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Trade and the Environment: An Economic Literature Survey

by

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Abstract: This document attempts to organize and summarize the major developments of the trade and environment literature observed during the last ten years. Both the major theoretical and empirical contributions are presented and discussed. This includes an overview of the different methods economists have used to describe the environmental externalities, and decompose their welfare effects in open economies. Additionally, guided by the literature we review the policy implications in the presence of two distortions: price (tariff) and environmental, when policymakers are benevolent or are more lenient for certain political groups. Finally, a brief review to the critique of traditional economic research is presented.

Keywords: Trade and Environment, Industry Location, Patterns of DFI, Political Economy, Renewable Resources, Transboundary Pollution, Strategic Trade Policy.

JEL Classification: F1, Q2, D7.

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The trade and environment literature started in the early 1970's as a response to the first environmental protection policy enacted in OECD countries. The concern was that this policy together with trade would force regulated industries to migrate to unregulated regions. During the 1980's environmental issues in general became less important amidst the world recession at the beginning of the decade. However, with the beginning of the next decade environment and trade issues took the headlines for the first time. Two passionate intellectual camps took positions: the anti-globalization group fiercely started to oppose further trade integration worried that globalization in general will translate in progressive lowering of environmental and labor standards. In the opposite side free-traders argued that integration (including trade) is the only policy that guarantees growth, which is unavoidably accompanied by improvements in income, labor and environmental standards. In the middle, or perhaps, isolated from the hot headed debate a rich economic literature bloomed, providing arguments for both camps, understanding the linkages, and providing the settings under which trade can be beneficial for the environment, as well as welfare.

This survey aims to collect in a comprehensive and orderly fashion the economic thought developed the last decade. This study is founded on early surveys done at the beginning of the nineties that helped this trade and environment literature boom (Dean (1992), Beghin et al. (1994), Xing and Kolstad (1996)), and hopes to help and guide a new and better generation of economic research on this subject of great consequence.

This exploration over the trade and environment literature will first take us over the theoretical literature. We will see how many second best results have been formalized, the effects of removing trade (price) distortions in the presence of a second distortion (the environmental externality). These results have been explored for different types of environmental externalities: when the environment is factor of production, when production damages the environment, when consumption depletes the environment, and when there are spillover transboundary environmental externalities. Additionally, we will see why when these two externalities are present environmental and trade policy are linked. Finally, we see how competition for policies can actually revert many policy effects that are thought to be unambiguous.

In the second section we revise the empirical literature. In this section we review how economists have measured the trade and environment links. We see different roads to measure environmental externalities and the effects of trade when these are present. Direct and indirect

channels through which trade can affect the environment are identified and estimated. Some important questions regarding trade policy, political economy forces and environmental effects are estimated in this literature. Do differences in environmental policy determine patterns of trade, industry location, and DFI flows? Does corruption matter?

Finally, we take a brief break to learn about the main criticism that this literature has received. Some argue that not all the environmentally degrading effects of trade are being considered by mainstream economics. The intention in reviewing this critique is to investigate areas that may be improved in future research.

I.- The Theory[1]

1. Environmental Regulations, Distortions and the Patterns of Trade

As OECD countries began to impose environmental regulations in the early 1970's, one of the first concerns of economists, when thinking about environment and trade, was that these controls could impose burdens too heavy that would alter patterns of trade, and ultimately make industries migrate to unregulated regions. Pethig (1976) using a two-sector Ricardian model with emissions and labor as inputs shows that a country will specialize in the production of the environmental-intensive good if their environmental regulations are less restrictive than the other country. Siebert (1977) expanded the analysis in a single factor model, but with non-linear technology. He shows that environmental policy improves the environment, but at the cost of reducing the output of the environmental intensive good, and further, reducing the standard gains from trade. If the environmental regulation becomes too restrictive, eventually it could revert the comparative advantage of a country in the pollution intensive good. These results are confirmed in a Heckscher-Ohlin framework by McGuire (1982). The author adds to the standard trade model one factor of production in one sector, the environment, which is subject to a quantitative restriction. As modeled, the restriction acts as negative technical change in the good that uses the environment, redistributing income between the standard factors of production, to the factor used intensively in the non-environmental good. If the restriction is large enough, it can revert a comparative advantage the country may enjoy in the good that uses the environment. Furthermore, if capital and labor are freely mobile across countries, the country that imposes the

[1] Many of the seminal papers discussed in this section have been recently compiled by Dean (2002).

restriction on the environment has its factors emigrate until it only produces the non-environment good, at the limit of the cone of diversification.

Lack of regulations, can also determine the patterns of trade. If a country has property rights problem in the access to the environment, there will be an over-exploitation of the environment that would give the country an apparent comparative advantage in the environment-intensive good (we describe this literature in detail in the next section).

Thus, environmental regulations can change the patterns of trade, altering the direction of Ricardian (technological) comparative advantage, and even standard comparative advantages based on relative factor abundance: at the margin it can drive industries out of international markets.

Copeland and Taylor (1994), show that environmental considerations can drive industries out of countries even when environmental policies are the same[2]. The authors construct a model with a continuum of goods indexed by their emissions intensity, with pollution affecting welfare as a bad, and an efficient government taxing emissions at their marginal damage level. Since the marginal damage, increases with income, i.e. environmental quality is a normal good, when countries trade the richer country specializes in cleaner goods (reducing pollution *vis-à-vis* autarky), while the poorer country specializes in the dirtier goods (augmenting pollution). Overall pollution increases for the same reasons there are standard gains from trade, the specialization expands output[3]. In Copeland and Taylor (1995a) the authors expand the analysis to the case of consumer generated pollution, showing that with the advent of trade, pollution decreases in the rich country and increases in the poor country, confirming in a broader sense that the dirty industry migrates from the richer to the poorer country.

Furthermore, differences in the environment's ability to replenish itself or to absorb pollution can also determine patterns of trade. Countries with "larger" environment, or with resources with a faster capacity to replenish themselves, enjoy a competitive advantage in the production of pollution intensive goods. Siebert (1977), for example, formalizes this result by showing that the country with an environment with higher assimilative capacity imposes a lower emissions tax which gives it a comparative advantage in the pollution intensive good. Leger

[2] In their model both countries use the same policy as they tax emissions at their marginal damage level. However, since the richer country imposes a different (higher) tax, the authors call this different environment policies.

[3] More specifically, the authors show pollution increase because pollution increasing composition effects dominate the scale (pollution increasing) and technique (pollution decreasing) effects. These effects are explained in the next section.

(1995) extends this idea in a model with regional distribution of industries. He presents a Heckscher-Ohlin model with regional differences in the environmental assimilative capacity, showing that countries will export the good produced in the region with the higher environmental assimilative capacity (although which industry locates in that region is determined by history/chance).

2. Renewable Resources and Property Rights Failure

When the environment is viewed as a factor of production, there is a potential for over-exploiting it due to property rights problem. For example, assume the relevant environment was a lake with fish in it. When property rights (private or common) are correctly enforced, in the economic decision of harvesting fish agents must consider the costs of extraction plus the cost imposed on the stock of fish by altering its ability to regenerate. In a property rights regime of open access, only the current costs of harvesting are considered which translates into an over-harvesting of the resource. In this case there is a dynamic externality as only current costs are internalized in the economic decision of fishing, while the cost over the future availability of the resource is ignored. In a static scenario, a similar analysis is valid. Imagine every agent makes the decision to extract from the environment, taking other agents extraction decisions as given. In (Nash) equilibrium the amount harvested depends on the amount of agents, and with a sufficiently large amount of agents, each extracts until revenues equal average costs, instead of marginal costs which would be optimal; i.e. there is over extraction of the resource. Note that the property rights failure is not a problem of lacking a private property rights regime. It is possible for a community to manage a common resource optimally and fail to do so when a private property regime is imposed[4].

There is a rather fertile literature that examines trade in a general equilibrium framework, when the environment is a factor of production subject to property rights failure. In this literature it has become customary to call the South the country/region with the externality in its access to the environmental resource, while the North is the region that optimally manages its resources. Obviously, these categories want to stress the fact that less developed nations, usually located in the South suffer from property rights failure.

[4] López (1998) provides an example of this.

2.1. North-South Trade Models

One of the earlier North-South trade models is presented by Chichilnisky (1994), which is an extension of the Heckscher-Ohlin model. Two final goods are produced with one factor, capital, in fixed supply, while the other factor is an intermediate good, an environmental good that is extracted from the environment[5]. The country without a complete property rights regime "South", extracts more from the environment than is optimal, for any given price of the environmental good in comparison to the North. In autarky the final good that uses the environmental intermediate good more intensively, is cheaper in the South. Therefore the South has the standard endowment Heckscher-Ohlin type comparative advantage in that good and exports it. But the comparative advantage is not a real comparative advantage, it is only apparent, given by the externality in the access to the environment. Due to this environmental distortion the South loses with trade, and exacerbates the environmental problem by over-harvesting even more the environment, while the North, externality free gets the standard gains from trade. She also shows that if the environmental good is produced by subsistence farmers-harvesters, reducing the price of the environmental intermediate good (for example with an export tax) may lead to more over-extraction as farmers try to maintain subsistence levels of income.

Brander and Taylor (1997b) expand the North-South model by allowing the environment to be a renewable resource[6]. They assume linear technologies; two goods, one using labor exclusively, and the other labor and the environment as production inputs. As before, the South over-extracts the environmental input, but does not always expand output with additional efforts committed to harvesting the environment. Renewable resources have a regeneration capacity that is a function the stock. The most common growth function for this type of resources is an inverted-U shaped function like, for example, logistic growth. This means that the resource grows slowly when the stock is too large due to congestion, or when the stock is too low and the growth is hindered by a reduced population; and grows at the highest rate when the stock is around half of its maximum or carrying capacity. This means in the context of the trade model, that when the stock is high (equivalently, the price of the resource good is low) additional efforts would increase output of the good that uses the renewable resource. However, after a certain threshold, steady state output of the resource good falls in the South as it employs more labor in

[5] In Chichilnisky (1993) the environment is modeled as a renewable, but all the main results hold.
[6] Brander and Taylor (1997a) presents the same model under the assumption of small open economy taking international prices as given.

this sector (which happens when the price of resource good is high and the stock in the South is low). Thus, the authors show, that Chichilnisky's result (South loses with trade while the North gains) is changed, when the price of the resource is high and the resource in the South is depleted. In this latter case, the North is more productive in the good that uses the environment, exports it, and both countries gain with trade.

Note that in these North-South trade models the North that is externality free always gains with trade. The South does not have a real comparative advantage in the good that uses the environment (more intensively), and if it exploits it loses with trade. When the North exports the environment good, trade is efficient, in the sense that it follows real comparative advantages, and is thus beneficial for both countries.

2.2 South-South Trade Models

When both trading partners have an environmental externality, the possibilities expand: trade can be beneficial for both partners, to only one, or even reduce welfare vis-à-vis autarky for both countries.

Brander and Taylor (1997) present a model where both countries have an open access externality, but have different endowments of production factors: labor and natural resources. This endowment differences will motivate trade. Here the country with more natural resources (higher natural growth rate of the resources) relative to labor, exports the resource good as expected. The country that exports the resource good loses with trade, while the other country gains. Thus if in an after-trade equilibrium the resource exporting country imposes an export tax, it will gain from it, and make the importing country lose. Furthermore, if the resource importing country imposes an import tariff, it will always benefit the resource exporting country, and may cause the importer to lose or gain from trade (i.e. the tariff may be Pareto improving).

Karp, Sacheeti, and Zhao (2001) present a South-South model where trade is motivated not by differences in endowment of productive factors, but by varying levels of the environmental externality, and environmental stock level. The authors build on the work of Chichilnisky (1994). They assume fixed proportions technology for the final goods, and they assume that one good is a subsistence good, consumed only to a maximum level. Additionally a Cobb-Douglas technology is assumed for the production of the intermediate environmental good, and they model the property rights externality in a way that it can vary from extreme open access to more moderate property rights problem. First, they show that, in autarky, when the stock of

the resource is more abundant the level of the environmental externality (property rights problem) does not affect the steady state level of the resource, but it does when the resource is very depleted. On the other hand, when the countries trade, the level of the externality will always have an effect on extraction levels, regardless of the initial abundance or scarcity of the resource.

The authors do not limit their analysis to steady states; so many possible trade outcomes are possible. We can delimit them into two groups efficient trade patterns (when trade is originated by real comparative advantage, and not generated by the property rights externality), and inefficient ones. Under inefficient patterns the country with a higher degree of environmental externality always loses from trade, but also can "pull down" the other and also make it a loser from trade. If the patterns of trade are efficient, then both countries can win or at the least one is indifferent and the other gains from trade. The results of the model can be conveniently organized according to the regeneration capacity of the renewable resource. When the environment has low growth (i.e. it is fragile) long run free trade and autarky levels are identical. For levels a bit higher of growth rate, both countries lose from trade. For still higher environmental growth levels, there exist initial conditions (initial stock levels) that can make both countries gain from trade. For even higher environmental growth rates (resilient environment) the country with the greater environmental externality always loses under free trade, while the other always gains (as in North-South trade models).

2.3. Multiple Equilibria

One of the reasons so many different welfare outcomes occur in the Karp, Sacheti, and Zhao (2001) model, is that their assumption of fixed proportions technology, and a subsistence good with maximum consumption level, translates into multiple possible equilibria in the renewable resource, both under autarky, and under trade. The possibility for multiple equilibria is more than a theoretical curiosity; it presents the possibility for trade to cause severe environmental depletion or even collapse.

Copeland and Taylor (1997) present a case were trade induces multiple equilibria, while under autarky this possibility does not exist. In their model a small open economy produces two goods, one of them a polluting good. A benevolent government taxes emissions optimally, in a static sense. However, pollution also affects natural capital which is used as a factor of production in the non-polluting sector. The government internalizes the effect of pollution in

welfare, but not the long-run effect of pollution on natural capital (a renewable resource): as in standard renewable resources model there is a property rights externality. In autarky the economy will have its natural capital move towards a unique steady state. When it opens to trade two different outcomes are possible. First, if the externality is weak, (which in this model corresponds to low productivity of natural capital, the one affected by the long-run externality), then opening to trade would produce the standard North-South models results. If it exports the polluting good, the economy has short terms gains, and over time the reduction of natural capital may completely offset these gains. If the country exports the non-polluting good it will have short and long-run gains. However, if the externality is strong, as defined by a high productivity of the non-polluting industry, for the same autarky price, the same steady state becomes unstable. Outside that unstable equilibrium there are two different stable equilibriums: the country either finishes in a low equilibrium with very low natural capital; or the opposite, it specializes in the non-polluting good. The welfare effects are exactly opposing, big long-run losses in the former case, and important long-run gains in the latter.

In Karp, Sacheti, and Zhao (2001), multiple equilibria is a result of the assumed technology together with low reproductive ability of the natural resource. In Copeland and Taylor (1997) multiple equilibria is a result of a large dynamic externality and trade, which for a small open economy de-links allocation of factors of production, output and relative prices. This type of results provides arguments for those who oppose trade, viewing it as an agent of environmental destruction, or can even provide economic explanations for known environmental breakdowns, like the one believed to have occurred in Easter Island, for example.

3. Trade and Transboundary Pollution

Transboundary pollution is understood by economists as a public bad. Public goods get undersupplied because economic agents can not preclude their use by other agents. Thus, to avoid free riders public goods get supplied in a smaller quantity than what is socially optimal. Equivalently, the public bad pollution gets over supplied when its transnational effects are not internalized. Put in a different way, the public good: transnational environmental quality gets undersupplied (less than optimal abatement effort) because not all of the benefits can be excluded by the ones who carry the burden of the cleaning effort.

In the presence of transboundary pollution, free trade is not optimal. If country A grants free trade (zero tariffs) to country B, then, since country B does not suffer from the

transboundary effects, it will have the incentives to pollute more than what is optimal, both from a global perspective, as well as from the point of view of country A. This result was formalized early by Markusen (1975a), who presents the optimal tariff structure for the country suffering from transboundary eyesore pollution (that pollution that affects welfare, but does not affect the country's production possibility set). Two caveats are highlighted by the author: the outcome is not Pareto optimum, which would involve cooperative solutions; and the author assumes that the other country does not retaliate with tariffs of its own. In Markusen (1975b) the author explores other second best instruments to deal with transboundary pollution, like consumption and production taxes.

If countries internalize through policy the domestic effects of pollution, but not the transboundary effects, then trade is likely to benefit the country that specializes in the dirty industries, while it reduces the welfare of the country that specializes in the clean goods. If countries are equivalent in every respect but initial endowment of income, this means surprisingly, that the rich country loses with trade, while the poor country gains. This result is formalized in Copeland and Taylor (1995), with a model that is an extension of Copeland and Taylor (1994). There is a continuum of goods produced with Cobb-Douglas technology using emissions and labor, and indexed between 0 and 1 according to their emission intensity. Consumers are affected by local pollution but also by a share of world pollution. Firms must pay for their emissions purchasing pollution permits priced at the local marginal damage, so that they internalize the damage caused by pollution within their boundaries (governments choose a permit price that maximizes welfare taken other countries' emissions as given), but the problem of global transboundary pollution lingers as a global public bad. Countries differ only in their endowment of labor which is understood as effective labor (raw labor times human capital), so that the rich nation is better endowed with labor. In autarky all countries generate the same amount of pollution regardless the amount of human capital: countries with higher human capital increase the demand for pollution permits, but the ensuing higher income reduces the pollution consumers are willing to accept raising taxes and moving the production towards cleaner goods (all are perfect substitutes). When countries open to trade the poor pollutes more, the North pollutes less, and world emissions remain unchanged (unless there is no factor price equalization in which case global pollution increases, note that this would occur if the world distribution of income was highly skewed). The South improves welfare from increased revenues from

pollution permits, while the North is made worse off with trade: less permit revenues and more transboundary pollution (this is consistent with the fact there is no local environmental externality). A final important result is that it takes just two player in this set of *n* global polluters for an agreement of emissions reduction to be welfare improving (i.e. only a unilateral emission reduction is welfare reducing). Of course the rest of the *n*-2 players (free riders) would always benefit from such an agreement.

Cross country differences in pollution damages generates comparative advantages. If one industry pollutes and affects the productivity of another clean industry, then the country that suffers less damage from pollution has a comparative advantage in the clean industry. This concept is formalized by both Benarroch and Thille (2001) and Unteroberdoerster (2001). Benarroch and Thille (2001) present a simple Ricardian model of trade, with pollution that differentiates both local effects as well as transboundary effect. There are two sectors, a dirty one (i.e. manufactures) that pollutes and affects the productivity of the clean sector (i.e. agriculture). Due to the pollution externality, the production possibility set is convex. Due to transboundary pollution, the relative price of goods does not always reflect the real comparative advantage. Thus there is a possibility for trade to cause the wrong or inefficient allocation of resources and direction of trade. In this case there is a possibility for both countries to lose with trade. When there is an efficient allocation of resources that reflect real comparative advantages, the country that remains specialized in the externality free, polluting good, wins with trade, while the other country may win if it specializes in the good that is non-polluting but affected by the externality. In other words the country that exports the clean good can win if it can earn large standard gains from trade, which in a Ricardian model requires specialization, to overcome the losses from the transboundary pollution. Thus there is a possibility for trade to be welfare improving for both countries, even though there is an externality.

Unteroberdoerster (2001) develops a very similar Ricardian model, with a dirty industry affecting a clean industry, and differentiating local from foreign pollution. The main results are the same than that of Benarroch and Thille (2001), but he explores further the determinants for trade being welfare improving for both countries or welfare reducing for both trading partners. He shows that when demand for the polluting good is high, the country that exports the clean good can not specialize and thus loses with trade. Also, if the pollution damage is strong both

countries lose with trade. On the other hand, when the demand for the cleaner good is large, both countries may win with trade.

Intuition would suggest that in the presence of transboundary pollution, if one country reduces emissions, that would provide incentives to the other country to expand output and emissions. Gürtzgen and Rauscher (2000) show that this is not always the case. The authors adapt a Dixit and Stiglitz (1977) model of intra-industry trade with monopolistic competition and endogenous number firms to include transboundary pollution. They show that when country tightens environmental policy, the number of firms in the trading partner can actually reduce if fixed costs are large and/or the monopolists' mark-up factor is low, i.e. demand is elastic.

Obviously one of the important challenges for the future is to design policy, ideally in a cooperative framework to deal with transboundary pollution. As green-house gases emissions increase, eventually countries will have to deal with the global "tragedy of the commons". Cooperative solutions have not proven to be very successful, as the Kyoto protocol commitments are not being upheld by some countries like the US. In Europe, there is a new transnational authority, the Community's government that can tackle the international externality. Some European economists have thus studied incentive proof policy that could deal with transboundary pollution. Harmonization of environmental policy does not produce efficient outcomes; because it is more efficient to make more emission reductions where it is cheaper (see for example Eyckmans (1999)). On the other hand, equalizing environmental standards has the merit of being easier to impose and supervise. Also, under asymmetrical information between polluters and policy makers the best policy could be harmonization of environmental policy (Bigano (1999)).

We can sum up the main findings in this literature by noting that trade in the presence of transboundary pollution is like South-South trade. Since both countries suffer from an externality trade can be welfare reducing for both countries. At the same time there is the possibility that trade improves the well-being of both countries, but in general that result requires either small transboundary effects or big standard gains from trade or both.

4. The Trade and Environment Policy Linkages

Given that bad environmental policy (i.e. existence of environmental externality) and barriers to trade represent two different distortions, initially economist suggested to deal with both problems separately (see for example Beghin et al. (1994)). Although first best treatment of these problems require that they be tackled with separate instruments it is necessary to deal with

them jointly. As Copeland (1994) notes, it is well known since the 1970's that in the presence of many distortions an arbitrary reduction in any given distortion may reduce or increase welfare, because of second best problems.

4.1. Linkages at the National Level

Both Copeland (1994) and Beghin et al. (1997) study trade policy for small economies (that take prices as given) in the presence of environmental externalities (sub-optimal pollution regulation) using dual function: restricted revenue functions and expenditure function. Beghin et al. (1997) additionally explore other policy instruments like consumption taxes. Both find that one can not generalize results about trade policy in the presence of both distortions. For example assume a country eliminates tariffs. That policy changes the composition of output, thus depending on whether the dirtier industries (more polluting) expand or contract the environment will improve or deteriorate. Although there will be standard gains from trade, the losses caused by a more polluted environment could over-compensate these gains for a net welfare loss. Thus additional assumptions are necessary to make welfare generalizations. For example, if all industries that are subject to trade protection (positive tariffs) are pollution intensive then a small equiproportionate reduction in tariffs will improve welfare. Also, if all industries that are subject to trade protection are pollution intensive then a small reduction in emission taxes in this sector is welfare improving. The intuition for the latter generalization is that the emissions taxes reduce the production of pollution-intensive sector which is indirectly subsidized by tariffs. The emission taxes reduction decreases the deadweight loss of the implicit production subsidy. The reader may refer to Copeland (1994) and Beghin et al. (1997) for additional generalizations.

Two conclusions can be highlighted from the previous two examples. First, environmental policy and trade policy are (imperfect) substitutes. Given that dealing with both distortions with one instrument is second best, only small changes in the policy instruments are welfare improving. Both papers highlight that small *coordinated* movements in both instruments toward first best are always welfare improving. The first best policy is to get rid of the trade distortion with zero tariffs (small country case) and to use emission taxes equal to marginal damage.

Zhao (2000) generates the same conclusions but modeling the environmental distortion as an open access externality and using iso-welfare curves which is a nice graphical tool that captures the necessity of coordinating policy in one easy to understand image. What the iso-

welfare curve shows is that coordinated reform toward first-best is always welfare improving. Also, it shows that large reductions in any one distortion, while keeping the other constant, is welfare decreasing. The message is that if a country suffers from large environmental distortions (for example no pollution regulation) and completely eliminates tariffs and opens to trade, most likely it will reduce well being rather than improving it.

Thus, at the national level the benevolent policy maker must link both environmental and trade policy.

4.2. Linkages at the International Level (Strategic Trade Policy)

Let us begin by noting that in practice there are international linkages between trade and the environment. There are several trade agreements that contain environmental provisions, like NAFTA, European Union. There are also some environmental agreements that contain trade sanctions like the Montreal Protocol on Substances that Deplete the Ozone Layer, or the Convention on International Trade in Endangered Species (CITES) that bans trade of certain endangered species and by-products like ivory and furs. Some authors in the policy world consider that these linkages are necessary to create credible threats necessary to make international law that deals with global environmental problems, and possibly as a tool of a future World Environment Organization (WEO), (see for example, Runge (1994)). On the other hand, the WTO has been consistent in not accepting differences in environmental damage of a product's production process as a ground for trade exceptions[7]. For the international organism, a product *x* is product *x* if it was produced with very clean or very dirty technology.

Many incompatibilities and challenges linger in the plane of international law. However, theory suggests that trade agreements should be linked to environmental agreements because environmental regulations may be used as an instrument to hide subsidies and gain international market shares. The GATT and later the WTO in their effort to facilitate trade have banned the use of non-tariff trade barriers and export subsidies. As we have indicated before, environmental policy can be used as an imperfect substitute of subsidies, and thus can be used to hide export subsidies.

[7] See for example the high profile Tuna-Dolphin case between the US and Mexico (Rugman (1994) and Sampson (2000)). Following the Marine Mammals Protection Act (MMPA- 1972) the US embargoed imports of tuna from Mexico because they had as by-catch more than 1.25 times the dolphins' by-catch of US fisheries. Mexico disputed this ban in the WTO (1991). The WTO found that the US measure was not valid because the ban was based on the process not the product, which violates the equal treatment of products provision of the GATT. The US did not abide by the ruling.

The concept of strategic environmental policy has been formalized by Ulph(1992), Barrett (1994), Rauscher (1994), and Copeland (2000). Strategic environmental policy refers to the use of environmental policy to help domestic oligopolistic competitors gain market shares. These models are based in Spencer and Brander (1983) and Brander and Spencer (1985) that show how by subsidizing these firms directly or supplying R+D subsidies to their sector, the firms can be turned from Cournot-Nash competitors to Stackelberg leaders. Rents are shifted from foreign firms to domestic firms increasing welfare. With strategic environmental policy instead of offering a direct subsidy (not allowed by a trade treaty like GATT), firms are granted emissions taxes which are below the environmental damage as a hidden subsidy (this has been called "environmental dumping"). Since there is a negative welfare effect from excess pollution firms are not granted enough emission allowance for them to become Stackelberg leaders, but they are still allowed to expand output to levels above the Cournot player capturing additional rents at the expense of other competitors, and most importantly, the local environment.

However, if one considers the general equilibrium effects it is not clear that always the policy to apply to expand the output of the oligopolist sector is to weaken their environmental standards. Rauscher (1994) shows that by weakening the environmental policy of a sector, it makes the good produced by in it cheaper, and that reduces the marginal returns of the factor employed there, forcing them to migrate to the other sector. This latter effect could overcome the direct effect of expanding output because of cheaper production. Copeland (2000) expands the discussion by showing in a two country scenario, that if the other country also subsidizes their oligopolist with strategic environmental policy, then they may end up in a new lose-lose Nash equilibrium. Countries lose, because as both expand output their monopoly rents are shrunk, and they further lose because of environmental deterioration: a classic prisoner's dilemma case.

Although, they have not been formalized in the literature, one can think of more scenarios where environmental policy can be used as strategic trade policy. For example, if an industry has economies of scale, it might be beneficial to subsidize it to drive competitors out of the market.

The policy implications of strategic environmental policy are straightforward. If countries commit to trade policy establishing tariffs and subsidies levels, they must also commit to environmental policy. This trade and environmental policy linkage is necessary to avoid countries gaining unfair market power, or even worse, end in a case of trade wars, where not only trade gains are lost, but furthermore, the environment is depleted.

This issue of "environmental dumping" is extremely tricky. What constitutes environmental dumping is not that countries have different environmental policy, but that they impose an environmental policy that is more lax than what is optimal for that country. Differences in environmental policy are expected to be observed, for the same reasons that there are comparative advantages: countries have different endowments of resources including the environment. For example it is natural to expect for a poorer country to have weaker environmental policy, because at its income level it is efficient for the country to trade off more pollution for additional income. Also, the ability of countries to absorb the environmental damage of output varies. For example the marginal damage of additional pollution is much higher in cities that are enclosed like Los Angeles, Santiago, and Mexico City, than in cities with good ventilation like New York. Furthermore, measuring if the environmental policy is too low is at best, very difficult. It must be shown that for given preferences, income level and the environment's ability to regenerate, the policy is too lax, i.e. taxes emissions below their marginal damage. At the current state of the art, we do not know how to value the environment accurately (although non-market techniques can provide lower bounds); nor do we know the real extent of the damage of pollutants to the environment, beyond their effect to human health.

There is some empirical support for linking trade and environmental agreements. Abrego et al. (1997) construct a Computed General Equilibrium (here forth CGE) model and allow for a repeated game to occur to determine trade and environmental policy. They study the effects of this policy on welfare, under different bargaining strategies: non-cooperative, bargaining over trade (Nash equilibrium), bargaining over trade and the environment (Nash equilibrium). In the model the South owns all of the environmental resources and it uses it to produce both the traded and non-traded good. The North does not use the environment as an input, but has a valuation for it. Results indicate both regions gain from expanding the trade bargaining set to include environment. However, compared to bargaining with cash side payments, linking trade and environmental policy through negotiation provides significantly inferior developing country (South) outcomes. Thus, in presence of non-use valuation of the environment by the North, a trade and environment policy-linked negotiation may be better than an environment-only negotiation, but negotiating compensation to developing countries for environmental restraint would be better.

5. Political Economy and Policy

Usually, the gains from trade are not equally distributed among factors of productions, as the Stolper-Samuelson theorem highlights in the Heckscher-Ohlin model. This redistribution of income brought about by trade also changes the political economy equilibrium, which may under certain circumstances improve environmental regulations and ultimately the environment. Furthermore, if the effects of environmental damage affect different groups of society with varying intensity (or some groups do not care about the damage), then there are incentives for these groups to compete and lobby for the policies that are more beneficial to them. These political economy linkages between trade and the environment are receiving an increasing amount of attention from economists.

Consider the case that pollution is originated by consumption, and only a group, "the greens" care about pollution (or are affected by it). Further, assume that home production is protected by a tariff. Hillman and Urpsrung (1992) show that in this case "the greens" would lobby for higher tariffs, because that would reduce consumption if as assumed foreign and local goods are less than perfect substitutes. The authors argue, that the more probable end result is that "the greens" displace the producers of the good in the lobby effort for higher tariffs, i.e. they free-ride the "green's" lobbying. These results change dramatically if pollution is assumed to be caused by production. In this case, the greens want free trade to displace contaminating production as much as possible to the other country. However, the trading partner's greens behave similarly, and the result is a prisoners' dilemma Nash equilibrium for the greens with both countries choosing free trade and maximizing pollution. However, if there are spillovers (transboundary pollution), the greens in both countries would lobby for protection.

Although, the efficient policy to control pollution is an environmental tax equivalent to the social marginal damage, Hoekman and Leidy (1994) argue that for political economy reasons this is not the more likely instrument used. The authors argue that quantitative restrictions are many times preferred because they are easier to enforce, and may appear as the more secure way of achieving emission reductions. The large deadweight losses that accompany inefficient policy may be reduced by the government by providing increased trade protection to the polluting and import competing sector. Thus the authors argue that inefficient environmental policies may be chosen for political reasons at the expense of free trade.

Fredriksson (1997) and Fredriksson (1999) explore the political economy competition for emission taxes when pollution is a by-product of production, and groups of society are affected differently by pollution. In this setup, greens of course want tight environmental policy to reduce pollution that decreases its welfare, while industrialists want lenient environmental policy that would allow them to increase output and increase rents. Additionally there is a government that maximizes a combination of social welfare and rents from lobby contributions (in a similar setup to Grossman and Helpman (1996)). In Fredriksson (1997) the author shows, that if all of society were a member of either lobby group then the pollution tax would not deviate from the social optimum. However, if this is not the case, than the higher the weight the Government gives to contributions relative to social welfare, then the further apart from its optimal level the pollution tax will be. That is as far as unambiguous relationships go. The political economy considerations bring counteracting forces into the comparative static of trade. For example assume that the environmental lobby group grows. It would be expected for the pollution tax to increase because (*i*) the disutility from pollution grows among the greens, and (*ii*) social welfare is more heavily affected by pollution. However there is a counteracting political economy effect (*iii*) a greater share of the tax revenues are rebated to the greens, which would want this group to prefer a higher tax. In Fredriksson (1999) the author explores the change in the pollution tax given a change in the trade policy. Note that, the pollution tax competition happens *given the trade policy*. Again, the effect of trade reform (reducing tariffs) has ambiguous effects over the pollution tax. Assume the production of the protected and polluting sector decreases after tariffs are reduced (as expected); then one side, the environmentalists lobby effort for a higher pollution tax is reduced because production falls *ceteris paribus*. On the other hand, the industrialists also reduce their lobby effort for a lower pollution tax as the tax affects less produced units. There is a final effect on rebated tax revenues; if the tax elasticity of revenues increases there is political economy effect pulling for a higher pollution tax.

Bommer and Schulze (1999), provide an example of how trade opening may cause tighter environmental policy to re-establish a political economy equilibrium after one sector receives all the gains from trade. The author develops a model with two sectors each with a fixed factor, and competing for labor. One sector, the export sector, additionally uses the environment for production, which is subject to a quota restriction as an environmental policy. There are four sectors lobbying for an environmental policy (quota) *given the trade policy*, the export sector and

labor, that want lower environmental standards, and the import competing sector and the environmentalist that want tighter environmental policy. The government chooses the environmental policy, given the trade policy, maximizing a welfare function that weighs the welfare level of all four lobby groups. As a consequence of opening to trade there are windfall gains for the export sector and labor, and losses for the other groups. In order to re-establish a political maximizing equilibrium, the government trades off some of these gains to the harmed sector by tightening environmental controls. Note however, that these results would be completely reverted if the sector that used the environment was the import competing sector, in that case as a result of opening to trade environmental policy would be relaxed to re-establish the political maximizing equilibrium.

Aidt (1998), with a very similar framework to that used by Fredriksson (1997) explore the more general case were lobby groups bid for both a pollution tax and a production subsidy (which can be understood as a protective tariff in an open economy). This exercise highlights the importance of targeting externalities with the right instrument. When there is political competition for both instruments simultaneously, only the pollution tax addresses the environmental externality, while the production tax/subsidy plays exclusively the role of distributing income. Of course, for the same political economy reasons the chosen pollution tax is different from the optimal Pigouvian rate. Schleich (1999) studies a very similar model, with a government choosing simultaneously trade and pollution policy, but instead of pollution affecting only the environmentalists, like in Aidt (1998) and Fredriksson (1997), all agents suffer disutility from pollution. In this case, the optimal pollution tax is also a deviation of the Pigouvian tax, but now the optimal trade policy is no price distortions with zero tariff/subsidy, even though lobby groups are competing for protection. All the income redistribution in this case is provided by the sector specific pollution tax. On the other hand, if pollution was caused by consumption, rather than production, then both the trade tariff/subsidy and the pollution tax are different from zero.

Damania (2001) expands the Fredrikksson (1997) setup and allows the possibility for polluters to invest in more efficient abatement technologies. He shows that under plausible assumptions of abatement technology, when the costs of less efficient technologies are high, polluters invest less in abatement and redirect resources to more contributions to obtain lower pollution taxes. The intuition of this result lies in the fact that when the least efficient (abatement

wise) have greater marginal benefits from a lower pollution tax. Additionally, lower investment in abatement technology acts as a credible threat for the government that profits are going to come down and so will political contributions. A government that values these hand-outs will lower the environmental tax.

Another linkage that could be beneficial for the environment is provided by the median voter, which is rational to believe in most countries is not a manufacturer or capital owner, but rather a consumer. As such, he receives only the externality of pollution, but not the direct rents from manufacturing goods. In a closed economy the median voter is willing to trade some weaker environmental policy for cheaper goods, but under free trade he would prefer zero pollution, because it would not affect price at he can buy the same imported goods (small country assumption). This idea is formalized by Yu (2000), in his model environmental regulations are tighter under free trade, but pollution is not brought to zero, because the government does not maximize its chances of being re-elected (follow the median voter's policy), but has an objective function that maximizes chances of being re-elected and contributions from lobbies (including the manufacturing/polluting sector).

6. Other Trade and Environmental Linkages

We now review other mechanisms presented in the economic literature by which trade can affect the environment.

6.1. The Terms of Trade Argument

Some authors have shown that very restrictive environmental policy may be pursued to restrict the output of an exported good that uses the environment and gain terms of trade benefits, assuming the country is big and can exert market power.

Alpay (2000) presents a simple Ricardian model with three goods produced, in a two country setting. Two are normal goods that can be traded, and another is environmental quality. Welfare depends on the goods that can be traded and the environmental quality, both: the one produced at home as well as the one produced abroad. Thus, the environmental good is a public good, that as is standard without cooperative behavior gets under-supplied. When countries trade, they may end supplying more of the environmental good than under autarky. This happens because there is a terms of trade incentive. By producing more environmental good one country reduces the supply of the good in which it is specialized, improving its terms of trade; also this effect is augmented by strategic behavior as the other country behaves just like the other. Thus

free trade through this term of trade effect can improve environmental quality, and under certain parameter restrictions, it can supply more environmental quality than in a cooperative game.

The balance in Alpay (2000) model is skewed towards environmental improvement, because the Ricardian model forces specialization in the traded goods, and all the terms of trade effect is channeled through the reallocation of resources from the traded sector to environmental investment. Rauscher (1994), shows the same result in a standard Heckscher-Ohlin framework where the factors of production are capital and emissions. In a Heckscher-Ohlin setting, if a country wants to improve its terms of trade it has to increase the relative price of the good that uses intensively the factor with which it is relatively well endowed (i.e. the good it exports). Thus a country well endowed with environmental resources should use a restrictive policy in the use of the environment, the opposite of environmental dumping. Note however, that the country relatively well endowed with capital should apply environmental dumping.

The terms of trade argument may apply in certain types of trade. What is important for it to be a relevant issue is that one country or a small group of countries own a big share of the world supply, in order to affect the world price. For example, OPEC country behave accordingly in their supply of oil (a non renewable natural resource), and one may conjecture it was the policy pursued by South American countries in early 20th century when they enjoyed the monopoly of natural rubber.

6.2. Debt, Resource Management, and Trade.

Rauscher (1989) points to another trade and environment link that is especially important for small open countries that are exporters of renewable resource intensive goods. He shows that the level of public debt that a country manages determines the speed at which renewable resources are depleted. The target steady state level of natural resources that the country would like to preserve is independent of the level of debt, as it depends on terms of trade, preferences and technology. However, during the transition phase when the stock of natural resources is being harvested; the level of debt determines the speed and effort spent in extracting renewable resources. The author shows that during transition if debt increases, so does the rate of extraction of renewable resources. That is, if public debt increases it is worthwhile for the country to reduce the debt faster, shifting extraction of the exportable resource from the future to the present. Obviously debt relief would have positive environmental effects, as extraction can be shifted from the present to the future.

II.- Empirical Analysis

1. Patterns of Trade and Industry Location

From the literature described above, the researcher expects to observe with the greater factor mobility and growth of trade among nations a constant migration of pollution/environment-intensive industries from the developed world to developing countries. Developing countries are poorer; because of income and political economy considerations have weaker environmental regulations; and in general, as a consequence of being in earlier stages of development have more abundance of environmental resources. For all these reasons, a growing share of the dirtier goods should be produced in the developing world. This phenomenon has been called: the "dirty industry migration" or "industry flight"; "displacement" of industry, when it is the tightening of the controls in developed countries that causes it; or "pollution haven" when it is the lack of regulations in the developing world that attracts the industries. Although there is broad theoretical support for this industry migration, the empirical evidence is rather mixed.

During the 1970's and 1980's some research was conducted among these lines, we briefly mention the most important results of this work, while focusing in the work published in the last decade[8]. Early studies found that the environmental abatement costs relatively to total cost were rather low. Walter (1973) estimates that environmental control costs relative to total costs of export goods were 1.75% (using 1968-1970 data). Robinson (1988) supplies some support for the industry migration hypothesis showing that in the US, between 1973 and 1982, pollution content of imported goods rose faster than the pollution content of the exported goods. In other words, during the period there was a shift in US trade towards importing relatively more pollution intensive goods. Tobey (1990) uses a Heckscher-Ohlin-Vanek model and a cross section of the most polluting industries (those whose abatement costs are higher than 1.85% of total production costs) from a pool of 64 standard industrial and agricultural sectors, covering 23 countries. Different regression analysis tests suggest that environmental control is not a valid variable in explaining the patterns of trade.

[8] The 1970's and 1980's research is more completely covered in earlier literature surveys, Dean (1992) and Xing and Kolstad (1996). Less comprehensive in this area, but also a good previous literature survey is Beghin et al. (1994).

Lucas et al. (1992) present evidence of polluting industry relocation, but they do not link the phenomenon to trade. The authors first calculate emissions per industry by linking Environmental Protection Agency's (EPA here forth) Toxic Release Inventory (1987) data to industrial census (1987) data, to calculate total toxic emission per dollar of output for different industries in the US. Then they assume that these pollution intensities remain constant through time (1960-88) and across countries (56 countries) to prepare a panel data set of toxic pollution per country and through time. Next, the authors review the effect of trade liberalization on toxic emissions. They conclude that although developing nations as a whole had greater toxic intensity growth during the 70's and 80's this trend was more pronounced in fast growing closed economies (i.e. trade would not have caused the toxic industry flight). Birdsall and Wheeler (1992) use Lucas et al. (1992) data for an empirical study of pollution intensive industries in Latin America. The authors regress the growth of toxic intensity of output on income growth, measures of openness to trade, and other control variables. They reach similar conclusions to that of Lucas et al. (1992): slow and closed economies exhibit faster toxic intensity pollution growth, while open and fast growing economies show lower toxic emission growth.

Low and Yeats (1992) explore the hypothesis of dirty industry migration by examining world trade data from 1967-68 and comparing it to 1987-88. They create a revealed comparative advantage index per industry: ratio of the country's share of export in one industry (i.e. country's export in that industry over the world total exports of that industry) to the country's share of total exports (i.e. country's total exports over world's overall exports). If the index is greater than 1, it is assumed that the country has a revealed comparative advantage in that industry. The authors study the evolution of the index for the five dirtiest industries according to the EPA's Toxic Release Inventory: iron and steel, nonferrous metals, refined petroleum, metal manufactures, paper and articles. The main conclusions are that: (*i*) the amount of countries with revealed comparative advantages in dirty industries has been growing; (*ii*) dirty industries account for a growing share of exports in some developing countries; while at the same time (*iii*) the share of dirty industries in total exports has been declining over time. Thus, the authors provide support for the hypothesis that dirty industries have been migrating, but they do not link it either to tougher environmental standards in developed countries (displacement) or opening to trade.

Grossman and Krueger (1993) repeat a similar exercise than that performed by Tobey (1990): check the effect of environmental regulation on trade flows, in their case import

penetration by industry. Grossman and Krueger use data on US imports from Mexico, and confirm Tobey (1990) results, that environmental policy has no effect over the trade flows.

Mani and Wheeler (1999) present evidence for the displacement theory, that is, tougher environmental standards in richer countries have forced polluting industries to relocate in developing nations with weaker regulations. The evidence comes from showing that in OECD countries the polluting to non-polluting output ratio has been falling, at the same time that the import to export ratio of polluting industries has been growing in the 1960-1995 span. The industries identified as most polluting are the top 5 of the EPA's Toxic Release Inventory. The support for the displacement theory is closed with evidence that the polluting to non-polluting output ratio has been growing in general in Latin America and in Asia (excluding Japan), and the import to export ratio of polluting industries has been falling in these same regions. However, the authors do not do a good job in convincing the reader that it is environmental regulations that cause this regional relocation of industries, since as they recognize different factors could explain the phenomenon: (*i*) income growth and the low income elasticity of demand of pollution intensive industries; (*ii*) the rise in the prices of energy and land (polluting industries are intensive in these inputs); (*iii*) tougher environmental standards (mostly since 1970s).

Wheeler (2001) supplies evidence that apparently contradicts the dirty industry migration hypothesis. The author shows that the countries that receive the greatest share of the world's overall foreign direct investment (FDI): Brazil, Mexico and China, have actually shown a reduction in the levels of urban air pollution (particulate matter).

The fact that different regression analysis shows that abatement costs, or environmental controls do not explain trade flows (Tobey (1990), Grossmann and Krueger (1993)) has puzzled researchers. A possible explanation is that higher abatement costs are not necessarily associated with reductions in output due to general equilibrium forces could be off-setting the intuitive result. Eskeland and Harrison (2002) show that when abatement costs rise, there is a substitution in production towards other factors, i.e. capital, if these factors are less polluting, they could reduce marginal costs, more than the rise in marginal costs produced by the hike in abatement costs; an unlikely but possible scenario. The authors, study foreign investment from US to Mexico and Venezuela, and French Investment to Morocco and Côte d'Ivoire discovering that these flows are not explained by the abatement costs these industries face in their homelands.

The authors are not surprised by the result, because as they argue previously larger abatement costs ought not to be unambiguously related to higher marginal costs.

Another possibility, for the ambiguous result of environmental policy explaining trade flows is provided by Levinson and Taylor (2001) and Ederington and Minier (2001), who argue that the economic theory we have reviewed above suggests that environmental policy is really endogenous. The strategic trade argument suggests that environmental policy can be used as a trade instrument to protect industries. Additionally, the political economy literature suggests that environmental policy may be used to redistribute income among groups in society. For these reasons, previous work that treated environmental policy as exogenous was getting biased results, and could explain the apparent ambiguity. Levinson and Taylor (2001) examine US imports (1974-1986) from Canada and Mexico and show that when environmental policy is treated as exogenous it does not explain imports. However, when they treat abatement costs as endogenous the ambiguity disappears; industries with the biggest increase in abatement costs import more. Ederington and Minier (2001) carry out a similar exercise using imports from a cross section of all US manufacturing industries (1978-1992). The authors find that environmental regulations have a significant but very minor effect on trade flows. They find more specifically that environmental regulations (measured as share of abatement costs of total costs) increases imports, but the elasticity is very low 0.53. However, when they treat the environmental regulation as an endogenous variable, and estimate a system of two equations with an efficient method (imports and environmental regulations) they find that the effect of environmental regulations on trade flows is much larger; they estimate an elasticity of 35. Additionally, the authors find evidence that environmental policy is being used as an indirect instrument for protecting industries, as import penetration has a significant (negative) effect over environmental policy.

A different method to test the effect of environmental policy on industry location is to estimate the marginal effect of environmental policy in the observed location choice for industrial plants. Levinson (1996) applies a conditional logit model to explain observed plant location of US firms in the 48 contiguous states controlling for the other factors that affect plant location like market size, infrastructure, wages, energy cost, etc. He uses different environmental stringency variables, with mixed result. However, both the FREE (Fund for Renewable Energy and the Environment) index of environmental law stringency and the industry's abatement costs,

jointly and separately are significant (and negative) in explaining industry location choices. List and Co (2000) use the same method to explain plant location of foreign firms, that is, US inbound FDI. Their results are unambiguous as all the measures of environmental regulation used explain negatively foreign plant location decisions. That is, states with lower abatement costs, and states which spend less effort in regulating polluters have a higher probability of receiving new foreign plants.

We can summarize the evidence supplied by this empirical literature by recognizing that originally the evidence seemed mixed, but the later research seems to converge to accepting the hypothesis of industry migration. On one hand, there seems to be a well documented relative growth of pollution-intensive industries in developing countries. At the beginning of the decade the mixed evidence for the industry migration hypothesis was justified by low abatement costs relative to other factors affecting industry location such as tax breaks, price of inputs, proximity to markets, political stability, etc. It was also argued that the growth of pollution in developing countries (Lucas et al. (1992)) could be justified by the development path rather than differences in environmental policy. However, the latest empirical research that more comprehensively collects the results from the theoretical literature and treats environmental policy as endogenous is showing that environmental policy does affect industry location and the patterns of trade.

2. Evaluating the Development, Trade, and Environment Linkages

A very useful tool in understanding the mechanisms by which trade affects the environment is decomposing the economic consequences of trade in scale, composition, and technique effects. This decomposition first suggested by Grossman and Krueger (1993), has been widely adopted by economists[9].

The scale effects refer to the changes in pollution emissions caused by output expansion assuming the nature of economic activity remains unchanged. That is, a change in pollution is purely caused by the scale effect when all sectors of the economy expand in equal proportions and the technique to produce output remains unchanged. However this is an unlikely outcome after an economy opens to trade. Trade will cause sectors that enjoy comparative advantages to expand, while others contract, as factors are reallocated with the change in relative prices that the opening to trade encompasses. This change in pollution caused by this modification of the

[9] Grossman and Krueger credit Task Force on the Environment and the Internal Market (1990) for proposing a similar decomposition.

structure of output is called the composition effect. Finally, the opening to trade and foreign investment is likely to change the technique used to produce output, changing the environmental damage by unit of output.

Many channels can explain this change in production techniques. For example, trade could bring the adoption of cleaner foreign technology. However, the main channel is through the growth in income. Although the empirical literature that examines it is not free of controversy, there is an overwhelming consensus that trade causes growth. Given that it is assumed that environmental quality is a normal good, as income grows after opening to trade, better environmental quality is demanded. Consequently, stricter environmental standards are imposed, which translate into the use of cleaner techniques or the investment in abatement efforts.

The scale effect is unambiguously environmentally degrading, the composition effect could either harm or improve the environment depending on the country's comparative advantages, and the technique effect has a positive effect on the environment. Thus, *a priori* one can not provide a definite answer for the question: Is trade good for the environment? For example, if the composition effects make a country leave the production of dirty industries and specialize in cleaner sectors, trade is then likely to be good[10]. In any case, globally the composition effect brought abroad by trade should be neutral as what one country does not produce should be produced in another place. Furthermore, if the technique effect becomes stronger with development (as income grows) eventually countries would observe environmental improvement. Grossman and Krueger (1993) supply evidence with a cross country study that emissions of both sulfur dioxide (SO_2) and dark matter (smoke) grow with income until a certain threshold, above which emissions begin to diminish. Thus, emissions plotted with respect to income follow an inverted-U shape further labeled in the literature as an Environmental Kuznets Curve (here forth EKC)[11].

Certain technological conditions and preference structures must be assumed to observe EKCs. López (1994) shows that the environmental Kuznets curve result relies both on a high degree of technical substitution elasticity between dirty and clean inputs, and on the preferences side, a high relative risk aversion (curvature of welfare with respect to income). Also, welfare

[10] Bandara and Coxhead (1999) provide an example (with a Computed General Equilibrium model for Sri Lanka) where trade is good to the environment because positive composition effects dominate.
[11] The original Kuznets Curve describes the relationship of income inequality with respect to income.

must be non-homothetic with respect to the environment and consumption goods. Alternatively, if the environmental improvement is thought of as the result of investment in abatement technologies, then that technology must show increasing returns to scale in order to observe a EKC, as Andreoni and Levinson (1998) show. It is important to refer to these technical requirements, because they may not describe all industries or economies.

Grossman and Krueger's finding of an EKC has inspired a vast literature trying to confirm or reject the findings for different samples (countries and periods), pollutants, and measures of environmental quality. It is not within the scope of this survey to cover comprehensively this literature, but we can refer to the main findings[12]. Most studies find that the EKC seems to exits for sulfur dioxide (SO_2), as Grossman and Krueger (1993) show. This finding, however, has been lately rejected as the product of time trend rather than income (Stern and Common (2001)). The evidence is mixed with respect to particulate matter. Grossman and Krueger (1993) reject the EKC for particulate matter, but Wheeler (2001) provides evidence of EKC for particulate matter in developing countries. The evidence for CO_2 is also mixed, see for example Galeotti and Lanza (1999). EKC do not seem to exist for industrial water pollution (Hettige et. al (1999)) or for deforestation (Koop and Tole (1999)). Furthermore, anecdotal evidence suggests that EKCs do no exist (or we have not observed the turning point) for pollutants like trash per person, ozone, and other.

In summary, there does not seem to be a predetermined road to environmental improvement where trade or development could lead to. Trade brings about changes in the economy that could be either harmful or beneficial to the environment. If comparative advantages are mostly determined by differences in environmental regulations, trade is likely to be harmful for the environment. EKC may exist for some pollutants, especially those that have important harmful effects at the local level, like NO_2 related to acid rain, but its existence is not so clear for emissions with global effects, like CO_2, a green house gas.

3. Empirical Evaluation of the Effects of Trade on the Environment and Welfare

3.1. CGE Estimations

Many of the empirical assessment of trade effects on the environment and welfare have been carried out with the use of CGE models. These models vary in their degree of generality,

[12] See Nordstrom and Vaughan (1999) for a more complete coverage of the empirical literature that has studied EKC of different pollutants and environmental quality measurements.

their realism, and how well calibrated they are. Their results should be taken with caution, as they are only an approximation, and especially when they try to measure the effects of large changes in the variables of the models like prices. General equilibrium holds relations at the margin, so large changes of variables may cause substitutions that are not necessarily captured either by the model or the assumed functional forms. In general, CGE simulations confirm theory discussed above (as they should); for example, trade does not necessarily improve welfare or the environment when the environmental externality is not addressed; also, trade may provide welfare gains in the presence of the externality if large positive composition effects dominate. We now review this research starting from the most general estimations to the country case studies.

Cole et al. (1998) and Cole et al. (2000) provide the most general results of the effects of trade on the environment, calculating the effects of the GATT Uruguay Round on five air pollutants (nitrogen dioxide, sulphur dioxide, carbon monoxide, suspended particulate matter and carbon dioxide), and the monetary costs associated with this emissions changes. Of course such global results are very rough estimates and require brave assumptions. They first combine estimations on composition changes associated to the trade agreement (borrowed from the literature) with separate estimations on pollution intensity by industrial sector (Lucas et al. 1992), to calculate the composition effects of emissions. Then they use the estimated income effects (borrowed from the literature) and econometrically estimate environmental Kuznets curves (assumed to exist for all pollutants) to compute what they call the combined technique and scale effect. Then they use estimates in the literature of the cost of pollution in health, labor, etc., to calculate the monetary costs of the pollution changes. They observe that all regions (9) are predicted to increase their nitrogen dioxide emissions, while sulphur dioxide, carbon monoxide and suspended particulate matter are predicted to increase in the developing world and fall in the developed world. There are overall costs associated to the trade agreement, especially in the case of nations that grow faster, that is when there are strong scale effects.

Perroni and Wigle (1994) also provide some general estimations of the effects of trade on the environment. The authors prepare a CGE model that incorporates environmental effects. There are three regions that trade goods. Production is affected by emissions, both produced at the local level, and also at the global level, i.e. transboundary pollution. The authors assume that governments charge an effluent tax for emissions, and that firms can pay to abate emissions. The

authors also assume that the emission revenues are transferred not to the affected parties, but to the consumers where the emissions are generated (an efficient but unrealistic possibility). The model is calibrated with very low abatement costs, as estimated in the literature (Walter (1973)). The results are standard in this CGE models. Without payment for emissions (without solving the environmental externality) trade worsens the environment quality. The authors are very happy to show that the damage is very low. However this damage depends on the environmental damage function that is assumed; no such function has been estimated in the literature. Also without emission payments welfare improves with trade as environmental quality is not valued in the welfare function. When the environmental externality is internalized through emission payments, there can be both environmental quality improvements and welfare gains with free trade.

There are many different CGEs that study the environmental and trade effects of policy in specific countries. We begin with one of the earlier such studies, Beghin et al. (1995), who apply a CGE model developed at the OECD and later also applied to Chile in Beghin et al. (2002). In this first paper the author use a dynamic and recursive CGE model for the Mexican economy including 9 sectors with different pollution intensities for 13 types of pollutants. The authors show that a unilateral trade opening would cause in the Mexican economy a composition change toward cleaner sectors, but the scale effect would dominate toward an overall more polluting end-result. Emissions taxes increase abatement, but cause overall income losses that vary by the type of emission targeted, but always with a negative income (output) effect. Linking emissions taxes with trade opening can result in both income gains and pollution reduction, the amount of the gains and the reduction of pollution varies with the type of emissions targeted. Very similar results are shown for Chile in Beghin et al. (2002), which actually has better welfare analysis because emissions are valued by their health impacts. Unilateral trade reform in Chile induces considerable worsening of the environment mainly caused by the cheaper access to imported energy sources. On the other hand trade agreements with NAFTA or the MERCOSUR have more benign environmental effects. Again, unilateral reform together with taxes on emissions (especially small particulate matter) can bring overall welfare gains.

There are different studies for Indonesia in the literature. Lee and Roland-Holst (1997), develop a CGE model that studies the trade pattern of Indonesia with special attention to the bilateral trade with Japan. The authors first examine the patterns of trade between Japan and

Indonesia, noting that Indonesia exports to Japan the more pollution intensive goods. Then they develop a three region (Japan, Indonesia and World) trade CGE model that includes emissions. The results indicate that unilateral trade liberalization by Indonesia would increase the ratio of emission levels to real output for almost all major pollution categories, which results actually in welfare losses. However, when tariff removal is combined with a cost-effective tax policy (that internalizes the environmental effects), the twin objectives of welfare enhancement and environmental quality improvement appears to be feasible. A more optimistic scenario is presented by Strutt and Anderson (2000) using a dynamic CGE. These authors, using a different model show that unilateral trade reform would actually improve air and water pollution over the horizon of 2 decades, and would slightly increase the degradation of renewable resources, even in the absence of policy directed to correct the environmental externality.

Dessus and Bussolo (1998) study the case of Costa Rica, also using a CGE. The authors find that environmental taxes alone, produce a small reduction in growth but sharply reduce emissions. On the other hand, unilateral trade reform, with across the board tariff reductions, promotes growth but also promotes specialization in dirty industries which translates into strong environmental damage. Like in the studies mentioned above, unilateral trade reform with the proper effluent taxes allows for growth and emission abatement.

Bandara and Coxhead (1999) develop a CGE model to study the effects of trade reform in the Sri-Lankan economy. The authors discover that unilateral opening to trade produces a win-win scenario for the country. That is, trade reform produces income gains as well as environmental improvements. This rather unconventional result is explained by the dominance of positive composition effects. Unilateral trade reform in Sri-Lanka would increase the demand for land for tea production. Being tea a much less erosive crop, causes trade to be environmentally improving.

3.2. Regression Analysis

A completely different approach to measure the effects of trade on the environment is offered by Antweiler et al. (2001). Instead of using CGE measurements, the authors use world trade data to separately estimate composition, scale, and technique effects of trade on the environment, using regression analysis. The authors first develop the micro-foundations for pollution emissions decomposing the scale, composition and technique effects. They use this theoretical equation to estimate the determinants of Sulfur Dioxide (SO2) emissions. The data

comes from the Global Environment Monitoring System (GEMS) spanning from 1971-1996 and covering 44 countries, mostly developed. They conclude that trade has a positive impact on the environment as they show that a 1% growth in the scale of output causes 0.3% increase in pollution concentrations, while at the same time income drives concentrations down by 1.4% via the technique effect. To the surprise of the authors they show that trade in itself is overall pollution reducing, when theory suggests that the overall effect should be zero, that is the aggregate composition effect should be zero. However, the results of these authors should be moderated, they do not show that trade is good for the environment as they pretend, but only show that trade reduces SO_2 emissions. From EKC studies we already knew that SO_2 emissions always seem to follow the EKC pattern. Also, the fact that trade reduces the emissions of one pollutant does not mean that it improves the environment, that result would require at least the same reduction pattern for a larger set of pollutants.

Dean (2000) follows a similar methodology to show that trade reform (opening) has been beneficial to the environment (water pollution) in China. The author develops a 2 by 2 trade model where pollution, a factor of production, is endogenized with an implicit demand for environmental quality (tolerance of pollution), which as theory indicates depends on income, price of goods and environmental policy. Based on the model the author estimates a system of two equations where water pollution growth and income growth are treated as endogenous, using province level data from China (1987-1995). The specification allows the identification of both composition and technique effects. The estimations suggests that trade liberalization has a direct negative effect over the environment via the composition effect. However, trade reform causes growth in income, which then causes a reduction in water pollution (technique effect) greater than the increase originally caused by the composition effect. Thus, trade appears to be good for the environment (reduces water pollution). One should be careful on generalizing these appealing results from China, because in China water pollution is taxed (which is why there is data on pollution), which reduces and potentially eliminates the environmental distortion.

3.3. Renewable Resources and Property Rights Failure

North-South trade models stress the over usage of natural resources, and the possibility of trade being welfare reducing under these circumstances. Unfortunately very few studies have attempted to measure the existence of this type of environmental externality, and the effects of trade under this externality. López (1998), and López (2000) provide empirical estimations of

this environmental externality by joining observed economic behavior from household surveys and environmental (biomass) depletion from satellite data in poor tropical countries. López (1997), estimates a production function for farms in Ghana (1988-1989), with biomass as a factor of production. He uses the estimated function to test the hypothesis that land is being cleared (after fallow periods) at socially optimal levels, and rejects it for assumed discount rates lower than 50%. He shows both, that biomass is an important factor of production (estimated factor share of 15-19%) and that biomass is overexploited, which reduces productivity of land and consequently farm income. Using, the parameters estimated, and others borrowed from the literature the author estimates the effect over national income of both reducing export taxes on agricultural goods, and across the board trade liberalization. Not surprisingly, reducing export taxes would diminish national income, as increasing the local price of agricultural goods would augment the pressure over biomass, reducing even further the productivity of farms. More surprising is the result that across the board trade reform would also reduce national income, that is, standard gains from removing price distortions, are less than the losses associated to the magnification of the environmental externality.

In López (1998), and López (2000), a similar exercise is carried out for Côte d'Ivoire (1985-1987). The author first estimates a revenue function for farms, where again biomass is a factor of production. The author shows that biomass is an important factor in production, with an implicit factor share estimated of 17%. Additionally, for reasonable social discount rates lower than 60%, the revenue estimation suggests that land is being over used, by clearing more forests and reducing fallow periods. Obviously this behavior results in sub-optimal productivity of land and lower rural revenues. In López (1998), the author argues that trade reform that improves the relative price of non-tree crops over tree crops, would increase land usage, magnifying the environmental externality, and potentially reducing national income. This issue is studied further in a general equilibrium framework in López (2000), where the author shows that complete removal of trade distortions increases real income up to 9% in the long run when land usage is in a new equilibrium.

4. The Political Economy of Environmental Policy

As Dean (2000), Levinson and Taylor (2000), Ederington and Minier (2001) argued, environmental policy can not be treated as exogenous. Furthermore, Fredriksson (1997) shows that environmental policy will deviate from the optimal depending on how the Government

values social welfare *vis-à-vis* lobby groups' contributions. Damania, Fredriksson and List (2000) argue that this relative valuation of lobby contributions may be understood as corruption. Using a similar framework to Fredriksson (1999) the authors show that trade opening reduces the pollution tax if corruption is low, and the opposite happens when corruption is high. The authors test this hypothesis estimating an equation for environmental policy (lead content on gas) for a time series pooled cross section of countries using different trade openness measures, a government honesty index, and other country characteristics as controls. The authors find evidence that their hypothesis is correct. First, government honesty tightens environmental policy, with a significant coefficient in all specifications. Furthermore, the cross product of the government honesty index and openness is always significant, and indicates that the effect of trade openness on the pollution tax depends on the degree of corruption of the government. Increased corruption amplifies the more stringent environmental policy effect brought by opening trade.

III.- The Ecological Economists' Critique

From the verge of mainstream economics, ecological economists have constructed a body of strong criticism to the way most economists have studies trade and environment issues. Some arguments are better founded than other, but is a productive exercise to review them, because it highlights the strengths and weaknesses of traditional economic analysis of the trade and environment debate.

One of the most important criticisms coming from the ecological economics camp has been called the *race to the bottom* hypothesis[13]. They argue that mainstream economists focus just on trade, ignoring the fact that there is factor movement in the globalized world we live in. If factors are allowed to move freely across borders, then traditional comparative advantages based on relative abundance of factors of production does not motivate trade, but instead absolute advantages do. Countries in an effort to gain absolute advantage will be forced to lower environmental standards, and labor standards as well, in a race to the bottom towards the lowest common denominator (see Daly (1993), Daly (1997)). Poor countries desperate for investments and jobs will lower their standards, while developed countries will be forced to lower theirs too

[13] A good summary of the ecological economics view of trade and the environment is given by Muradian and Martínez-Alier (2001).

in an effort to stop the exodus of capital, as the world falls in a vicious cycle of lowered wages and destroyed environment.

A well thought response to this hypothesis is given by Wheeler (2001). The author rejects the "race to the bottom" hypothesis, and its policy implication: equalizing international environmental standards and the possible use of trade as a coercive instrument. He first shows that in developing countries that captured most of the world's foreign direct investment (FDI) in recent years (Brazil, Mexico, and China), pollution (particulate matter) has been decreasing over time; the opposite result to what the "race to the bottom" hypothesis predicts. The "race to the bottom" hypothesis is flawed, according to Wheeler, because: (*i*) pollution control is not a critical cost factor for most firm; (*ii*) even low income communities penalize toxic polluters, and even in the absence of regulation; (*iii*) rising income strengthens environmental regulation; (*iv*) local businesses sometime control pollution because abatement reduces costs; and (*v*) large multinational firms generally adhere to OECD environmental standards in their developing-country operations. We can add that although there is a better integrated worldwide economy, we are far from observing perfect factor mobility. The proof lies in the simple examination of rates of return to capital in different nations; even after accounting for expected devaluation and country risk premium, rates of return are far from equalizing. Furthermore, asymmetric information in the risks involved in investing in a particular country, and the friction imposed by local policy to capital flows indicates that perfect capital mobility will not be an empirical regularity in the foreseeable future.

Nonetheless, there is certain theoretical support for the race to the bottom argument. Rauscher (1995) shows that when countries compete for industry location by offering tax rates for the environmental damage, the tax rate chosen varies from the cooperative tax rate. When the environmental damage is low, countries offer a lower rate than what would be optimal if countries chose the tax rate cooperatively and shared the benefits and costs of industry location. Furthermore, if there are large transboundary effects of pollution then countries may end up offering zero tax (or even a subsidy if possible) to attract industry location. These results follow Markusen et al. (1995) study for environmental policy competition within regions of a country: when disutility from pollution is low, regions compete undercutting each other's tax level; and when pollution disutility is high the polluting industry is driven off the market with high taxes.

Ecological economists also argue that economists assume very easily the dogma of two causal relationships: first, trade causes growth, and second, growth causes better environmental protection (and eventually improvement). There is widespread consensus that trade causes growth, however this is not undisputable. Standard gains from trade are static, but there is theoretical support for trade causing growth: economies of scale, monopolistic competition, diffusion of technology and learning by doing, etc. In the end if trade causes growth is an empirical issue, and the literature that has examined this question has not been exempt of controversy. There is overwhelming support for a positive empirical correlation between openness to trade and growth, but the causality arrow can not be shown to be unambiguously there. The second correlation is suggested by theory: if we value the environment positively, as we grow richer we are willing to make higher trade offs between income and the environment. However, the point at which environmental improvements become observable is very important on itself and seems to be ignored.

This latter argument appears to be the best founded criticism against traditional economic analysis. In economic analysis ecological considerations are ignored. Ecosystems are characterized by a complex web of inter-relationships some linear, some non-linear, some discontinuous, some not apparent, etc. Limiting the analysis of the effects of trade on the environment to EKCs can be extremely misleading. For example, a complete ecosystem may be destroyed by acid rain (and in turn destroying the sustainability of growth) in a certain region, before the economic threshold of reducing SO_2 emissions is achieved. This is possible because the point of irreversible damage for a particular ecosystem may be reached before the economic turning point for environmental improvement. Abatement is not always the solution. The abatement cost to recover extinguished species is infinite. How do we even value the genetic information contained in disappeared species? Thus, the fact that eventually, through income growth, there is demand for environmental improvement nothing guarantees that the supply will be there. Furthermore, it is efficient to trade off some environmental damage for income; however, agents and governments may be dealing with this trade off with severe under-valuing of the environmental damage due to ignorance.

IV. Conclusion

Although the literature that studies trade and environment has grown productively during the last decade, there are still many gaps to cover. A better multi-disciplinary approach is needed to determine more clearly the effects of output and emissions on the environment. For starters, it is necessary to deal with the toxicity of the emissions mix as very few studies have done. Furthermore, for the benefit of the policy makers it is necessary to delimit more clearly the conditions under which trade reform can be welfare improving in the presence of both local environmental externalities and transboundary pollution. Finally, in the ground of empirical evaluation more estimations are necessary beyond CGE analysis to creatively determine the effects of trade on the environment, differentiating among the competing effects brought about by trade.

REFERENCES

Abrego, Lisandro; Perroni, Carlo; Whalley, John; Wiggle, Randall, "Trade and Environment: Bargaining Outcomes from Linked Negotiations", National Bureau of Economic Research Working Paper: 6216, 1997.

Aidt, Toke S., "Political Internalization of Economic Externalities and Environmental Policy", Journal of Public Economics 69(1), 1998, pp. 1-16.

Alpay, Salvas, "Does Trade Always Harm the Global Environment? A Case for Positive Interaction", *Oxford Economic Paper*", 52(2) 2000, pp. 272-288.

Andreoni, James; Levinson, Arik, "The Simple Analytics of the Environmental Kuznets Curve", National Bureau of Economic Research Working Paper: 6739, 1998.

Antweiler, Werner ; Copeland, Brian R. ; Taylor, M. Scott, "Is Free Trade Good for the Environment?", *American Economic Review* 91(4), 2001, pp. 877-908.

Bandara, Jayatilleke S.; Coxhead, Ian , "Can Trade Liberalization Have Environmental Benefits in Developing Country Agriculture? A Sri Lankan Case Study" , *Journal of Policy Modeling*, 21(3), 1999, pp. 349-74

Barett, Scott, "Strategic Environmental Policy and International Trade", *Journal of Public Economics* 54(3), 1994, pp. 325-38

Beghin, John ; Roland-Holst, David; van der Mensbrugghe, Dominique, "A Survey of the Trade and Environment Nexus: Global Dimensions", *OECD Economic Studies* 23, 1994, pp. 167-92.

Beghin, John; Roland-Holst, David; van der Mensbrugghe, Dominique, "Trade Liberalization and the Environment in the Pacific Basin: Coordinated Approaches to Mexican Trade and Environment Policy", *American Journal of Agricultural Economics*, 77(3), 1995, pp. 778-85.

Beghin, John ; Roland-Holst, David ; van der Mensbrugghe, Dominique, "Trade and Pollution Linkages: Piecemeal Reform and Optimal Intervention", *Canadian Journal of Economics* 30(2), 1997, pp. 442-55.

Beghin, John; Bowland, Brad; Dessus, Sébastien; Roland-Holst, David; van der Mensbrugghe, Dominique, "Trade Integration, Environmental Degradation and Public Health in Chile: Assesing the Linkages", *Environment and Development Economics*, forthcoming, 2002.

Benarroch, Michael ; Thille, Henry, "Transboundary Pollution and the Gains from Trade", *Journal of International Economics* 55(1), 2001, pp. 139-59.

Bigano, Andrea, "Environmental Dumping, Transboundary Pollution and Asymmetric Information: Some Insights for the Environmental Regulation of the European Electricity Market", Fondazione Eni Enrico Mattei Note di Lavoro: 36/99, 1999.

Birdsall, Nancy; Wheeler, David, "Trade Policy and Industrial Pollution in Latin America: Where Are the Pollution Havens?", in Low, Patrick, ed., "International Trade and the Environment", World Bank Discussion Papers, no. 159. Washington, D.C.: World Bank, 1992, pp. 159-67.

Bommer, Rolf ; Schulze, Gunther G., "Environmental Improvement with Trade Liberalization", *European Journal of Political Economy* 15(4), 1999, pp. 639-61.

Brander, James A.; Spencer, Barbara J., "Export Subsidies and International Market Share Rivalry", *Journal of International Economics* 18(1-2), 1985, pp. 83-100.

Brander, James and Scott Taylor, "International Trade and Open Access Renewable Resources: The Small Open Economy Case", *Canadian Journal of Economics* 30(3), 1997a, pp. 526-52.

Brander, James and Scott Taylor, "International Trade between Consumer and Conservationist Countries", *Resource and Energy Economics* 19(4), 1997b, pp. 267-97.

Brander, James and Scott Taylor "Open Access Renewable Resources: Trade and Trade Policy in a Two-Country Model", *Journal of International Economics* 44(2), 1998, pp. 181-209.

Chichilnisky, Graciela, "North-South Trade and the Dynamics of Renewable Resources", *Structural Change and Economic Dynamics* 4(2), 1993, pp. 219-48.

Chichilnisky, Graciela, "North-South Trade and the Global Environment", *American Economic Review*, 84(4), 1994, pp. 851-74.

Cole, M. A. ; Rayner, A. J. ; Bates, J. M.,"Trade Liberalisation and the Environment: The Case of the Uruguay Round", *World Economy* 21(3), 1998, pp. 337-47

Cole, Matthew A. ; Rayner, Anthony J., "The Uruguay Round and Air Pollution: Estimating the Composition, Scale and Technique Effects of Trade Liberalization", *Journal of International Trade and Economic Development* 9(3), 2000, pp. 339-54.

Copeland, Brian R., "International Trade and the Environment: Policy Reform in a Polluted Small Open Economy", *Journal of Environmental Economics and Management* 26(1), 1994, pp. 44-65.

Copeland, Brian R., "Trade and Environment: Policy Linkages", *Environment and Development Economics* 5(4), 2000, pp. 405-32.

Copeland, Brian, and M. Scott Taylor, "North-South Trade and the Environment", *Quarterly Journal of Economics* 109(3), 1994, pp. 755-87.

Copeland, Brian, and M. Scott Taylor, "Trade and the Environment: A Partial Synthesis", *American Journal of Agricultural Economics* 77(3), 1995a, pp. 765-71.

Copeland, Brian R.; Taylor, M. Scott, "Trade and Transboundary Pollution", *American Economic Review* 85(4), 1995, pp. 716-37.

Copeland, Brian R.; Taylor, M. Scott, "The Trade-Induced Degradation Hypothesis", *Resource and Energy Economics* 19(4), 1997, pp. 321-44.

Damania, Richard ; Fredriksson, Per G. ; List, John A., "Trade Liberalization, Corruption, and Environmental Policy Formation: Theory and Evidence", CIES Working Paper # (2000), *Journal of Environmental Economics and Management*, forthcoming.

Damania, Richard, "When the Weak Win: The Role of Investment in Environmental Lobbying", *Journal of Environmental Economics and Management* 42(1), 2001, pp. 1-22.

Daly, Herman, "The Perils of Free Trade", *Scientific American* 269, 1993, pp. 24-29.

Daly, Herman, "Reconciling Internal and External Policies for Sustainable Development", in Dragun, Andrew, Jakobsson, Kristen, eds., *Sustainability and Global Environmental Policy: New Perspectives*, Edward Elgar, UK, 1997.

Dean, Judith M., "Trade and the Environment: A Survey of the Literature", in Low, Patrick, ed., International Trade and the Environment, World Bank Discussion Papers, no. 159. Washington, D.C.: World Bank, 1992, pp. 15-28.

Dean, Judith M., "Does Trade Liberalization Harm the Environment? A New Tes", CIES Policy Discussion Paper #0015, http://www.adelaide.edu.au/cies, 2000. *Canadian Journal of Economics*, forthcoming.

Dean, Judith M., "International Trade and the Environment", International Library of Environmental Economics and Policy Series, Ashgate, UK 2002.

Dessus, Sebastien ; Bussolo, Maurizio, "Is There a Trade-off between Trade Liberalization and Pollution Abatement? A Computable General Equilibrium Assessment Applied to Costa Rica", *Journal of Policy Modeling* 20(1), 1998, pp. 11-31.

Dixit, Avinash K.; Stiglitz, Joseph E., "Monopolistic Competition and Optimum Product Diversity" *American Economic Review* 67(3), 1977, pp. 297-308.

Ederington, Josh; Minier, Jenny, "Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis", Social Science Research Network, http://www.ssrn.com, 2001.*Canadian Journal of Economics*, forthcoming.

Eskeland, Gunnar; Harrison, Ann, "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis", NBER Working Paper # 8888, 2002.

Eyckmans, Johan, “Strategy Proof Uniform Effort Sharing Schemes for Transfrontier Pollution”, *Environmental and Resource Economics* 14(2), 1999, pp. 165-89.

Fredriksson, Per G., “The Political Economy of Pollution Taxes in a Small Open Economy”, *Journal of Environmental Economics and Management* 33(1), 1997, pp. 44-58.

Fredriksson, Per G., “The Political Economu of Trade Liberalization and Environmental Policy”, *Southern Economic Journal* 65(3), 1999, pp. 513-525.

Galeotti, Marzio; Lanza, Alessandro, “Desperately Seeking (Environmental) Kuznets”, Fondazione Eni Enrico Mattei Note di Lavoro: 02/99, 1999.

Grossman, Gene M. ; Helpman, Elhanan, “Protection for Sale”, *American Economic Review* 84(4), 1994, pp. 833-850

Grossman, Gene M. ; Krueger, Alan B., “Environmental Impacts of a North American Free Trade Agreement”, in Garber, Peter M., ed., The Mexico-U.S. free trade agreement, Cambridge and London: MIT Press, 1993, 13-56.

Gürtzgen, Nicole ; Rauscher, Michael, “Environmental Policy, Intra-industry Trade and Transfrontier Pollution”, *Environmental and Resource Economics* 17(1), 2000, pp. 59-71

Hettige, Hemamala ; Mani, Muthukumara ; Wheeler, David, “Industrial Pollution in Economic Development: Kuznets Revisited”, in Fredriksson, Per G., ed., “Trade, global policy, and the environment”, Discussion Paper, no. 402, World Bank, Washington, D.C., 1999, 65-82.

Hillman, Arye L.; Ursprung, Heinrich W., “The Influence of Environmental Concerns on the Political Determination of Trade Policy”, in “The greening of world trade issues”, Ann Arbor: University of Michigan Press, 1922.

Leidy, Michael P.; Hoekman, Bernard M., “'Cleaning Up' while Cleaning Up? Pollution Abatement, Interest Groups and Contingent Trade Policies”, *Public Choice* 78(3-4), 1994, pp. 241-58

Karp, Larry; Sacheti, Sandeep; Zhao, Jinhua, “Common Ground between Free-Traders and Environmentalists”, *International Economic Review* 42(3), 2001, pp. 617-47.

Koop, Gary; Tole, Lise, “Is There an Environmental Kuznets Curve for Deforestation?”, *Journal of Development Economics* 58(1), 1999, pp. 231-44.

Lee, Hiro; Roland-Holst, David, “The Environment and Welfare Implications of Trade and Tax Policy”, *Journal of Development Economics* 52(1), 1997, pp. 65-82.

Leger, Lawrence A., “Environmental Degradation as an Incentive for Trade”, *Review of International Economics* 3(3), 1995, pp. 307-18.

Levinson, Arik, "Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures", *Journal of Public Economics*, 62(1), pp. 5-29.

Levinson, Arik; Taylor, Scott, "Trade and the Environment: Unmasking the Pollution Haven Effect", manuscript, 2001.

List, John; Co, Catherine, "The Effects of Environmental Regulations on Foreign Direct Investment", *Journal of Environmental Economics and Management* 40(1), 2000, pp. 1-20.

López, Ramón, "The Environment as Factor of Production: The Effects of Economic Growth and Trade Liberalization", *Journal of Environmental Economics and Management* 27(2), 1994, pp. 163-84.

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

López, Ramón, "The Tragedy of the Commons in Côte d'Ivoire Agriculture: Empirical Evidence and Implications for Evaluating Trade Policies", *The World Bank Economic Review* 12(1), 1998, pp. 105-31.

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

Low, Patrick; Yeats, Alexander, "Do "Dirty" Industry Migrate?", in Low, Patrick, ed., "International Trade and the Environment", World Bank Discussion Papers, no. 159. Washington, D.C.: World Bank, 1992, pp. 89-103.

Lucas, Robert E. B.; Wheeler, David; Hettige, Hemamala, "Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960-88", in Low, Patrick, ed., "International Trade and the Environment", World Bank Discussion Papers, no. 159. Washington, D.C.: World Bank, 1992, pp. 67-86.

Mani, Muthikumara ; Wheeler, David, "In Search of Pollution Havens? Dirty Industry in the World Economy, 1960-1995", in Fredriksson, Per G., ed., "Trade, global policy, and the environment", Discussion Paper, no. 402, World Bank, Washington, D.C., 1999, pp. 115-28.

Markusen, James R., "Cooperative Control of International Pollution and Common Property Resources", *Quarterly Journal of Economics* 89(4), 1975a, pp. 618-32.

Markusen, James R., "International Externalities and Optimal Tax Structures", *Journal of International Economics* 5(1), 1975b, pp. 15-29.

Markusen, James; Morey, Edward; Olewiler, Nancy, " Competition in Regional Environment Policies When Plant Locations Are Endogenous", *Journal of Public Economics* 56(1), 1995, pp. 55-77.

McGuire, Martin, “Regulation, Factor Rewards, and International Trade”, *Journal of Public Economics* 17, 1982, pp. 335-54.

Muradian, Roldan; Martínez-Alier, Joan “Trade and the Environment: From a 'Southern' Perspective”, *Ecological Economics*, 36(2), 2001, pp. 281-97.

Nordstrom, Hakan; Vaughan, Scott, “Trade and environment”, Special Studies 4, World Trade Organization, Geneva, 1999.

Perroni, Carlo ; Wigle, Randall M., “International Trade and Environmental Quality: How Important Are the Linkages?”, *Canadian Journal of Economics* 27(3), 1994, pp. 551-67.

Pethig, Ruediger, “Pollution, Welfare and Environmental Policy in the Theory of Comparative Advantage”, *Journal of Environmental Economics and Management* 2, 1976, pp. 160-9.

Rauscher, Michael, “Foreign Debt and Renewable Resources”, *Metroeconomica* 40(1), pp. 57-66, 1989.

Rauscher, Michael, “On Ecological Dumping”, *Oxford Economic Papers* 46, 1994, pp. 822-40

Rauscher, Michael, “Environmental Regulation and the Location of Polluting Industries”, *International Tax and Public Finance* 2(2), 1995, pp. 229-44.

Robison, H. David, “Industrial Pollution Abatement: The Impact on Balance of Trade”, *Canadian Journal of Economics* 21(1), 1988, pp. 187-99.

Runge, C. Ford, “Freer trade, protected environment: Balancing trade liberalization and environmental interests”, Council on Foreign Relations Press, New York, 1994.

Sampson, Gary P., “Trade, environment, and the WTO: The post-Seattle agenda”, Overseas Development Council, Washington, D.C., 2000.

Schleich, Joaquim, “Environmental Quality with Endogenous Domestic Trade Policies”, *European Journal of Political Economy* 15(1), 1999, pp. 53-71.

Siebert, Horst, “Environmental Quality and the Gains from Trade”, *Kyklos* 30(n4), 1977, pp. 657-73.

Spencer, Barbara J.; Brander, James A., “International R & D Rivalry and Industrial Strategy”, *Review of Economic Studies* 50(4), 1983, pp. 707-22.

Stern, David I.; Common, Michael S., "Is There an Environmental Kuznets Curve for Sulfur?", *Journal of Environmental Economics and Management* 41(2), 2001, pp. 162-78.

Strutt, Anna ; Anderson, Kym, “Will Trade Liberalization Harm the Environment? The Case of Indonesia to 2020”, *Environmental and Resource Economics* 17(3), 2000, pp. 203-32.

Task Force on the Environment and the Internal Market, “1992: The Environmental Dimension”, Bonn, Economica Verlag, 1990.

Tobey, James A., “The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test”, *Kyklos* 43(2), 1990, pp. 191-209.

Ulph, Alistair, “The Choice of Environmental Policy Instruments and Strategic International Trade”, in R. Pethig ed., *Conflicts and Cooperation in Managing Environmental Resources*, Springer, Berlin, 1992.

Unteroberdoerster, Olaf , “Trade and Transboundary Pollution: Spatial Separation Reconsidered”, *Journal of Environmental Economics and Management* 41(3), 2001, pp. 269-85

Walter, Ingo, “The Pollution Content of American Trade”, *Western Economic Journal* 11(1), 1973, pp. 61-70.

Wheeler, David, “Racing to the Bottom? Foreign Investment and Air Pollution in Developing Countries”, *Journal of Environment and Development* 10(3), 2001, pp. 225-45.

Xing, Yuqing ; Kolstad, Charles D., “Environment and Trade: A Review of Theory and Issues”, University of California, Santa Barbara, Working Papers in Economics: 02/96, 1996.

Yu, Zhihao, "Environmental Protection and Free Trade: Direct and Indirect Competition for Political Influence", Centre for Globalisation and Labour Markets Research Paper 2000/3.

Zhao, Jinhua, “Trade and Environmental Distortions: Coordinated Intervention”, *Environment and Development Economics* 5(4), 2000, pp. 361-75.