. If this effect is not accounted for, then the researcher may mistakenly conclude either that pollution regulation does not deter exports, or that it may actually promote them, perhaps via the Porter hypothesis.

Recent work suggests that this is important empirically. Much of the empirical work prior to 1997 found no evidence that environmental policy affected plant location and trade flows (see Jaffee et al. 1995). However, virtually all of this work used cross-sectional data and was not able to control for unobserved heterogeneity, nor was there much effort directed towards explicitly dealing with policy endogeneity. More recent work using panel data has been able to control for

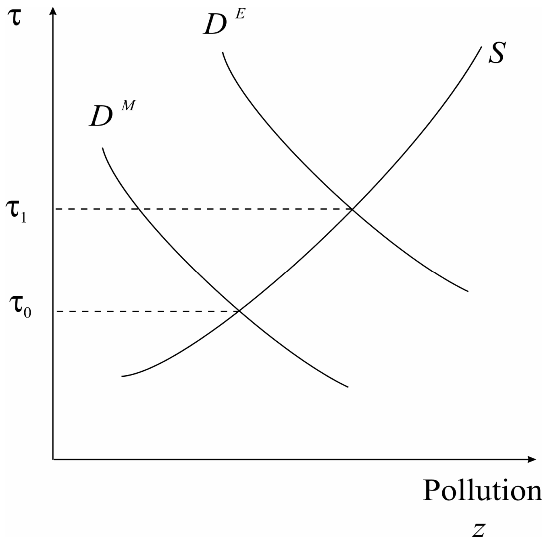

Figure 4. Exogenous vs. Endogenous Policy

unobserved heterogeneity and has focused on endogeneity issues. That work has found that environmental regulation does affect trade flows (Levinson 1999, Levinson and Taylor 2004), plant location (Becker and Henderson 2000, Greenstone 2002, List et al. 2003), and inward foreign direct investment into U.S. states (Keller and Levinson 2002).[2] One weakness of this work is that it is based entirely on U.S. data. However, it suggests that taking the endogeneity of environmental policy seriously is critically important in interpreting the empirical evidence.

Empirical Evidence on Openness and Environmental Quality

Endogeneity of policy may also lead to misinterpretations of the data linking increased openness to environmental quality. Suppose there are two types of governments: good and bad.[3] Good governments have good policy, and suppose this means that they have both lower trade barriers and more stringent pollution regulation. Figure 5 illustrates a case where both *B* and *G* are exporters of pollution-intensive goods. *B* has a low pollution tax and *G* has a high one. And suppose that both pollution taxes are rigid and unresponsive to short-run changes in pressure on the environment. *G* has more liberal trade policies and so its polluting industry has higher emissions demand (D^G) than does country *B* (with D^B).

Notice that *G* is more open and has less pollution. In a regression of pollution on openness, one might conclude that more open economies are cleaner so that trade is good for the environment. However, this would be misleading. More openness actually increases pollution in country *G* (because it shifts out the pollution demand curve). In this case, it is differences in the quality of government that is causing both openness and environmental outcomes. Good government leads to both more open trade and a cleaner environment. However, controlling for government type, openness may well worsen environmental quality.

Global Environmental Issues

As a final example of the ways in which a focus on endogenous policy is important in understanding the effects of trade on pollution, I briefly discuss global pollution. Results contingent on the policy regime may be adequate if the purpose of analysis is to advise domestic policymakers (assuming that the domestic policymakers can control the policy regime). However, in many cases, one needs to predict the effects of changes in the world economy on *foreign* pollution. This is critical in cases where domestic agents care about environmental damage originating in foreign countries.

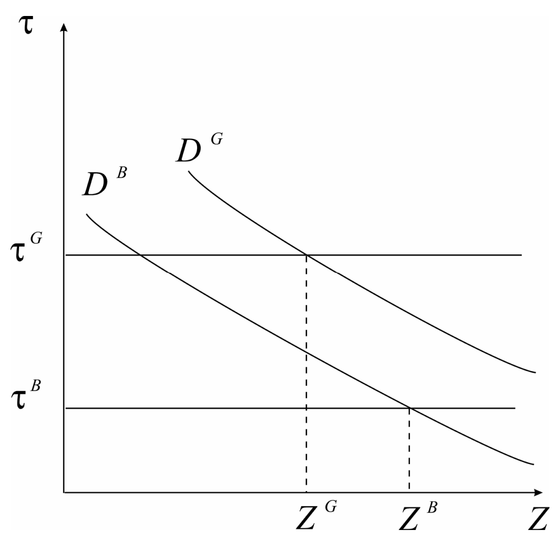

Figure 5. Openness and Environmental Quality

[2] See Copeland and Taylor (2004a) for an extensive discussion of this work.

[3] This example is discussed in Antweiler, Copeland, and Taylor (2001).

Consider global pollution and the Kyoto Protocol. Suppose there are two groups of countries—those that agree to cut emissions, and those that do not. We denote these latter countries collectively as "ROW" for "rest of world." If the Kyoto countries reduce their emissions, this raises the price of pollution-intensive goods, causing ROW to increase its production of these goods, and thus increase its pollution. This is carbon leakage.

Suppose instead that pollution policy is endogenous and that ROW exports polluting goods. Then the increased price of polluting goods induced by the cut in emissions by the Kyoto countries improves ROW's terms of trade and increases its real income. If environmental quality is a normal good, this will lead to a tightening of environmental policy in ROW, and this tends to dampen and may possibly reverse the increase in pollution in ROW. That is, pollution in ROW may fall in response to a cut in emissions by the Kyoto countries: domestic and foreign emissions may be strategic complements when policy in the foreign country is endogenous.[4]

Trade and Renewable Resources

In contrast to the literature on pollution, much less work has been done on the effects of trade on the sustainability of renewable resources. Most of that work has focused on two types of management regimes: either fully optimal resource management or pure open access. Differences in the policy regime can have particularly dramatic implications for the effects of trade on renewable resources. Consequently, the possibility that trade liberalization may lead to changes in the intensity of resource management is a potentially important issue, but one that has so far received relatively little attention in the literature.

To illustrate the contrast between the effects of trade under different management regimes, consider the simple Brander and Taylor (1997) model,[5] with two sectors, manufacturing (M) and harvesting (H), one primary market-supplied factor (labor), and a resource stock S. Assume that for a given level of the resource stock S, there is constant returns to scale in production. Then the short-run production frontier is linear, as illustrated by PPF_0 in Figure 6.

First, consider the case where the resource is open access. Suppose that the economy is initially in a long-run steady state equilibrium at point E—the initial domestic relative price of H is equal to the slope of the short-run production frontier. Finally, suppose that the country exports the harvest good in a free trade regime.

Now, consider the effects of a trade liberalization that raises the relative price of H to p_1. First, suppose that the resource is open access. Then there will initially be short-run gains from trade (utility rises from U_0 to U_1). However, as H increases, the stock S is depleted, causing the short-run production frontier to rotate inward toward PPF_1. If the economy continues to produce both goods in the new steady state, the production frontier will continue to rotate inward until its slope is equal to that of the new world price (since that is the only frontier consistent with diversified production). Trade therefore leads to stock depletion and a decline in steady state real income. For a sufficiently low discount rate, discounted real income must fall.

In contrast, if we have efficient resource management, then trade must raise discounted real income and will lead to stock depletion only if it is optimal to do so. In terms of Figure 6, the manager could, for example, keep harvest rates at H_0,

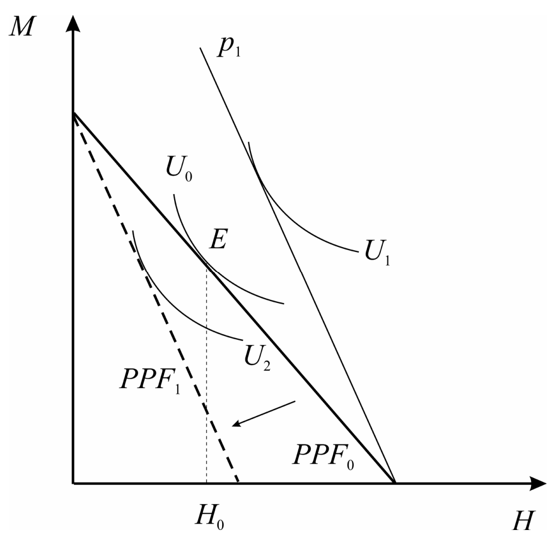

Figure 6. Trade Liberalization in an Open Access Fishery

[4] See Copeland and Taylor (forthcoming) for more details.

[5] Chichilnisky (1994) also developed a model with similar predictions.

in which case the production frontier would not rotate inwards and the economy would reap consumption gains from trade. Alternatively, the manager could initially allow some increased harvesting to take advantage of higher harvest prices, and then cut harvesting back once the stock reaches its new optimal steady state level.

This example illustrates how the consequences of weak resource management policy are potentially much more damaging for an economy than in the case of pollution. Poor resource management leads to both environmental devastation (stock depletion) and reductions in long-run income. This decline in long-run income may reduce the demand for other types of environmental quality and can lead to the type of downward ecological spiral hypothesized by Daly (1993) in which trade leads to resource degradation, which leads to lower income, which leads to more resource degradation, and so on.[6] Moreover, low income people in developing countries tend to be more dependent on renewable resources than are high income people in those countries.[7] Consequently, resource depletion may adversely affect the distribution of income as well as its level.

There is still relatively little evidence on the effects of openness to trade on resource depletion. There are a number of case studies that look at the effects of trade liberalization on specific resources in specific countries. López (1998) is a very interesting study that estimates empirically the extent to which villagers internalize externalities in their use of common property land in Côte d'Ivoire. He finds that the externalities are not internalized and estimates the losses in income from this to be about 14 percent. Similar results are found for Ghana in López (1997). He finds that trade liberalization exacerbates environmental problems in Ghana because it encourages the expansion of agriculture and exacerbates the common property problems. Benhin and Barbier (2001) also find that trade liberalization increases deforestation in Ghana. However, López (2000) finds that trade liberalization is good for the environment in Côte d'Ivoire because it has a comparative advantage in tree crops, and so this reduces pressure from agriculture on the local biomass.

Several papers use cross-country data on deforestation to show that institutions, such as property rights, and corruption indexes are an important factor in explaining deforestation (see for example Deacon 1994, Bohn and Deacon 2000, and Barbier and Burgess 2001). Ferreira (2004) is one of the few papers to directly test the hypothesis that the effects of trade on resource depletion depend on the management regime. The author uses cross-country data on deforestation as well as data on the quality of property rights. She finds that openness to trade increases deforestation only for those countries with weak property rights.

A separate literature sometimes known as the "resource curse" literature has also provided evidence that property rights regimes are critical in determining how markets interact with natural resource endowments to affect economic well-being. In a well-known paper, Sachs and Warner (1995) found a negative correlation between the importance of resources in a country's exports and its economic performance. This was interpreted as evidence that an abundance of natural resources may paradoxically be bad for a country. However, recent work has suggested that the policy regime is fundamentally important in determining whether a large endowment of natural resources deters economic growth. Mehlum, Moene, and Torvik (2002) develop a simple theoretical model in which agents decide whether to engage in productive activity or attempt to poach resource rents. They find that increases in resource endowments lower income in countries with poor institutions (because it leads to too much increased poaching and rent-seeking behavior). However, in countries with good institutions, increases in the resource endowment raise real income. In their empirical work, they confirm that resource abundance acts as a drag on economic growth only via an interaction effect with poor institutions. They do not explore the implications of openness to trade, but their work provides more evidence that the quality of the resource management regime is critical in determining market outcomes in countries with natural resources.

While the evidence is still fairly sketchy, the recent empirical work on the importance of institutional variables is supportive of the view that the management regime will be critical in determining the effects of trade liberalization on a

[6] See Copeland and Taylor (1997) for a formal treatment of this possibility.

[7] See Barbier (2004).

country exporting renewable resources. One weakness of this work, however, is that management regimes are treated as exogenous. There is a great deal of heterogeneity in the effectiveness of resource management both across countries and across resource types within countries. One would expect this heterogeneity to be endogenous—management regimes are determined by an interaction between characteristics of the resource, market conditions, national institutions and culture, and other factors. If this is the case, then one might expect that trade could lead to a change in the intensity of resource management.

Ostrom (1990), Baland and Platteau (1996), and others have documented the wide variety of ways that rural communities have found to deal with common property management. Many of these regimes rely on social norms and traditions. One concern is that exposure to international trade and investment could lead to a collapse of these systems. Another possibility is that trade and investment could increase the value of the resource and consequently increase the incentive to set up a viable management regime. As yet, we know very little about how trade may play a role in transforming management regimes in renewable resources.

In what follows, I briefly review some of the recent work that attempts to endogenize the management regime in simple general equilibrium trade models with renewable resources.

Threshold Models

Francis (2001), Margolis and Shogren (2002), and Bergeron (2002) develop threshold models of renewable resource management to analyze the effects of trade liberalization. In these models, there is a fixed cost of managing the resource, and a management system is not set up until the potential rents generated by the resource surpass a threshold level beyond which the benefits of regulation exceed the costs. They build on the endogenous enclosure models of Cohen and Weitzman (1975) and De Meza and Gould (1992).[8]

The model can be illustrated with reference to Figure 7. The sustainable steady state harvest is $H(L)$, which has a standard inverse-U shape—sustained high levels of labor allocated to harvesting depletes the stock and so the sustainable harvest is decreasing in L for sufficiently high L. The opportunity cost of labor measured in terms of the harvest good is wL/P, where P is the price of the harvest good. Two such lines are drawn, corresponding to two different prices: $P_0 < P_1$.

Suppose that the country exports the harvest good, and that high levels of protection result in a relatively low price for the harvest good P_0. At this point the maximal surplus generated by the resource would be given by the distance *ab*. Let E denote the fixed cost of setting up an enforcement system (measured in terms of a numeraire good). Then if $ab < E$, it is not cost effective to manage the resource, and the open access outcome obtains.

Now suppose that trade liberalization raises the harvest price to P_1.[9] The potential rents from the resource are now given by the distance *cd*. If $cd > E$, then trade liberalization leads to the creation of a management regime.

This model predicts that a country that starts out with an open access management regime may make a transition to full resource management as the resource becomes more valuable via trade. Conversely, if the country imports the resource, a pre-existing management regime may collapse as the resource becomes less valuable. Francis (2001) and Margolis and Shogren (2002) both point out,

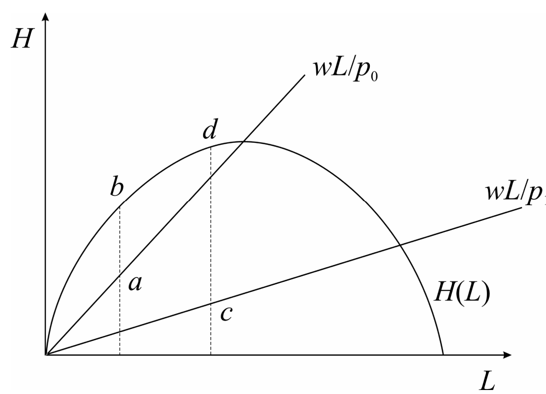

Figure 7. Threshold Model of Resource Management

[8] Threshold models have also been used in pollution literature to explain the environmental Kuznets curve. If environmental quality is a normal good, then the benefits of regulating pollution increase in income. If there are fixed costs of environmental regulation, then such a model predicts that countries will not set up a pollution regulation system until they are sufficiently rich. See Copeland and Taylor (2003) for an exposition of these models.

[9] This could result either from a reduction in import tariffs in the rest of the economy (which would raise the relative domestic price of H), or from a reduction in import restrictions on H in the rest of the world.

however, that trade liberalization need not raise welfare even when it induces a transition to an effective management regime. This is because management is costly. In the absence of management, trade would lower welfare for an exporter in these models; the introduction of management dampens this effect, but need not offset it. However, once the management system is set up, further increases in the export price must raise welfare.

Another interesting implication of these models, although not discussed by the authors, is that they can shed some light on the issue of sequencing of trade and resource management reforms. If we observe a country with an open access management regime, then we might want to be cautious about liberalizing trade until an effective management regime is set up. But such a regime may not be viable until the resource is capable of generating a sufficiently large surplus.

The authors of all of these papers are interested mainly in welfare results, and in particular in showing that it is possible that trade may still lead to welfare losses even with endogenous transition of management regimes. However, for empirical purposes, these models allow us to investigate the interesting questions of which types of countries are likely to make the transition, which types of resources within a country will be well managed, and which types of countries might experience real income losses from trade. One of the implications of these models is that anything that raises surplus increases the likelihood of management regime. Higher prices for the harvest good, faster growing resource stocks, better harvest technology, imports of low-cost intermediate goods used in harvesting, etc., will all lead to an increased likelihood of an effective management regime emerging. Moreover, these models predict that as the harvest good price p gets very high, all resources are manageable.

These models have some weaknesses. As the price of the harvest good rises, we expect more pressure on the resource; however, in these models cost of enforcement is independent of pressure on the resource. Other sources of pressure include population pressure, and pressure from foreign investors, and possibly from foreign harvesters. None of these affect enforcement costs in these models. Finally, these models focus on the open access problem. They are essentially enclosure models. Once the enforcement cost is paid, there is no difference between the renewable resource and any other privately run economic activity. There is no common property problem; and to the extent that many resources, such as fisheries, have at their root a common property problem, they go only partway towards providing a theory of endogenous management.

Poaching Models

Hotte, Long, and Tian (2000) develop a model with variable enforcement costs. They also restrict themselves to the open access problem. A single agent owns a pool of resources, but must spend resources to enforce the property rights. The agent sets up a line of defense, and poachers must spend a fraction γ of their time evading these defenses. Hence the effective cost of labor in poaching is $w/(1-\gamma)$. The resource manager can choose γ. Higher γ deters poaching, but requires more defenses. Let $c(\gamma)$ denote the increasing and convex enforcement cost function.

The manager's problem can be illustrated with a couple of diagrams. In Figure 8, I have plotted the usual steady state sustainable harvest function $H(L)$, where L is labor input. The manager's opportunity cost of labor is wL/p. The open access outcome (with no enforcement) is at L_1, and the surplus maximizing point is L^*. The opportunity cost of labor for poachers is $wL/[p(1-\gamma)]$. Notice that this imposes a constraint (a lower bound) on the amount of labor the manager can allocate to the resource. Poachers will enter and dissipate rents as long as their expected profit is positive; and this will occur if $L < L(\gamma)$. Hence the manager will always choose to deter poaching by keeping $L \geq L(\gamma)$.

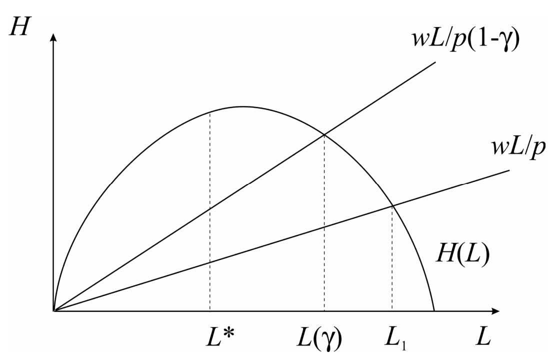

Figure 8. Poaching Constraint

Finally, the manager chooses γ. This is illustrated in Figure 9. As γ rises, poaching is deterred more, and profits to the manager (excluding enforcement costs), π, rise. For γ sufficiently high, the poaching constraint will not bind and the manager can maximize sustainable surplus. Further increases in γ do not affect profits. Hence the profit function $\pi(\gamma)$ has the shape illustrated.

The manager's objective is to choose *g* to maximize $\pi(\gamma) - c(\gamma)$. Three different enforcement cost functions are illustrated. If enforcement is very costly (as captured by c_0), then $\gamma = 0$, and the open access outcome prevails. This corresponds to the cases in the fixed-cost models where the surplus generated by the resource is not enough to cover enforcement costs. For intermediate levels of enforcement costs (such as c_1), an entry deterrence equilibrium is obtained—a management system is in place, but the manager overharvests to deter poaching. Finally, if enforcement is cheap (such as c_2), then an outcome very close to the first best is obtained.

As in the fixed-cost models, an increase in the price of the resource via exporting will shift up the profit function, and increase the benefits of enforcement. Thus trade can lead to a shift in the *de facto* management regime. Hotte, Long, and Tian (2000) focus on the welfare aspects of their model, and their main result is that trade liberalization may be welfare-decreasing even if it creates a shift from open access to enforcement of property rights. This comes about for two reasons. Without enforcement, trade would reduce welfare, as in the Brander-Taylor model. This welfare loss from trade can be offset by introducing an enforcement scheme. But since enforcement is costly, this may not be enough to offset the tendency for losses from trade.

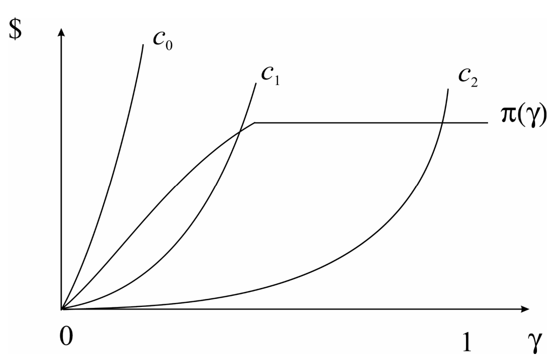

Figure 9. Choice of Enforcement Level

An interesting question for empirical work is which types of countries will have good enforcement, and which will have weak enforcement. Although Hotte, Long, and Tian (2000) do not pursue this, their model would predict heterogeneity both across countries and across different types of resources within a country. One would expect this to vary systematically with parameters such as the growth rate of the resource stock, population pressure (which affects the supply of poachers), etc. Finally, one could use this model to ask which types of countries will be expected to undergo a transition to better resource management when trade liberalizes.

Managing Common Property

The above models all focus on the problem of limiting access of outsiders to a resource and assume that a single private manager controls the resource. Many resources, however, are managed as common property resources. This applies to both rich and poor countries. Fisheries are often treated as a common property resource. A large number of agents are allowed access to the resource, and a manager attempts to place limits on their harvesting effort. Other types of common property resources include access to forests for fuel wood, access to grazing land, and access to water supplies.

Copeland and Taylor (2004b) develop a simple general equilibrium trade model of a common property renewable resource in which a manager attempts to internalize the harvest externality, but with imperfect monitoring. Agents are given harvest restrictions. If they cheat and over-harvest, they are punished by having their rights of access to the resource taken away. This yields an incentive constraint which is much like that found in efficiency wage models: agents must expect to receive some surplus from the resource in order for exclusion from the resource to be a costly punishment. However, if the surplus is too high, agents face an irresistible incentive to cheat, and open access obtains.

As the resource becomes more valuable (such as via export-driven trading opportunities), the surplus from the resource rises, thus increasing the cost of cheating. But the short-run benefits of cheating also rise. Whether or not the former effect is enough to make the management system effective varies across countries.

The model predicts three types of economies. Some economies will never be able to satisfy the incentive constraint: there is too much pressure on the resource for the incentive mechanism to be effective. These are economies with slow-growing resources, impatient agents, very efficient harvesting technologies, and large numbers of agents with a right of access to the resource.

In economies with less pressure on the resource, management is not effective at low resource prices, but as prices increase, the economy can make a transition into effective management. In some but not all such economies the incentive constraint will not bind at sufficiently high resource prices, and the first best will be obtained.

It is interesting to note that the predictions of this model differ in some respects from the threshold model. In threshold models, anything that increases surplus from the resource increases the likelihood of effective management. However, in the incentive constraint model of Copeland and Taylor (2004b), factors that put increased pressure on the resource can lead to collapse of the management regime—for example, improved harvest technology and imports of low-cost intermediate goods used in harvesting will increase the likelihood of effective management in the threshold models. However, these factors can lead to the collapse of the management regime in the Copeland-Taylor model.

Conclusion

This paper has reviewed several different approaches to modeling endogenous policy in the literature on trade and the environment.

In the context of pollution, models with endogenous policy have had a major impact on both the theoretical and empirical literature. The earlier consensus that environmental policy does not affect trade and investment flows as surveyed by Jaffe et al. (1995) has been undermined mainly because of a recognition of the importance of endogenous policy differences.

There are still many opportunities for more research in this area in the context of pollution. Most of the empirical work uses U.S. data, and as data from other countries becomes available, more work focusing on the role of endogenous differences in policy across countries in affecting trade flows will be possible. As well, early empirical work on the political economy of trade and environmental policy suggests some conflicting results, and so there is much scope for more investigation.

Work on the effect of trade on renewable resources with endogenous management systems is still in its very early stages. Early work in this area is beginning to yield some clear testable hypotheses about how measurable differences across countries and resource stocks might affect both management and trade outcomes. Hopefully, this paper will help to stimulate an empirical investigation of these hypotheses.

References

Antweiler, W., B.R. Copeland, and M.S. Taylor. 2001. "Is Free Trade Good for the Environment?" *American Economic Review* 91(4): 877–908.

Baland, J.M., and J.P. Platteau. 1996. *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* Oxford, U.K.: Clarendon Press.

Barbier, E.B. 2004. "Natural Capital, Resource Dependency, and Poverty in Developing Countries: The Problem of Dualism within Dualism." Initiative for Policy Dialogue working paper, Columbia University.

Barbier, E.B., and J.C. Burgess. 2001. "The Economics of Tropical Deforestation." *Journal of Economic Surveys* 15(3): 413–433.

Becker, R., and V. Henderson. 2000. "Effects of Air Quality Regulations on Polluting Industries." *Journal of Political Economy* 108(2): 379–421.

Benhin, J., and E.B. Barbier. 2001. "The Effects of the Structural Adjustment Program on Deforestation in Ghana." *Agricultural and Resource Economics Review* 30(1): 66–80.

Bergeron, N. 2002. "International Trade and Conservation with Costly Natural Resource Management." Research Group in Energy, Environmental and Natural Resource Economics (GREEN) Working Paper No. 0204, Laval University, Québec.

Bohn, H., and R.T. Deacon. 2000. "Ownership Risk, Investment, and the Use of Natural Resources." *The American Economic Review* 90(3): 526–549.

Bommer, R., and G.G. Schulze. 1999. "Environmental Improvement with Trade Liberalization." *European Journal of Political Economy* 15(4): 639–661.

Brander, J., and M. Taylor. 1997. "International Trade and Open Access Renewable Resources: The Small Open Economy Case." *Canadian Journal of Economics* 30(3): 526–552.

Chichilnisky, G. 1994. "North-South Trade and the Global Environment." *American Economic Review* 84(4): 851–874.

Cohen, J.S., and M.L. Weitzman. 1975. "A Marxian Model of

Enclosures." *Journal of Development Economics* 1(4): 287–336.

Copeland, B.R., and M.S. Taylor. 1994. "North-South Trade and the Environment." *Quarterly Journal of Economics* 109(3): 755–787.

____. 1995. "Trade and Transboundary Pollution." *American Economic Review* 85(4): 716–737.

____. 1997. "The Trade-Induced Degradation Hypothesis." *Resource and Energy Economics* 19(4): 321–344.

____. 2003. *Trade and the Environment: Theory and Evidence.* Princeton, NJ: Princeton University Press.

____. 2004a. "Trade, Growth and The Environment." *Journal of Economic Literature* 42(1): 7–71.

____. 2004b. "Trade, Tragedy and the Commons." NBER Working Paper No. 10836, National Bureau of Economic Research, Cambridge, MA.

____. Forthcoming. "Free Trade and Global Warming: A Trade Theory View of the Kyoto Protocol." *Journal of Environmental Economics and Management.*

Daly, H. 1993. "The Perils of Free Trade." *Scientific American* 269(5): 50–57.

Damania , R., P. Fredriksson, and J. List. 2003. "Trade Liberalization, Corruption, and Environmental Policy Formation: Theory and Evidence." *Journal of Environmental Economics and Management* 46(3): 490–512.

Dasgupta, S., A. Mody, S. Roy, and D. Wheeler. 1995. "Environmental Regulation and Development: A Cross-Country Empirical Analysis." Policy Research Department Working Paper No. 1448 (April), World Bank, Washington, D.C.

Deacon, R.T. 1994. "Deforestation and the Rule of Law in a Cross-Section of Countries." *Land Economics* 70(4): 414–430.

De Meza, D., and J. Gould. 1992. "The Social Efficiency of Private Decisions to Enforce Property Rights." *Journal of Political Economy* 100(3): 561–580.

Ederington, W.J., and J. Minier. 2003. "Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis." *Canadian Journal of Economics* 36(1): 137–154.

Eliste, P., and P.G. Fredriksson. 2002. "Environmental Regulations, Transfers and Trade: Theory and Evidence." *Journal of Environmental Economics and Management* 43(2): 234–250.

Ferreira S. 2004. "Deforestation, Property Rights, and International Trade." *Land Economics* 80(2): 174–193.

Francis, M. 2001. "Trade and the Adoption of Environmental Standards." Working paper (July), School of Economics and Marketing, University of Canberra.

Greenstone, M. 2002. "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and the 1977 Clean Air Act Amendments and the Census of Manufactures." *Journal of Political Economy* 110(6): 1175–1219.

Grossman, G.M., and E. Helpman. 1994. "Protection for Sale." *American Economic Review* 84(4): 833–850.

Hilton, H., and A. Levinson. 1998. "Factoring the Environmental Kuznets Curve: Evidence from Automotive Lead Emissions." *Journal of Environmental Economics and Management* 35(2): 126–141.

Hokby, S., and T. Soderqvist. 2003. "Elasticities of Demand and Willingness to Pay for Environmental Services in Sweden." *Environmental and Resource Economics* 26(3): 361–383.

Hotte L., N.V. Long, and H. Tian. 2000. "International Trade with Endogenous Enforcement of Property Rights." *Journal of Development Economics* 62(1): 25–54.

Jaffe, A., S. Peterson, P. Portney, and R. Stavins. 1995. "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic Literature* 33(1): 132–163.

Keller, W., and A. Levinson. 2002. "Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States." *Review of Economics and Statistics* 84(4): 691–703.

Kriström, B., and P. Riera. 1996. "Is the Income Elasticity of Environmental Improvements Less Than One?" *Environmental and Resource Economics* 7(1): 45–55.

Levinson, A. 1999. "State Taxes and Interstate Hazardous Waste Shipments." *American Economic Review* 89(3): 666–677.

Levinson, A., and S. Taylor. 2004. "Trade and the Environment: Unmasking the Pollution Haven Effect." National Bureau of Economic Research (NBER) Working Paper No. 10629, Cambridge, MA.

List, J.A., W.W. McHone, D.L. Millimet, and P.G. Fredriksson. 2003. "Effects of Environmental Regulations on Manufacturing Plant Births: Evidence from a Propensity Score Matching Estimator." *Review of Economics and Statistics* 85(4): 944–952.

López, R. 1997. "Environmental Externalities in Traditional Agriculture and the Impact of Trade Liberalization: The Case of Ghana." *Journal of Development Economics* 53(1): 17–39.

____. 1998. "Agricultural Intensification, Common Property Resources and the Farm-Household." *Environmental and Resource Economics* 11(3-4): 443–458.

____. 2000. "Trade Reform and Environmental Externalities in General Equilibrium: Analysis for an Archetype Poor Tropical Country." *Environment and Development Economics* 5(4): 377–404.

Margolis, M., and J. Shogren. 2002. "Unprotected Resources and Voracious World Markets." Discussion Paper No. 02–30 (June), Resources for the Future, Washington, D.C.

Mehlum, H., K. Moene, and R. Torvik. 2002. "Institutions and the Resource Curse." Mimeo, Department of Economics, University of Oslo.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* New York: Cambridge University Press.

Pargal, S., and D. Wheeler. 1996. "Informal Regulation of Industrial Pollution in Developing Countries: Evidence from Indonesia." *Journal of Political Economy* 104(6): 1314–1327.

Pethig, R. 1976. "Pollution, Welfare and Environmental Policy in the Theory of Comparative Advantage." *Journal of*

Environmental Economics and Management 2(3): 160–169.
Sachs, J.D., and A.M. Warner. 1995. "Natural Resource Abundance and Economic Growth." National Bureau of Economic Research (NBER) Working Paper No. 5398, Cambridge, MA.
Schleich, J. 1999. "Environmental Quality with Endogenous Domestic Trade Policies." *European Journal of Political Economy* 15(1): 53–71.