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Environmental Effects of International Trade

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For working paper, tables 6&7, could restore 4 (fixed effects,time) columns]

Environmental Effects of International Trade

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Summary

The report surveys the state of our knowledge regarding the effects of trade on the environment. A central question is whether globalization helps or hurts in achieving the best tradeoff between environmental and economic goals. Do international trade and investment allow countries to achieve more economic growth for any given level of environmental quality? Or do they damage environmental quality for any given rate of economic growth? Globalization is a complex trend, encompassing many forces and many effects. It would be surprising if all of them were always unfavorable to the environment, or all of them favorable. The highest priority should be to determine ways in which globalization can be successfully harnessed to promote protection of the environment, along with other shared objectives, as opposed to degradation of the environment.

The report considers whether globalization has damaged environmental goals**.** Trade has some of its effects through the channel of accelerating economic growth, because trade contributes to growth analogously to investment, technological progress, and so on. Other effects come even when taking the level of income as given. In the case of each of the two channels, effects can be either positive or negative.

Concerning effects via the income channel, a common finding is the so-called Environmental Kuznets Curve: a loose U-shaped relationship between income and environmental quality. At early stages of economic development, growth brings a deterioration in the environment. But then after a particular peak level is reached further growth tends to bring an improvement in the environment. The peak is estimated to come at per capita income of around $5,000-$6,000 per year, in the case of sulphur dioxide (SO2). After that, the increased pollution coming directly from the greater scale of economic activity is outweighed by a switch from more highly polluting sectors (manufacturing) to less polluting sectors (services) as well as a switch within given industries from dirtier techniques to cleaner techniques.

Concerning effects of trade that come through non-income channels, they can again be negative or positive. On the negative side, the well-known "race to the bottom" hypothesis is that open countries in general, out of fear of adverse effects on their international competitiveness, adopt less stringent environmental regulations than less open countries. A less well-known set of possible effects could be called the "gains from trade" hypothesis: globalization could encourage technical innovation, ratchet up environmental standards, or lead to the exercise of consumer power and the adoption of corporate codes of conduct.

Finally, openness to trade might encourage some countries to specialize in dirtier activities, and to export their products to others with higher environmental standards. Under this "pollution havens" hypothesis, globalization has its primary effect on the distribution of pollution across countries, rather than on the overall average.

Any of these hypotheses is plausible. The question is empirical. The report reviews empirical evidence.

Empirical studies of cross-country data generally find no detrimental effects of trade on some measures of environmental degradation such as local SO2 (sulphur dioxide) air pollution, controlling for income. Thus globalization and the environment need not necessarily be in conflict. Trade and growth give countries the means to clean the air, provided they have effective institutions of governance in place at the national level**.** (Democratic governance is another determinant of environmental quality.)

The evidence does suggest that trade and growth can exacerbate *other* measures of environmental degradation, however, particularly CO2 emissions (carbon dioxide). The difference can be explained by the observation that CO2 is a global externality, which cannot be addressed at the national level due to the free rider problem. Institutions of governance are necessary at the multilateral level, and these have not been in place, at least until recently.

One point to be emphasized here is that it is an illusion to think that environmental issues could be effectively addressed if each country were insulated against incursions into its national sovereignty at the hands of international trade or the World Trade Organization (WTO). Increasingly, people living in one country want to protect the air, water, forests, and animals not just in their *own* countries, but also in *other* countries as well. To do so international cooperation is required. National sovereignty is the obstacle to such efforts, not the ally. Multilateral institutions are a potential ally, not the obstacle. The report then discusses whether the WTO has in the past been hostile to environmental goals. Most environmentalists have failed to understand the substantial evolution over time: There is now more legal basis than in the past for using trade measures to help enforce multilaterally agreed environmental initiatives, provided they are non-discriminatory.

The last part of the report focuses exclusively on the question of trade aspects of nations' climate change policy, which may be on a collision course with the global trade policy regime. In both Washington, DC, and Brussels, legislation implementing emission caps is likely to lead also to the unilateral application of tariffs (or their equivalent, a requirement for importers to surrender tradable permits) against carbon-intensive imports from countries that are deemed not to be doing enough to cut emissions. In practice such trade measures are likely to run afoul of the WTO, and for good reason. If they are to address valid concerns regarding leakage and competitiveness, it is suggested that border measures should follow certain principles. The principles include:

- Measures should only be applied by countries obeying emission targets of the Kyoto Protocol and/or its successors under the UN Framework Convention on Climate Change (UNFCCC).
- Judgments as to findings of fact -- what countries are complying or not, what industries are involved and what is their carbon content,

what countries are entitled to respond with border measures, or the nature of the response – should be made by independent panels of experts, not politicians who are vulnerable to political pressure from interest groups for special protection.

- Measures should try to equalize the marginal cost of carbon at the border. This rules out subsidies – whether in the form of money or extra permit allocations -- to domestic sectors that are considered to have been put at a competitive disadvantage, as currently contemplated the European Union.
- Import penalties should narrowly target fossil fuels, and a few of the most energy-intensive major industries, such as aluminum, cement, steel, paper, glass, and perhaps iron and chemicals. They should not target products that are further removed from the carbon-intensive activity, such as firms that use inputs that are produced in an energy-intensive process. Nor should unilateral measures seek to sanction an entire country.

This report recommends very specifically that when the Conference of Parties meets to negotiate a Kyoto successor (at Copenhagen, December 2009, in particular), it should agree on a multilateral framework for trade measures, rather than leaving it up to individual states without guidelines.

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Environmental Effects of International Trade

Introduction

Ten years ago, at the Ministerial meeting of the World Trade Organization (WTO) in Seattle in November 1999, some protestors wore turtle costumes while launching the first of the big anti-globalization demonstrations. These demonstrators were concerned that international trade in shrimp was harming sea turtles by ensnaring them in nets. They felt that a WTO panel had, in the name of free trade, negated the ability of the United States to protect the turtles, simultaneously undermining the international environment and national sovereignty.

Subsequently, anti-globalization protests became common at meetings of multi-national organizations. Perhaps no aspect of globalization worries the critics more than its implications for the environment. The concern is understandable. It is widely (if not universally) accepted that the direct effects of globalization on the economy are positive, as measured by Gross Domestic Product. Concerns rise more with regard to "non-economic" effects of globalization.[1] Of these, some, such as labor rights, might be considered to be a subject properly of national sovereignty, with each nation bearing the responsibility of deciding to what extent it wishes to protect its own labor force, based on its own values, capabilities, and politics. When we turn to influences on the environment, however, the case for countries sticking their noses into each other's business is stronger. We all share a common planet.[2]

Pollution and other forms of environmental degradation are the classic instance of what economists call an externality. This term means that individual people and firms, and sometimes even individual countries, lack the incentive to restrain their pollution, because under a market system the costs are borne primarily by others, rather than by themselves. The phrase "tragedy of the commons" was originally coined in the context of a village's shared pasture land, which would inevitably be over-grazed if each farmer were allowed free and unrestricted use. It captures the idea that we will foul our shared air and water supplies and deplete our natural resources unless somehow we are individually faced with the costs of our actions.

1. Objectives

[1] The quotation marks are necessary around "non-economic," because economists' conceptual framework fully incorporates such objectives as environmental quality, even though pollution is an externality that is not measured by GDP. For further reading on how economists think about the environment, see Hanley, Shogren, and White (1997) or Stavins (2000).

[2] The literature on trade and the environment is surveyed in Dean (1992, 2001) and Copeland and Taylor (2003b).

It is important to begin a consideration of these issues by making clear that both economic income and environmental quality are worthy objectives. Individuals may disagree on the weight that should be placed on one objective or another. But we should not let such disagreements lead to deadlocked political outcomes in which the economy and the environment are both worse off than necessary. Can globalization be made to improve the environment that comes with a given level of income in market-measured terms? Many seem to believe that globalization necessarily makes things worse. If Turkey grows rapidly, is an increase in pollution inevitable? Is it likely, on average? If that growth arises from globalization, rather than from domestic sources, does that make environmental damage more likely? Less likely? Are there policies that can simultaneously promote *both* economic growth and an improved environment? These are the questions of interest.

Two objectives: GDP and the environment

An extreme version of environmental activism would argue that we should turn back the clock on industrialization – that it is worth deliberately impoverishing ourselves -- if that is what it takes to save the environment. If the human species still consisted of a few million hunter-gatherers, man-made pollution would be close to zero. Thomas Malthus, writing in the early 19th century, predicted that geometric growth in population and in the economy would eventually and inevitably run into the natural resource limits of the carrying capacity of the planet.[3] In the 1960s, the Club of Rome picked up where Malthus had left off, warning that environmental disaster was coming soon. Some adherents to this school might favor the deliberate reversal of industrialization -- reducing market-measured income below current levels in order to save the environment.[4]

But environmental concerns have become more mainstream since the 1960s. We have all had time to think about it. Most people believe that both a clean environment and economic growth are desirable, that we can have a combination of both, and it is a matter of finding the best tradeoff. Indeed, that is one possible interpretation of the popular phrase "sustainable development."

To evaluate the costs and benefits of globalization with regard to the environment, it is important to be precise conceptually, for example to make the distinction between effects on the environment that come *via* rapid economic growth and those that come *for a given level* of economic output.

We have a single concept, GDP, that attempts to measure the aggregate value of goods and services that are sold in the marketplace, and that does a relatively good job of it. Measurement of environmental quality is much less well advanced. There are many different aspects of the environment that we care about, and it is hard to know how to combine them into a single overall measure. It would be harder still to agree on how to combine such a measure with GDP to get a measure of overall welfare. Proponents of

[3] Malthus was an economist. A contemporary commentator reacted by calling economics the dismal science. This description has stuck, long after ecology or environmental science broke off as independent fields of study, fields that in fact make economists look like sunny optimists by comparison.

[4] Meadows, et al (1972), and Daly (1993). For a general survey of the issues, see Esty (2001).

so-called *green GDP accounting* have tried to do exactly that, but so far the enterprise is very incomplete. For the time being, the best we can do is look at a variety of separate measures capturing various aspects of the environment.

A classification of environmental objectives

For the purpose of this report, it is useful to array different aspects of the environment according to the extent to which damage is localized around specific sources, as opposed to spilling out over a geographically more extensive area.

The first category of environmental damage is pollution that is ***internal*** to the household or firm. Perhaps 80 percent (by population) of world exposure to particulates is indoor pollution in poor countries -- smoke from indoor cooking fires -- which need not involve any externality.[5] There may be a role for dissemination of information regarding long-term health impacts that are not immediately evident. Nevertheless, what households in such countries are primarily lacking is the economic resources to afford stoves that run on cleaner fuels.[6] In the case of internal pollution, higher incomes directly allow the solution of the problem.

Some categories of environmental damage pose potential externalities, but could be internalized by assigning property rights, at least in theory. If a company has clear title to a depletable natural resource such as an oil well, it has some incentive to keep some of the oil for the future, rather than pumping it all today.[7] The biggest problems arise when the legal system fails to enforce clear divisions of property rights. Tropical forest land that anyone can enter to chop down trees will be rapidly over-logged. Many poor countries lack the institutional and economic resources to enforce laws protecting such resources. Often corrupt arms of the government themselves collude in the plundering. Another example is the dumping of waste. If someone agreed to be paid to let his land be used as a waste disposal site, voluntarily and without hidden adverse effects, economics says that there would not necessarily be anything wrong with the arrangement. Waste has to go somewhere. But the situation would be different if the government of a poor undemocratic country were to agree to be paid to accept waste that then hurt the environment and health of residents who lacked the information or political

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[5] Chaudhuri and Pfaff (2002) find an inverted U-shaped relationship between income and the generation of indoor smoke, across households. In the poorest households, rising incomes mean more cooking and more indoor pollution. Still-higher incomes allow a switch to cleaner fuels. Government intervention is not required.

[6] Some health risks in industrial production are analogous. Workers in every country voluntarily accept dangerous jobs, e.g., in mining, because they pay better than other jobs that are available to someone with the same set of skills.

[7] Even when property rights are not in doubt and there is no externality, a common environmental concern is that the welfare of future generations does not receive enough weight, because they are not here to represent themselves. From the economists' viewpoint, the question is whether the interest rate that enters firms' decisions incorporates the correct *discount rate*. This topic is beyond the scope of this report, but Goulder and Stavins (2002) provide a concise survey.

clout to participate in the policy decision or to share in the benefits. In that case the environmental effects do not belong in the first category.

The second category, ***national externalities***, includes most kinds of air pollution and water pollution, the latter a particularly great health hazard in the third world. The pollution is external to the individual firm or household, and often external to the state or province as well, but most of the damage is felt within the country in question. Intervention by the government is necessary to control such pollution. There is no reason why each national government cannot undertake the necessary regulation on its own, though the adequacy of economic resources to pay the costs of the regulation is again an issue.

A third category is ***international externalities***. Increasingly, as we will see, environmental problems cross national boundaries. In these cases, some cooperation among countries is necessary. Acid rain and downstream pollution of rivers are examples of externalities that spill across the border of the national state but affect only geographical neighbors. The strongest examples of international externalities are purely ***global externalities***: chemicals that deplete the stratospheric ozone layer, greenhouse gases that lead to global climate change, and habitat destruction that impairs biological diversity. Individual countries should not expect to be able to do much about global externalities on their own. These distinctions will turn out to be important.

The Environmental Kuznets Curve

Economic growth has both harmful effects on environmental quality and beneficial effects. As a generalization, the harmful effects come via the scale of industry and the beneficial effects come via shifts toward cleaner sectors and cleaner production techniques. What is the net outcome of these conflicting effects? A look at data across countries or across time allows some rough generalizations. For some important environmental measures, an inverted U-shaped relationship appears: at relatively low levels of income per capita, growth leads to greater environmental damage, until it levels off at an intermediate level of income, after which further growth leads to improvements in the environment. Grossman and Krueger (1993, 1995), and the World Bank (1992), brought to public attention this empirical relationship finding for a cross section of countries, using measures of local pollution.[8] Grossman and Krueger (1993) are evidently the ones to have named the inverted U-shaped pattern "the Environmental

[8] Grossman and Krueger (1993, 1995) found the U-shaped pattern for urban air pollution (SO_2 and smoke) and several measures of water pollution; Selden and Song (1994) found it for SO_2, suspended particulate matter (PM), NOx, and carbon monoxide; Shafik (1994) for suspended PM and SO_2 [and deforestation]; Hilton and Levinson (1998) for automotive lead emissions; Bimonte (2001) for the percentage of national territory that is protected land; and Bradford, Fender, Shore and Wagner (2005) for arsenic, COD, dissolved oxygen, lead and SO_2 (but not for PM and some other measures of pollution). Stern and Common (2001) review the case for sulphur, and emphasize the importance of including developing countries in the sample. The overall EKC literature is surveyed by Dasgupta, Laplante, Wang and Wheeler (2002).

Kuznets Curve." [9] Grossman and Krueger (1995) estimated that SO_2 (Sulfur Dioxide) pollution peaked when a country's income was about $5,000-$6,000 per capita (in 1985 dollars). Frankel and Rose (2003) estimated the peak at about $5,770. Most developing countries have not yet reached these thresholds.

For countries where a long enough time series of data is available, there is also some evidence that the same inverted U-shaped relationship can hold across time. The air in major industrialized cities was far more polluted in the 1950s than it is today. A similar pattern holds typically with respect to deforestation in rich countries: the percentage of US land that was forested fell in the 18th century and first half of the 19th century, but rose in the 20th century.[10]

The idea behind the Environmental Kuznets Curve is that, although growth is bad for air and water pollution at the initial stages of industrialization, later on it reduces pollution as countries become rich enough to pay to clean up their environments. It would be inaccurate to portray the Environmental Kuznets Curve (EKC) as demonstrating that if countries promote growth, the environment will eventually take care of itself. Only if pollution is largely confined within the home or within the firm does that Panglossian view apply. Most pollution, such as SO_2, NOx, etc., is external to the home or firm.[11] For such externalities, higher income and a popular desire to clean up the environment are not enough. There must also be effective government regulation, which usually requires a democratic system to translate the popular will into action (something that was missing in the Soviet Union, for example), as well as the rule of law and reasonably intelligent mechanisms of regulation. The empirical evidence confirms that the participation of well-functioning democratic governments is an important part of the process. That is at the national level. The requirements for dealing with cross-border externalities are greater still.

Another possible explanation for the pattern of the Environmental Kuznets Curve is that it works naturally via the composition of output. In theory, the pattern could result from the usual stages of economic development: the transition from an agrarian economy to manufacturing, and then from manufacturing to services. Services tend to generate less pollution than heavy manufacturing.[12] This explanation is less likely than

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[9] The phrase is by analogy with the classic Kuznets curve, an inverted U-shaped relationship between inequality and income per capita, discovered by Simon Kuznets, a winner of the Nobel Memorial Prize in Economic Sciences.

[10] Cropper and Griffiths (1994) find little evidence across countries of an EKC for forest growth. But Shafik (1994) does find the relationship for deforestation. Foster and Rosenzweig (2003) find supportive evidence in the time series for India.

[11] The term NOx includes both Nitric oxide (NO) and Nitrogen dioxide (NO_2), components of smog.

[12] Arrow, et al, (1995); Panayotou (1993).

the conventional view to require the mechanism of effective government regulation. If the Kuznets curve in practice resulted solely from this composition effect, however, then high incomes should lead to a better environment even when externalities arise at the international level, which is not the case. Importantly, most past research has not found a Kuznets curve for carbon dioxide, as we will see below.[13] Even though emissions *per unit of GDP* do tend to fall, this has not been enough to reduce overall carbon emissions.

2. Environmental Effects of Trade in the Average Country

Some environmental effects of international trade come via economic growth, and some arise even for a given level of income. In both cases, the effects can be either beneficial or detrimental. Probably the strongest effects of trade are the first sort, via income. Much like saving and investment, technological progress, and other sources of growth, trade tends to raise income. As we have seen, higher income in turn has environmental effects that are initially adverse even though, according to the Environmental Kuznets Curve, they eventually turn favorable in the case of some environmental criteria such as SO_2.

What about effects of trade that do not operate via economic growth? They can be classified in three categories: systemwide effects that are adverse, systemwide effects that are beneficial, and effects that vary across countries depending on local "comparative advantage." We consider the first two categories in this part of the report, and the third in the part of the report on pollution havens. The adverse systemwide effects can be classified under the phrase "race to the bottom." The beneficial effects can be put under the general rubric "gains from trade."

The "**Race to the bottom" hypothesis**

The notion of a *race to the bottom* is perhaps the strongest basis for fearing that international trade and investment specifically (rather than industrialization generally) will put downward pressure on countries' environmental standards and thus damage the environment across the global system.[14] Leaders of industry, and of the unions whose members are employed in industry, are always concerned about competition from abroad. When domestic regulation raises their costs, they fear that they will lose competitiveness against firms in other countries. They warn of a loss of sales, employment, and

[13] E.g., Holtz-Eakin and Selden (1995).

[14] There do exist other possible channels whereby international trade can be environmentally detrimental. Costello and McAusland (2003) and Costello, Springborn, McAusland and Solow (2006) study the problem of damage from the introduction of invasive or exotic species through trade,

investment to foreign competitors.[15] Thus domestic producers often sound the competitiveness alarm as a way of applying political pressure on their governments to minimize the burden of regulation.[16]

The "race to the bottom" concern is that, to the extent that countries are open to international trade and investment, environmental standards will be lower than they would otherwise be. But how important is this in practice?

Economists' research is mixed on how important is environmental regulation as a determinant of firms' ability to compete internationally. When deciding where to locate, multinational firms seem to pay more attention to such issues as labor costs and market access than to the stringency of local environmental regulation.[17]

We now consider possible factors that could work in the opposite direction, benefiting the environment, before turning to some statistical evidence on the question.

The "Gains from trade" hypothesis

While the possibility that exposure to international competition might have an adverse effect on environmental regulation is familiar, less widely recognized and more surprising is the possibility of effects in the beneficial direction, which we will call the *gains from trade hypothesis*. Trade allows countries to attain more of what they want, which includes environmental goods in addition to market-measured output.

How could openness have a positive effect on environmental quality, once we set aside the possibility of accelerating progress down the beneficial slope of the Environmental Kuznets Curve? A first possibility concerns technological and managerial innovation. Openness encourages ongoing innovation.[18] It then seems possible that openness could encourage innovation beneficial to environmental improvement as well as economic progress. A second possibility is an international

[15] Levinson and Taylor (2001) find that those US industries experiencing the largest rise in environmental control costs have indeed also experienced the largest increases in net imports. Mulatu, Florax, and Withagen (2004), add data also from Germany and the Netherlands to study the role of differences in environmental regulation, alongside the traditional role of differences in factor endowments, as determinants of net trade in various manufacturing industries.

[16] McAusland (2008) and Schleich (1999) find that opening to international trade raises political opposition to regulation of producer-generated ("smokestack") pollution but reduces opposition to regulation of household-generated ("tailpipe") pollution.

[17] Jaffe, Peterson, Portney and Stavins (1995), Grossman and Krueger (1993), Low and Yeats (1992), and Tobey (1990). A few other researchers, however, have found more of an effect of environmental regulation on direct investment decisions: Lee and Roland-Holst (1997) and Smarzynska and Wei (2001).

[18] Trade speeds the absorption of frontier technologies and best-practice management. This explains why those countries that trade more than others are observed to experience higher sustained growth, rather than just the one-time increase in the level of real income predicted by classical trade theory.

ratcheting up of environmental standards.[19] The largest political jurisdiction can set the pace for others. Within the United States, it is called the "California effect:" When the largest state sets high standards for auto pollution control equipment, for example, the end result may be similar standards in other states as well. The United States or the European Union can play the same role globally.

Multinational corporations (MNCs) are often the vehicle for these effects. They tend to bring clean state-of-the-art production techniques from high-standard countries of origin, to host countries where they are not yet known. The claim is not that all multinational corporations apply the highest environmental standards when operating in other countries. Rather the claim is that the standards tend on average to be higher than if the host country were undertaking the same activity on its own.[20]

Corporate codes of conduct offer a new way that residents of some countries can pursue environmental goals in other countries.[21] Formal international cooperation among governments is another way that interdependence can lead to higher environmental standards rather than lower.[22]

Estimates of the overall correlation of trade with environmental quality

Once again, it is important to distinguish (1) the fear that globalization will lead to a race to the bottom in regulatory standards, from (2) fears that the environment will be damaged by the very process of industrialization and economic growth itself. Opening of national economies to international trade and investment could play a role in both cases, but the two possible channels are very different. In the first case, the race to the bottom hypothesis, the claim is that openness undermines environmental standards even for a given path of economic growth. This would be a damning conclusion from the standpoint of globalization, because it would imply that by limiting trade and investment in some way, we might be able to attain a better environment for any given level of GDP. In the second case, the implication would be that openness only affects the environment in the way that investment, or education, or productivity growth, or any other source of growth affects the environment, by moving the economy along the Environmental Kuznets Curve. Trying to restrict trade and investment would be a less attractive strategy in this case, because it would amount to deliberate self-impoverishment.

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[19] E.g., Vogel (1995), Braithwaite and Drahos (2000), Porter (1990, 1991) and Porter and van der Linde (1995). This ratcheting up may be more effective for product standards than for standards regarding processes and production methods.

[20] Esty and Gentry (1997, pp. 157, 161, 163) and Schmidheiny (1992).

[21] Ruggie (2002).

[22] Neumayer (2002).

The question of most interest is thus: If a set of countries opens up to trade, is it on average likely to have a positive or negative effect on the environment *for a given level of income*? Which tend in practice to dominate, the unfavorable "race to the bottom" effects or the favorable "gains from trade" effects? Econometrics can help answer the question.

Statistically, some measures of environmental quality are positively correlated with the level of trade. For example, countries more open to international trade on average experience lower levels of SO_2 pollution.[23] Figure 1 shows the data for a cross-section of countries. On the horizontal axis, openness is measured by the ratio of total trade (imports plus exports) to GDP. On the vertical axis, pollution is measures by SO_2 concentrations. A negative correlation is evident, especially when one looks within either of the set of countries distinguished by those that are more democratic and those that are less so.[24]

[Insert Figure 1 about here]

But correlation is not causality. The causal relationships are complex, running in many directions simultaneously. One would not want to claim that trade leads to a cleaner environment, if in reality they are both responding to some other third factor, such as democracy or economic growth or population density.

A number of studies have sought to isolate the independent effect of openness. Lucas, et al. (1992), study the toxic intensity implied by the composition of manufacturing output, and find that trade-distorting policies increase pollution in rapidly growing countries. Dean (2002) finds on net a beneficial effect of liberalization for a given level of income. Antweiler, Copeland and Taylor (2001) and Copeland and Taylor (2001, 2003, 2004) also conclude that the net effect of trade liberalization on SO_2 concentrations is beneficial.

None of these studies makes allowance for the problem that trade may be the *result* of other factors rather than the cause. Antweiler, Copeland and Taylor (2001) point out this potential weakness.

Updated evaluation of the overall effect of trade on the environment

Frankel and Rose (2003) attempt to disentangle the various causal relationships for data across countries in the year 1990. It attempts to isolate the effects that trade have

[23] E.g., Eiras and Schaeffer (2001, p. 4).

[24] Barrett and Graddy (2000) is one of several studies to find that an increase in civil and political freedoms significantly reduces some measures of pollution. Fredriksson and Mani (2004) find that the *combination* of trade integration and political stability enhances the stringency of environmental regulation.

independently of income by means of the gravity model.[25] Thus it begins by considering the relationship between pollution and income. Consistent with much of the rest of the literature, it finds statistical support for the famous Environmental Kuznets Curve for all three measures of air pollution -- SO2, NOx and PM[26] – but finds the opposite for CO2: emissions continue to accelerate with growth indefinitely, as estimated inside the observed range. Holding constant for income, openness as measured by the ratio of trade to income is estimated to reduce air pollution for all three pollutants, especially so for SO2. This suggests that the "gains from trade" effects are at least as powerful as the "race to the bottom" effect. But again the opposite result emerges for CO2: openness is estimated to worsen emissions, at any given level of income, with a moderate level of statistical significance. This suggests fears that competitiveness concerns will engender a race to the bottom in regulation are more justified in the case of carbon.[27]

The difference between the CO2 case and the case of local pollution is easily explained. Ordinary air pollution is an externality from the standpoint of the household or firm, but much less so from the standpoint of the nation. If a society has the means and will to clean up its air, which requires both an adequate level of income and an effective mechanism of governance, it will do so. But this happens by government regulation, not automatically. Externalities such as ozone depletion, species diversity, and GHG emissions are purely global. National governments cannot address them effectively on an individual basis, due to the free rider problem. Absent an effective multilateral governance mechanism, there is nothing to restrain detrimental effects of trade and growth on the global environment.

Chintrakarn and Millimet (2006) have used the gravity model to obtain similar results at the sub-national level. Kellenberg (2008) has recently used it to obtain similar results for a panel of 128 countries. He finds that the beneficial environmental effects of trade -- reducing emissions of four local air pollutants -- arises among poor countries and among rich countries. For middle-income countries Kellenberg finds the opposite effect.[28]

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[25] The gravity model specifies exogenous determinants of a country's level of trade: distance from major trading partners, common borders or languages, landlockedness, size, income per capita, and others.

[26] PM is Particulate Matter, linked to heart disease, lung cancer, and other health hazards.

[27] The contribution of that study is that it addresses the problems of causality that are likely to follow because trade is endogenous, and income too. It focuses on exogenous variation in trade across countries attributable to factors such as geographical location. When the statistical technique (Instrumental Variables) corrects in this way for the endogeneity of trade and income, it finds qualitatively similar answers (similar to the Ordinary Least Squares case). Trade and growth (at higher levels of income) both tend to be beneficial for measures of national air pollution, but detrimental for emissions of CO_2.

[28] Appendix 1 addresses a recent critique regarding these papers.

We now update the Frankel-Rose study, to include data more recent than 1990. We seek to explain the dependent variable, which takes the form, in sequence, of several measures of environmental degration. Of the explanatory variables, the one we are most interesting in estimating is the environmental effect of trade. Econometric techniques allow us to control for the effects of income, democratic governance (measured by Polity[29]) and population density (captured by its inverse, land area per capita). See Frankel and Rose (2003) for more details. Tables 1 and 2 pertain to 1990, and generally reproduce the original findings: SO2 and PM emissions show Environmental Kuznets Curves, i.e., pollution turns down when income becomes sufficiently high.[30] Openness has a significant dampening effect on SO2 in column (3) of Table 1, and a significant exacerbating effect on CO2 emissions in column (1), but is insignificant in the other cases. Democracy generally has a statistically beneficial effect.[31] Estimation for net forestation shows statistically insignificant results, and is not reported in this paper.

Tables 5, 6 and 7 (in Appendix 2) update the estimation to 1995, 2000 and 2004, respectively.[32] The results are not as strong as before, especially for PM10. Part of the problem may be inadequate sample sizes in the case of the most recent observed year, 2004; many countries are missing from the sample because they do not report data on a timely basis. Accordingly, in Tables 3 and 4 [formerly 6 and 7] we gather together data for the entire period 1990-2004 into a single sample, i.e., a panel study. The more data that are used, the more reliable are the estimates. Table 3 treats each year as a single cross section of data points, while Table 4 represents each year by the subsequent five-year average, with the objective of averaging out some noise in measurement.

The results for CO2 are fairly strong: An Environmental Kuznets Curve has now appeared – suggesting that emissions may eventually turn down at high levels of income after all -- perhaps as a result of efforts among some high-income countries since the

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[29] The Polity IV Project continues the "Polity" research tradition of coding the authority characteristics of states in the world system for purposes of comparative, quantitative analysis. The original Polity conceptual scheme to measure concomitant qualities of democratic and autocratic authority in governing institutions was formulated, and the original Polity I data collected, under the direction of Ted Robert Gurr. Polity envisions a spectrum of governing authority that spans from fully institutionalized autocracies to fully institutionalized democracies. The "Polity Score" captures this regime authority spectrum on a 21-point scale ranging from -10 (hereditary monarchy) to +10 (consolidated democracy).

[30] This follows from the result that the coefficient on the quadratic term (income squared) is significantly less than zero.

[31] The reproduction does not entirely match the original because we have used different measures of environmental quality. Air pollution is measured in terms of emissions (metric tons per capita), rather than concentrations. Furthermore, these tables use PM10 (particulate matter with aerodynamic diameter of 10 micrometers) in place of the broader measure of PM. In addition, the sample sizes here vary; they have been chosen to match those for which subsequent-year data are available.

[32] Water pollution now shows a EKC for 1995 and 2000. The water results are reported in the panel tables (below) but not cross-sections for individual years.

1997 Kyoto Protocol established a modicum of multilateral governance. Trade, however, continues to show up as exacerbating CO2 emissions.[33]

[33] It has been suggested that the quadratic equation may be too confining as a functional form to capture the relationship between income and environmental quality. Harbaugh, Levinson, and Wilson (2001) emphasize the sensitivity of the standard Environmental Kuznets Curve findings to such details as functional form. Grossman and Krueger (1993, 1995), Selden and Song (1994) and Panayotou (2000) in fact used quadratics [Candia, 2003]. Frankel and Rose tried a spline function as an alternative to the cubic (which made little difference to the results). Here, in the appendix tables 1A-7A, we try the cubic functional form. In some cases, particularly 1995, the data do seem to fit the cubic form more comfortably than the quadratic. But there are no major qualitative changes regarding our main focus of interest: the effect of openness on the environment, conditional on income. Trade still appears to exacerbate emissions of CO2.

Table 1: Determination of Environmental Degradation, 1990, OLS

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**CO2,** F-R2004	**CO2,** 2008	**SO2,** F-R 2004	**SO2,**2008	**PM,** F-R'04	**PM10,** 2008
Trade/GDP	0.017**	0.001	-0.306***	0.002	-0.374	0.001
	(0.008)	(0.002)	(0.079)	(0.002)	(0.337)	(0.001)
Log real GDP per capita	-17.879***	2.492**	287.250**	0.363	566.651	0.967
	(4.365)	(1.051)	(118.806)	(0.919)	(336.189)	(0.720)
Log real GDP p/c squared	1.329***	-0.063	-16.584**	0.032	-35.566*	-0.075*
	(0.284)	(0.062)	(6.781)	(0.055)	(19.056)	(0.042)
Polity (democracy)	-0.016*	-0.010**	-6.579***	0.001	-6.697*	-0.001
	(0.009)	(0.004)	(2.049)	(0.002)	(3.416)	(0.005)
Log of Area per capita	0.155	-0.068	-2.921**	0.146**	-13.024**	-0.021
	(0.155)	(0.099)	(1.394)	(0.064)	(6.292)	(0.039)
Observations	102	132	41	134	38	133

Table 2: Determination of Environmental Degradation, 1990, IV

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**CO2,** F-R2004	**CO2,** 2008	**SO2,** F-R 2004	**SO2,**2008	**PM,** F-R'04	**PM10,** 2008
Trade/GDP	-0.011	0.025*	-0.220	0.006	-1.311	0.005
	(0.022)	(0.013)	(0.394)	(0.008)	(1.012)	(0.006)
Log real GDP per capita	-15.201***	0.218	245.369	-0.693	578.784**	0.374
	(3.462)	(2.053)	(186.551)	(1.287)	(251.316)	(0.916)
Log real GDP p/c squared	1.165***	0.059	-14.335	0.093	-35.826**	-0.041
	(0.215)	(0.120)	(10.287)	(0.075)	(14.590)	(0.053)
Polity (democracy)	-0.022	0.004	-6.265***	0.002	-7.242**	0.001
	(0.018)	(0.011)	(2.148)	(0.007)	(2.674)	(0.005)
Log of Area per capita	0.032	0.069	-0.748	0.202***	-16.548*	0.015
	(0.234)	(0.110)	(7.760)	(0.070)	(9.447)	(0.050)
Observations	97	117	38	118	35	118

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses.

Notes: Robust standard errors in parentheses.

1. F-R'04: the Frankel & Rose (2004) result
2. F-R'08: update with Penn World Table 6.2, and new environmental data:
3. New CO2 country emission data from WB WDI ---- National CO2 emissions (metric tons per capita)
4. New SO2 country emission data: from WRI and EDGAR ---- National SO2 emissions (metric tons p.c.)
5. New PM10 country level data: from WB WDI ---- PM10 country level (micrograms per cubic meter)

Table 3: Determination of Environmental Degradation, Panel

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**
		Random Effects		
Trade/GDP	0.002***	-0.000	-0.000	-0.001
	(0.000)	(0.001)	(0.000)	(0.000)
Log real GDP per capita	1.797***	-0.240	0.891***	3.027***
	(0.131)	(0.628)	(0.144)	(0.309)
Log real GDP p/c squared	-0.060***	0.059	-0.071***	-0.154***
	(0.008)	(0.038)	(0.009)	(0.018)
Polity (democracy)	-0.000	0.001	-0.000	-0.001
	(0.000)	(0.002)	(0.000)	(0.001)
Log of Area per capita	-0.363***	0.102*	0.504***	-0.000
	(0.020)	(0.053)	(0.027)	(0.036)
Observations	5371	443	2149	1952
Number of cid	157	158	158	136

Table 4: Determination of Environmental Degradation, 5-year Panel

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**
		Random Effects		
Trade/GDP	0.002***	0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Log real GDP per capita	2.260***	0.982	0.915**	3.104***
	(0.307)	(0.771)	(0.395)	(0.571)
Log real GDP p/c squared	-0.077***	-0.015	-0.073***	-0.147***
	(0.018)	(0.046)	(0.024)	(0.034)
Polity (democracy)	0.001	0.002	-0.001	-0.001
	(0.001)	(0.003)	(0.001)	(0.002)
Log of Area per capita	-0.195***	0.109**	0.124***	-0.078*
	(0.035)	(0.054)	(0.037)	(0.044)
Observations	1118	463	463	494
Number of cid	157	158	158	136

*** p<0.01, ** p<0.05, * p<0.1

Notes: Robust standard errors in parentheses.

1. New CO2 country emission data from WB WDI ---- National CO2 emissions (metric tons per capita)
2. New SO2 country emission data: from WRI and EDGAR ---- National SO2 emissions (metric tons p.c.)
3 New PM10 country level data: from WB WDI ---- PM10 country level (micrograms per cubic meter)
4. Water Pollution: from WB WDI Organic water pollutant emissions (kg per day per capita)

3. The Pollution Haven Hypothesis

So far we have only considered effects that could be expected to hold for the *average* country, to the extent that it is open to international trade and investment. What if the effect of trade is that the environment improves in some open countries and worsens in others? An oft-expressed concern is that, to the extent that countries are open to international trade and investment, some will specialize in producing dirty products, and export them to other countries. Such countries could be said to exploit a comparative advantage in pollution. The prediction is that the environment will be damaged in this set of countries, as compared to what would happen without trade. The environment will be *cleaner* in the second set of countries, those that specialize in clean production and instead import the dirty products from the other countries. Leaving aside the possibility of a race to the bottom effect, the worldwide environment on average might even benefit somewhat, just as aggregate output should benefit, because of the gains from trade. But not everyone would approve of such a bargain.

Differential effects arising from comparative advantage

What determines whether a given country is expected to be in the set of economies specializing in clean or dirty environmental production? There are several possible determinants of comparative advantage, arising from cross-country differences in, respectively: capital endowments, natural resource endowments, and regulation.

Endowments and comparative advantage

First, trade patterns could be determined by endowments of capital and labor, as in the standard neoclassical theory of trade, attributed to Heckscher, Ohlin, and Samuelson. Assume manufacturing is more polluting than alternative economic activities, such as services. (If the alternative sector, say agriculture, is instead just as polluting as manufacturing, then trade has no overall implications for the environment.) Since manufacturing is capital intensive, the country with the high capital/labor ratio – say Japan – will in theory specialize in the dirty manufactured goods, while countries with low capital/labor ratios – say India – will specialize in cleaner goods.

For example, Grossman and Krueger (1993) predicted that NAFTA might reduce overall pollution in Mexico and raise it in the United States and Canada, because of the composition effect: Mexico has a comparative advantage in agriculture and labor-intensive manufacturing, which are relatively cleaner, versus the northern comparative advantage in more capital intensive sectors. This composition effect runs in the opposite direction from the usual worry, that trade would turn Mexico into a pollution haven as a result of high demand for environmental quality in the United States. That theory is discussed in the next section, below.

Second, comparative advantage could be determined by endowments of natural resources. A country with abundant hardwood forests will tend to export them if given the opportunity to do so. Here there cannot be much doubt that trade is indeed likely to

damage the environment of such countries.[34] True, in theory, if clear property rights can be allocated and enforced, someone will have the proper incentive to conserve these natural resources for the future. In practice, it seldom works this way. Poor miners and farmers cannot be kept out of large tracts of primitive forest. And even if there were clear property rights over the natural resources, private firms would not have the correct incentives to constrain external side effects of logging and mining, such as air and water pollution, soil erosion, loss of species, and so on. Government regulation is called for, but is often stymied by the problems of inadequate resources, at best, and corruption, at worst.

Pollution havens

Third, comparative advantage could be deliberately created by differences in environmental regulation itself. This is the pollution haven hypothesis most narrowly defined.[35] The motivation for varying levels of regulation could be differences in demand for environmental quality, arising, for example, from differences in income per capita. Or the motivation could be differences in the supply of environmental quality, arising, for example, from differences in population density.

Many object to an "eco dumping" system according to which economic integration results in some countries exporting pollution to others, even if the overall global level of pollution does not rise. The desire to "harmonize" environmental regulation across countries, and the arguments against it, are analyzed by Bhagwati and Srinivasan (1996).

Those who object find distasteful the idea that the impersonal market system would deliberately allocate environmental damage to an "underdeveloped" country. A Chief Economist of the World Bank once signed his name to an internal memo with economists' language that read (in the summary sentence of its most inflammatory passage) "Just between you and me, shouldn't the World Bank be encouraging *more* migration of the dirty industries to the LDCs [Less Developed Countries]?" After the memo was leaked, public perceptions of the young Larry Summers were damaged for years.

There is a little empirical evidence, but not much, to support the hypothesis that countries that have a particularly high demand for environmental quality – the rich countries – currently specialize in products that can be produced cleanly, and let the poor countries produce and sell the products that require pollution. Suri and Chapman (1998) find that middle-income countries' growth only leads to lower domestic pollution if they increase imports of manufactures. Muradian, O'Connor and Martinez-Alier (2001) find evidence that the imports of rich countries embody more air pollution than their exports. Ederington, Levinson and Minier (2003) find that pollution abatement costs are relevant

[34] Smulders, van Soest, and Withagen (2004) study trade-induced habitat destruction.

[35] Chua (2003) and Regibeau and Gallegos (2004) develop some of the theory. The latter paper argue thats, although some openness to trade is good for the environment, pollution havens are more likely to arise when the government has completely committed to free trade than when it retains some trade barriers; the intricate argument is that only by retaining some barriers can the government credibly offer the carrot of protection as an incentive to persuade domestic firms to adopt cleaner technologies.

for only a small sub-set of trade: imports from developing countries in sectors that are especially mobile geographically. Kander and Lindmark (2006) find that the pollution haven hypothesis does not apply to Sweden: the country has continued to be a net exporter of energy-intensive and carbon-intensive goods even while its income climbs relative to that of most trading partners. When it comes to regular air pollution, however, Muradian, O'Connor and Martinez-Alier (2002) find that, imports of pollution-embodying goods by among 18 industrialized countries in Europe and elsewhere rose relative to such exports, over the period 1976 to 1994. Khan and Yutaka (2004) also find general support for the pollution haven hypothesis: As a nation's income rises, its exports of dirty goods decrease relative to its exports of clean goods. But the evidence is stronger for countries outside of a Regional Trading Arrangement such as the European Union or NAFTA than for those inside.

For the specific case of SO2, Frankel and Rose (2003) find that, if anything, trade apparently leads to a reallocation of pollution from the poor country to the rich country, rather than the other way around. We do not find significant evidence of other pollution-haven effects, based on population density or factor endowments, or for other pollutants. This is consistent with the finding of Antweiler, Copeland and Taylor (2001) that trade has a significantly less favorable effect on SO2 emissions in rich countries than in poor countries. Their explanation is the first of the three: that rich countries have higher capital/labor ratios, capital-intensive industries are more polluting, and this factor-based pollution-haven effect dominates the income-based pollution-haven effect.

4. Does Economic Globalization Conflict with Environmental Regulation?

There is a popular sense that globalization is a powerful force undermining environmental regulation. This can be the case in some circumstances. The "race to the bottom" phenomenon can potentially put downward pressure on the regulatory standards of countries that compete internationally in trade and investment. But, as an argument against globalization, it leaves much out.

First is the point that, for most of us, environmental quality is one goal, but not the only goal. As already noted, we care also about income, and trade is one means of promoting economic growth. The goals often need to be balanced against each other.

Environmental concerns can be an excuse for protectionism. If policymakers give in to protectionist arguments and erect trade barriers, we will enjoy less growth in trade and income. We will not even necessarily end up with a better environment. Import-competing corporations (or their workers), in sectors that may themselves not be particularly friendly to the environment, sometimes seek to erect or retain barriers to imports in the name of environmental protection, when in reality it is their own pocketbooks they are trying to protect. In other words, environmentalism in such a case would be an excuse for protectionism.

Often, the problem is less sinister, but more complex. To see how the political economy works, let us begin with the point that most policy debates are settled as the outcome of a complicated mix of multiple countervailing arguments and domestic interest groups on both sides. Most of the major viewpoints are in some way represented "at the table" in the national government decision-making process. In the case of environmental measures, there are often adversely affected industry groups sitting across the table from the environmentalists, and they have an effect on the final political outcome. But when the commodity in question happens to be produced by firms in foreign countries, then that point of view largely disappears from the table around which the decision is made. If the issue is big enough, the Foreign Affairs Ministry may weigh in to explain the potential costs facing foreign countries. But, understandably, the foreigners receive less weight in the policy process than would the identical firms if they were domestic. The result is that the environmental policies that are adopted on average can discriminate against foreign firms relative to domestic firms, without anyone ever deliberately having supported a measure out of protectionist intent.

One possible example is the strong opposition in Europe to Genetically Modified Organisms (GMOs). A Biosafety Agreement was negotiated in Montreal, January 29, 2000, in which the US felt it had to agree to label grain shipments that might in part be bio-engineered, and to allow countries to block imports of GMOs. (*The Economist*, Feb. 5, 2000.) The United States has been reluctant to bring the GMO case to the WTO, out of a fear of that the outcome might be a political failure even if a legal success. As Victor and Runge (2002, 112-113) argue, the Europeans were sufficiently traumatized in the 1990s by a series of scandals in the regulation of their food, such as the UK government's failure to stop "Mad Cow" disease, that an attempt by the US to use the WTO dispute settlement process to pry the European market open for GMOs would be counterproductive, regardless of the scientific evidence.

In some ways, these negotiations might serve as a useful model for compromise in other areas. Environmental NGOs were allowed inside the meeting hall, a new precedent. *FT*, Feb. 1, 2000.

But why have Europeans decided so definitively that they want to keep out genetically modified varieties of corn, despite the emergence of little or no scientific evidence against them as of yet, where American consumers are far less agitated? Is it because Europeans are pre-disposed to have higher standards for environmental issues? Perhaps. But it is interesting that some health issues have gone the other way. The US has in the past cared more about feared carcinogens than Europeans. The US requires cheese to be pasteurized, and the EU does not. (David Vogel, 1995.) An important part of the explanation is that Monsanto and other US technology companies, and US farmers, are the ones who developed the technology and produce the stuff, not European companies or European farmers. Thus it is American producers, not Europeans, who stand to lose from the European squeamishness. European agriculture need not consciously launch a campaign against GMOs. All that the European movement needed was an absence around the table of producers who would be adversely affected by a ban. But the result is to reduce trade, hurt American producers, and benefit European farmers.

Whatever the source of different perceptions across countries, it is important to have a set of internationally agreed rules to govern trade, and if possible a mechanism for settling disputes that arise. That is the role of the WTO. The need for such an institution does not vanish when environmental issues are a part of the dispute. Certainly if one cares at all about trade and growth, then one cannot automatically sign on to each and every campaign seeking to block trade on environmental grounds. But even if one cares solely about the environment, claims need to be evaluated through some sort of neutral process. One can be easily misled; American corporations, for example, make dubious claims to environmental motivations in seeking federal support of "Clean Coal" research or ethanol production. Most of the time, there is no substitute for investigating the details and merits of the case in question. One should not presume that an interest group's claims are right just because that group happens to be of one's own nationality.

The Impossible Trinity of global environmental regulation

The concerns of anti-globalizers can be understood by means of a trilemma of regulation, called the principle of the Impossible Trinity of Global Governance. In designing a system of global governance, three kinds of goals are desirable. First, *globalizatio*n is desirable, other things equal, for its economic benefits if nothing else. Second, *regulation* is desirable when it comes to externalities like pollution, or other social goals not adequately addressed by the marketplace. Third, national *sovereignty* is desirable, because different countries have different needs or preferences, and also because nations take pride in their political independence. The principle of the Impossible Trinity points out that it is feasible to design a system with any two of these attributes, but not with all three.

[Insert Figure 2 about here]

The three attributes are represented as the sides of the triangle in the accompanying figure. The lower left corner represents a system of complete laissez faire. The private market is given responsibility for everything. With no government regulation, there is nothing to coordinate internationally, and thus no loss in national sovereignty. If another country wants to make the mistake of heavy-handed intervention, that is its affair. The lower right corner represents multilateral regulation at the global level. While there are not many "world federalists" around today, a proposal to establish a powerful World Environment Organization would be a step in this direction. The top corner represents isolationism. Only if countries cut themselves off from trade, investment, and other international interactions, can they preserve complete national sovereignty, while practicing whatever kind of regulation they wish.

The environmental concerns created by globalization can be understood in terms of this diagram. The process of international economic integration has moved most countries downward in the graph, toward the bottom side of the triangle. As a result, globalization is creating a growing conflict between the needs of environmental regulation and the demands of national sovereignty, or so goes the theory. National sovereignty has been winning, which means that the movement has been toward the

lower left corner. The claim is that globalization has undermined the ability of sovereign governments to impose the level of environmental standards they would like.

Although the impossible trinity can be a useful way to think about the potential for globalization to undercut national environmental regulation, it can be very misleading in some contexts. There are two main reasons for this. First, even for environmental externalities that are largely confined within countries, such as local air pollution, there is little empirical evidence that the "race to the bottom" hypothesis in fact holds, i.e., that international trade and investment in fact put significant downward pressure on environmental regulation in the aggregate. Indeed, international trade and activities of multinational corporations may sometimes put upward pressure on environmental standards. Second, and more importantly, some environmental issues spill over across national borders even in the absence of international trade and investment, making it difficult for individual countries to address them through independent regulation. Environmental protection requires international cooperation, and cooperation in turn requires some loss of "sovereignty."

Cross-border institutions for cross-border problems

Even someone who does not care about trade at all should appreciate the role of international agreements and institutions. The reason is the increasing importance of major sources of environmental damage that cross national borders, and that would do so even if there were no such thing as international trade. Some externalities have long spilled over from each country to its neighbors -- such as SO_2 pollution, which is responsible for acid rain, or water pollution, which flows downriver. They can be addressed by negotiations between the two countries involved (e.g., Germany and the Netherlands). An increasing number of environmental externalities are truly global, however. The best examples are greenhouse gases. A ton of carbon dioxide creates the same global warming potential regardless where in the world it is emitted. Other good examples of direct global externalities are stratospheric ozone depletion, depletion of ocean fish stocks, and threats to biodiversity.

The question of PPMs

Even localized environmental damage, such as deforestation, is increasingly seen as a valid object of international concern. A distinction is traditional between trade measures that target specific undesirable products, such as asbestos, and those that target *Processes and Production Methods* (PPMs), such as the use of prison labor in the manufacture of the commodity in question. It is clear that a country concerned about its own health or environment has the right to tax or ban products that it regards as harmful, so long as it does not discriminate against foreign producers. Such bans are less liable to become a vehicle for surreptitious protectionism, than are attempts to pass judgment on other countries' production methods that are unrelated to the physical attributes of the product itself. But is it legitimate for importing countries also to discriminate according to how a given product was produced? Some ask: what business is it of others whether

the producing country wants to use its own prison labor, or cut down its own forests, or pollute its own environment?[36]

Often an international externality can be easily identified. Forests absorb carbon dioxide (a process called sequestration, or carbon sinks), so logging contributes to global climate change. An endangered species may contain a unique genetic element that someday could be useful to international scientists. Desertification can lead to social instability and political conflict, which can in turn produce problems for international security. Thus environmental damage in one country can have indirect effects on others.

WTO panel cases

Environmentalists are keen to interject themselves into the WTO. Those who live in the world of international trade negotiations tell those who live in the environmentalist world that their concerns may be valid, but that they should address them outside the WTO, in their own, separate, negotiations, and their own multilateral agencies.[37]

In the post-war period, the vehicle for conducting the multilateral negotiations that succeeded in bringing down trade barriers in many countries was the General Agreement on Tariffs and Trade (GATT). In 1995 the GATT organization was replaced with a real agency, the World Trade Organization. One reason why the change was important is that the new institution featured a dispute settlement mechanism, whose findings were to be binding on the member countries. Previously, a party that did not like the ruling of a GATT panel could reject it.

Why do so many environmentalists apparently feel that the WTO is a hostile power? The allegation that the GATT and WTO are hostile to environmental measures could conceivably arise from the core provisions of the GATT, which prohibit a member country from discriminating against the exports of another, in favor of "like products" made either by a third country (that is the Most Favored Nation provision of Article I) or by domestic producers (the national treatment provision of Article III). But Article XX allows for exceptions to the non-discrimination principle for environmental reasons (among others), provided that the measures in question are not "a means of arbitrary or unjustifiable discrimination" or a "disguised restriction on international trade."

Under the GATT, there was ambiguity of interpretation as to what was to happen when Article XX conflicted with the non-discrimination article. To clarify the matter, in the preamble of the Articles agreed at Marrakech establishing the WTO, language was added specifying that its objectives were not limited to promoting trade but included also optimal use of the world's resources, sustainable development, and environmental protection; and the 2001 Doha Communiqué that sought to start a new round of

[36] See Charnovitz (2003a) on the history, law, and analysis of PPMs. He argues that the public failure to understand environment-friendly developments in the late 1990s within GATT/WTO jurisprudence regarding PPMs is now an obstacle to further progress (e.g., in the WTO Committee on Trade and Environment; p. 64, 103-04).

[37] The most prominent and articulate spokesman of the viewpoint opposing linkage between trade and unrelated issues is Jagdish Bhagwati (2000).

negotiations declares: “the aims of ... open and non-discriminatory trading system, and acting for the protection of the environment ... must be mutually supportive.” Environmental objectives are also recognized specifically in the WTO agreements dealing with product standards, food safety, intellectual property protection, etc.

How does one explain the common view in the anti-globalization protest movement that the WTO is actively harmful to the environment? When members of the protest movement identify specifics, they usually mention the rulings of WTO panels under the dispute settlement mechanism. The panels are quasi-judicial tribunals, whose job is to rule in disputes whether parties are abiding by the rules that they have already agreed to. Like most judicial proceedings, the panels themselves are not intended to be democratic. But the rulings to date do not show a pattern of having been dominated by any particular country or interest group. There have been three or four fairly prominent WTO panel rulings that concern the environment in some way. Many observers within the environmentalist and NGO community have at some point acquired the belief that these rulings told the United States, or other defendant country, that their attempts to protect the environment must be repealed. The mystery is why this impression is so widespread, because it has little basis in fact.

The four WTO cases that will be briefly reviewed here are Canadian asbestos, Venezuelan reformulated gasoline, U.S. hormone-fed beef, and Asian shrimp and turtles. We will also touch on the Mexican tuna-dolphin case. Each of the cases involves an environmental measure that the producer plaintiff alleged to have trade-distorting effects. The complaints were not based, however, on the allegation that the goal of the measure was not valid, or that protectionism was the original motivation of the measure. In most of the cases, the allegation was that discrimination against foreigners was an incidental, and unnecessary, feature of the environmental measure.

Canadian asbestos

One case is considered a clear win for the environmentalists. The WTO Appellate Body in 2001 upheld a French ban on asbestos products, against a challenge by Canada, who had been exporting to France. This ruling made real the WTO claim that its charter gives priority to health, safety and environmental requirements, in that for such purposes GATT Article XX explicitly allows exceptions to the Most Favored Nation and national treatment rules.[38]

Venezuelan reformulated gasoline

In the reformulated gasoline case, Venezuela successfully claimed that US law violated national treatment, i.e., discriminated in favor of domestic producers. The case was unusual in that the intent to discriminate had at the time of passage been made explicit by U.S. administration officials seeking to please a domestic interest group. If the WTO had ruled in the US favor, it would have been saying that it was fine for a country to discriminate needlessly and explicitly against foreign producers so long as the law came under an environmental label. Anyone who opposed this panel decision would have provided ready-made ammunition for the viewpoint that environmental activism is a false disguise worn by protectionist interests.

[38] *New York Times*, July 25, 2000.

The United States was not blocked in implementing its targets under the Clean Air Act. Rather, the offending regulation was easily changed so as to be nondiscriminatory and thus to be permissible under the rules agreed by members of the WTO. This case sent precisely the right message to the world's governments: that environmental measures should not and need not discriminate against foreign producers.

Shrimp-turtle

Perceptions regarding the WTO ruling on a dispute about shrimp imports and the protection of sea turtles probably vary more widely than on any other case. The perception among many environmentalists is that the ruling struck down a U.S. law to protect sea turtles that are caught in the nets of shrimp fishermen in the Indian Ocean. (The provision was in a 1980s law pursuant to the U.S. Endangered Species Act.) In reality, the dispute resembled the gasoline case in the respect that the American ban on imports from countries without adequate regulatory regimes in place was unnecessarily selective and restrictive. The WTO panel decided that the US application of the law, in several ways, was arbitrarily and unjustifiably discriminatory against the four plaintiff countries. For one thing, the US had unilaterally and inflexibly banned shrimp imports from countries that did not have in place for all production a specific (expensive) turtle-protection regime of its own liking. For another, the US had not given Asian producers a chance to negotiate a mutually satisfactory arrangement first, as it had with Western Hemisphere shrimp producers.

The case should in fact be considered a victory for the environmentalists, in that the WTO appeals body in 1998 explicitly stated that the US could pursue the protection of endangered sea turtles against foreign fishermen. The United States subsequently allowed more flexibility in its regulation, and made good-faith efforts to negotiate an agreement with the Asian producers, which it could have done in the first place. The WTO panel and appellate body in 2001 found the new US regime to be WTO-compliant.[39] The case set a precedent in clarifying support for the principle that the WTO rules allow countries to pass judgment on other countries' Processes and Production Methods, even if it means using trade controls to do so, provided only that the measures are not unnecessarily discriminatory.[40] Charnovitz and Weinstein (2001) argue that the environmentalists fail to realize the progress they have made in recent WTO panel cases, and may thereby miss an opportunity to consolidate those gains. It is not only some environmentalists who are under the impression that the GATT/WTO rules do not allow PPMs. Some developing countries also claim that PPMs violate the WTO. (The motive of the first group is to fight the WTO, while the motive of the second group is to fight PPM measures.)

Tuna-dolphin

In an earlier attempt to protect another large flippered sea animal, the United States had banned imports of tuna from countries that allowed the fishermen to use nets

[39] Charnovitz (2003a).

[40] For a full explanation of the legal issues, see Charnovitz (2003a). Also Michael Weinstein, "Greens and Globalization: Declaring Defeat in the Face of Victory," *NY Times*, April 22, 2001. .

that also caught dolphins. Mexico brought a case before the GATT, as this pre-dated the WTO. The GATT panel ruled against the U.S. law, in part due to its unilateralism[41] and in part due to features that discriminated unnecessarily against Mexican fishermen in favor of US fisherman. The GATT report was never adopted. The parties instead in effect worked out their differences bilaterally, "out of court." The case was considered a setback for trade-sensitive environmental measures, at least unilateral ones. But the setback proved temporary. A system for labeling tuna in the US market as either "dolphin safe" or not was later found consistent with the GATT. The American consumer response turned out to be sufficiently great to accomplish the desired cessation of non-dolphin-safe imports.

That the GATT ruling in the tuna case did not affirm the right of the US to use trade bans to protect the dolphins shows how much the environmentalist cause has progressed under the WTO, in the subsequent gasoline and shrimp-turtle cases.

Are PPM measures compatible with the WTO?

The true import of the 1998 WTO panel decision on the shrimp-turtle case was missed by almost everyone at the time. The big significance was a pathbreaking ruling that environmental measures can target, not only exported products (Article XX), but also partners' Processes & Production Methods (PPMs) -- subject, as always, to non-discrimination (Articles I & III). The United States was in the end able to seek to protect turtles in the Indian Ocean, provided it did so without discrimination against Asian fishermen. Environmentalists failed to notice or consolidate the PPM precedent, and to the contrary were misguidedly up in arms over this case.[42]

Another important precedent was the Montreal Protocol on stratospheric ozone depletion. Scientists in the 1970s discovered that widely used man-made substances such as Chlorofluorocarbons (CFCs) were depleting the Ozone Layer, thus letting more Ultraviolet B radiation reach the surface of the earth and producing higher rates of skin cancer. To solve the problem, the Montreal Protocol was negotiated, phasing out the substances. The treaty, which entered into force in 1989, contained trade controls. The controls had two motivations[43]:
(1) to encourage countries to join, and
(2) if major countries had remained outside, the controls would have minimized leakage, the migration of production of banned substances to nonparticipating countries. In the event (1) worked, so (2) was not needed.

Barrett (1997, 2003) has shown theoretically how multilateral trade sanctions can sometimes successfully enforce a multilateral environmental treaty such as the Montreal

[41] Around the same period, members of the International Commission for the Conservation of Atlantic Tunas (ICCAT), which seeks sustainability of stocks, adopted bans in a multilaterally coordinated fashion against imports of Atlantic bluefin tuna and swordfish from some overfishing countries, particularly Central American non-parties (Barrett, 2003, pp.325-327).

[42] For a full explanation of the legal issues, see Charnovitz (2003a). Also Charnovitz and Weinstein (2001) and M. Weinstein, "Greens and Globalization: Declaring Defeat in the Face of Victory," *The New York Times*, 22 April, 2001.

[43] Benedick (1991) and Brack (1996).

Protocol. National border tax adjustments[44], such as those discussed in the context of Kyoto later in this report, may not provide enough of a "stick" to deter free-riders, i.e., to motivate recalcitrant countries to join the agreement.[45] National threats to impose more stringent sanctions may not be credible, because individual countries will not find it rational to adopt trade barriers that impose as much economic harm on themselves as on the targeted country. Barrett (1997; 2003, p. 314-320) applies the key assumption from "new trade theory" á la Brander and Krugman (1983) -- imperfect competition -- to the question of international environmental cooperation. In contrast to classic theories of trade by firms and countries that are too small to affect the world prices for their products, the assumption of imperfect competition implies that without international cooperation, it is economically rational for each government to weaken the standards for emissions abatement that it imposes on its own firms.[46] Barrett's solution is to structure the international environmental agreement with provision for strong trade sanctions, and with the usual rule that the treaty does not go into effect until a threshold number of countries joins. Then the desired outcome could well be a sustainable equilibrium: all countries join, the threat of sanctions need not be carried out, and trade remains unimpeded, as turned out to be the case with the Montreal Protocol.

The two examples of the Montreal Protocol and the shrimp-turtle case, together, go a long way to establishing the legitimacy of trade measures against PPMs. It must be noted that many economists and international lawyers are not yet convinced, let alone representatives of India and other developing countries. Some trade experts continue to believe that even multilateral trade penalties against non-members might not be permissible under international trade law. [47]

5. The Kyoto Protocol and the Leakage/Competitiveness Issue

The Kyoto Protocol on Global Climate Change, negotiated in 1997, is the most ambitious attempt at a multilateral environment agreement to date. The task of addressing Climate Change while satisfying the political constraints of the various factions (particularly, the US, EU, and developing countries) was an inherently impossible task. Most economists emphasize that the agreement as it was written at Kyoto would impose large economic costs on the United States and other countries, while making only a minor dent in the problem. The Clinton Administration's interpretation of the Protocol insisted on so-called flexibility mechanisms, such as international trading of

[44] Early analyses include Markusen (1975).

[45] Barrett (2003, p. 309-310) argues that an alternative "stick" proposed by Carraro and Siniscalco (1994), a threat by participants to withhold research and development from non-participants, was shown by the Montreal Protocol to be largely irrelevant in practice.

[46] Barrett (1994, 1997), Kennedy (1994), Ulph (1994) and Xing and Kolstad (1996).

[47] See Sampson (2000), p.87. One GATT legal expert advised those negotiating the Montreal Protocol that he considered its trade sanctions to be GATT-consistent; but others in the GATT Secretariat subsequently disagreed (Benedick, 1998; Barrett, 2003). No country ever brought a case against the Protocol. Barrett (2003, p.312) argues, "In the anarchic international system, this is more significant than a legal opinion."

emission permits, to bring the economic costs down to a modest range. Without the flexibility mechanisms, the United States would be out of the Protocol, even if the subsequent administration had been more environmentally friendly than it was. (As European and other countries have gone ahead without the United States, they have been finding that they cannot manage without such trading mechanisms.)

Even most of those who for one reason or another do not believe that Kyoto was a useful step, however, should acknowledge that multilateral agreements will be necessary if the problem of Global Climate Change is to be tackled. The administration of George W. Bush, even after it got past its resistance to the science, was reluctant to face up to this. The point for present purposes is that a system in which each country insists, based on an appeal to national sovereignty, that it be left to formulate environmental policies on its own, would be a world in which global externalities like greenhouse gas emissions would not be effectively addressed.

The global climate regime is now on a collision course with the global trade policy regime. [48] National efforts to reduce emissions of greenhouse gases (GHGs) instill among environmentalists fears of leakage and among businesspeople fears of lost competitiveness. Policy-makers respond to these fears. In 2008, legislative attempts in both Washington, DC, and Brussels to enact long-term targets for reduced emission of GHGs included provisions for possible penalties against imports from countries perceived as non-participating. In the view of the author, trade measures, if well designed, could in theory be WTO-compatible, in light of the precedent of the shrimp-turtle case, in particular. But the actual provisions emerging from the political process are likely to violate the rules of the WTO, which poses the scenario of a WTO panel rejecting a major country's climate change legislation. That would be a nightmare for the supporters of the WTO and free trade as much as for the supporters of the Kyoto Protocol and environmental protection. The issue is just the latest and largest instance of fears among many environmentalists that the WTO is an obstacle to their goals in general. The first parts of this report discussed the broader issue of whether environmental goals in general are threatened by the global free trade system. The rest of the report focuses exclusively on the narrower question of trade measures in the effort to implement climate change policy and whether they are likely to be successful. It concludes with specific recommendations for how border measures could be designed so that they were more likely to be true to the goal of reducing leakage and yet consistent with the WTO.

Developing countries, leakage, and competitiveness

We need developing countries inside whatever regime is the successor to Kyoto, for several reasons**.** The developing countries will be the source of the big increases in emissions in coming years even under the Business-as-Usual path (BAU). China, India, and other developing countries will represent up to two-thirds of global carbon dioxide emissions over the course of this century, vastly exceeding the OECD's expected contribution of roughly one-quarter of global emissions. Without the participation of

[48] Frankel (2005a,b).

major developing countries, emissions abatement by industrialized countries will not do much to mitigate global climate change.[49]

But the situation is worse than that. If a quantitative international regime is implemented without the developing countries, their emissions are likely to rise even faster than the BAU path, due to the problem of leakage. Leakage of emissions could come about through several (interrelated) channels. First, output of energy-intensive industries could relocate from countries with emissions commitments to countries without. This could happen either if firms in these sectors relocate their plants to unregulated countries, or if firms in these sectors shrink in the regulated countries while their competitors in the unregulated countries expand. A particularly alarming danger is that a plant in a poor unregulated country might use dirty technologies and so emit more than the plant producing the same output would have in the high-standard rich regulated country, so that aggregate world emissions actually go up rather than down !

Another channel of leakage runs via world energy prices. If participating countries succeed in cutting back consumption of the high-carbon fossil fuels, coal and oil, demand will fall and the prices of these fuels will fall on world markets (other things equal). This is equally true if the initial policy is a carbon tax that raises the price to rich-country consumers as if it comes via other measures. Non-participating countries would naturally response to declines in world oil and coal prices by increasing consumption. Conversely, demand for clean natural gas would increase in the rich countries, driving up the world price of LNG, and reducing reliance on it in non-participating countries. Hence more emissions.

Estimates vary regarding the damage in tons of increased emissions from developing countries for every ton abated in an industrialized country. Two important studies of leakage, and of the size of border adjustments or "green tariffs" that would be necessary if countries were legitimately to counteract the problem of leakage, concludes that they would be small on most traded goods.[50] But one authoritative survey reaches a less sanguine conclusion: "Leakage rates in the range 5 to 20 per cent are common."[51] Another reports that studies' estimates of leakage range from 8 to 11 percent.[52]

Even more salient politically than leakage is the related issue of competitiveness: American industries that are particularly intensive in energy or in other GHG-generating activities will be at a competitive disadvantage to firms in the same industries operating

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[49] An additional reason we need developing countries in is to give industrialized countries the opportunity to buy relatively low-cost emissions permits, which is crucial to keeping low the economic cost of achieving any given goal in terms of concentrations. Elaboration is available from Aldy and Frankel (2004), Frankel (2007), Seidman and Lewis (2008) and many other sources.

[50] And therefore "benefits produced by border adjustment would be too small to justify their administrative complexity or their deleterious effects in trade." -- McKibbin and Wilcoxen (2008). The other study is Hauser, et al.(2008). Researchers at the OECD, however, have larger estimates of leakage and corresponding necessary border taxes, especially on the part of the EU, if it is the only region that is seriously taxing carbon domestically, which is pretty much the current state of affairs (Braathen, 2008).

[51] International Panel on Climate Change (2001), Chapter 8.3.2.3, pp. 536-544 .

[52] Bordoff (2008, fn. 4). One of the estimates, McKibben et al (1999), is that if the US had adopted its Kyoto target unilaterally, leakage would have been 10%.

in non-regulated countries.[53] Such sectors as aluminum, cement, glass, paper and steel will point to real costs in terms of lost output, profits, and employment.[54] They understandably will seek protection and are likely to get it. The public tends to assume that if these industries face costs it follows that the country in the aggregate does as well; offsetting gains to new green-technology fields and other carbon-saving sectors are not as visible.

6. Measures in Climate Change Legislation to Address Competitiveness and Leakage

The result of environmentalists' leakage concerns and businessmen's competitiveness concerns is that much of the legislation recently proposed at the national level includes provisions to apply certain measures to imports of carbon-intensive products from countries that are deemed not to be making sufficient efforts themselves to address climate change.

Names for measures against imports from unregulated countries

There is a confusing variety of names for the sort of protection that carbon-intensive sectors are likely to get against imports from non-participating countries. The phrases vary widely in their connotations. Some, but not all of the variation, is semantic. Perhaps over the next few years, as the discussion of this new topic grows, the language will converge on one or two terms. Enumerating the terms is a first step toward clarity in thinking.

- Border adjustment taxes. Technically, this widely used phrase applies not just to import tariffs but also equally to export subsidies, which are apparently not under active contemplation currently.
- Green tariffs. "Import tariffs" are the most accurate description of what we are talking about; the adjective "green" converts a negative-sounding term into a positive one.
- Import barriers. The advantage of the word "barriers" is that it clearly includes the likely option of requiring importers to buy emission permits as opposed to explicit tariffs. For economists, permit requirements are precisely equivalent to import tariffs, but others would not so readily make the jump. The disadvantage is that the word has the pejorative flavor of protectionism.
- Import penalties. "Penalties" are a bit like "barriers" in their generality. They have the added advantage of connoting a tie to behavior in the exporting country,

[53] It is not theoretically meaningful to talk about an adverse effect on the competitiveness of the American economy in the aggregate. Those sectors low in carbon-intensity would in theory *benefit* from an increase in taxation of carbon relative to everything else. This theoretical point is admittedly not very intuitive. Far more likely to resonate publicly is the example that producers of renewable energy, and of the equipment that they use, would benefit.

[54] Hauser, et al. (2008).

that is, insufficient action on climate change, while yet being less extreme than "sanctions".

- Import measures. "Measures" is the term that maximizes generality and neutrality.
- Carbon-equalization taxes. A well-designed policy to target leakage and competitiveness could be described as equalizing the effective tax on the carbon content of goods produced domestically or imported from abroad. One hopes this is not used as a euphemism for something else (such as the domestic subsidies contemplated by the EU for its exposed industries).
- Trade controls. An alternative function of import measures is to encourage those countries not participating in the post-Kyoto multilateral architecture to enlist. .Trade controls, on the one hand, fall only on environmentally relevant sectors.
- Trade sanctions, on the other hand, are more aggressive than trade controls in that they target products that are arbitrary and unrelated to the non-compliant act. They are used multilaterally only by the WTO and UN Security Council, and are not currently under consideration to address climate change.[55]

Possible application of trade barriers by the United States

Of twelve market-based climate change bills introduced in the 110th Congress, almost half called for some border measures: either a tax to be applied to fossil fuel imports (unobjectionable, *provided* the same tax is applied to domestic production of the same fossil fuels) or a requirement that energy-intensive imports surrender permits corresponding to the carbon emissions embodied in them.[56] The Bingaman-Specter "Low Carbon Economy Act" of 2007 would have provided "If other countries are deemed to be making inadequate efforts [in reducing global GHG emissions], starting in 2020 the President could require importers from such countries to submit special emission allowances (from a separate reserve pool) to cover the carbon content of certain products)." Similarly the Lieberman-Warner bill would have required the president to determine what countries have taken comparable action to limit GHG emissions; for imports of covered goods from covered countries, starting in 2020, the importer must buy international reserve allowances. [57] These requirements would be equivalent to a tax on the covered imports. The major presidential candidates in the US election campaign supported some version of these bills, including import measures in the name of safeguarding competitiveness vis-à-vis developing countries.

In addition, Congress has already enacted a different law that poses similar issues: The Energy Independence & Security Act 2007 "limits US government procurement of alternative fuel to those from which the lifecycle greenhouse gas emissions are equal to or less than those from conventional fuel from conventional petroleum sources."[58] Canada's oil sands are vulnerable. Since Canada has ratified the Kyoto Protocol and the US has not, the legality of this measure strikes the author as questionable.

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[55] Charnovitz (2003b, page 156).
[56] Source: Resources for the Future.
[57] S. 2191: America's Climate Security Act of 2007. Sections 6005-6006.
[58] Section 526. Source: *FT*, Mar. 10, 2008.

Possible application of trade barriers by the EU

It is possible that many in Washington don't realize that the US is likely to be the victim of legal sanctions before it is the wielder of them. In Europe firms have already entered the first Kyoto budget period of binding emission limits, competitiveness concerns are well-advanced, and the non-participating United States is an obvious target of resentment.[59]

After the United States failed to ratify, European parliamentarians proposed a "Kyoto carbon tax" against imports from the United States.[60] The European Commission had to make a decision on the issue in January 2008, when the European Union determined its emission targets for the post-Kyoto period. In preparation for this decision, French President Sarkozy warned:

> "…if large economies of the world do not engage in binding commitments to reduce emissions, European industry will have incentives to relocate to such countries…The introduction of a parallel mechanism for border compensation against imports from countries that refuse to commit to binding reductions therefore appears essential, whether in the form of a tax adjustment or an obligation to buy permits by importers. This mechanism is in any case necessary in order to induce those countries to agree on such a commitment." [61]

The envisioned mechanism sounds similar to that in the Bingaman-Specter and Lieberman-Warner bills, with the difference that it could go into effect soon, since Europe is already limiting emissions whereas the US is not.

In the event, the EU Commission included instead the following provision in its Directive:

> "Energy-intensive industries which are determined to be exposed to significant risk of carbon leakage could receive a higher amount of free allocation or an effective carbon equalization system could be introduced with a view to putting EU and non-EU producers on a comparable footing. Such a system could apply to importers of goods requirements similar to those applicable to installations within the EU, by requiring the surrender of allowances." [62]

The second of the two options, "carbon equalization" sounds consistent with what is appropriate (and with the sort of measures suggested by Sarkozy, and spelled out in detail in the US bills). The first option, however, is badly designed. Yes, it would help European industries that are carbon-intensive and therefore vulnerable to competition from non-members by giving them a larger quantity of free emission permits. Given the market in trading permits that already exists in the EU, to give a firm permits is the same

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[59] Bierman and Brohm (2005) and Government of Sweden (2004).

[60] *FT*, Jan 24, 2008.

[61] Letter to EU Commission President Jose Manuel Barroso, January 2008.

[62] Source: Paragraph 13, Directive of the European Parliament & of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emissions allowance trading system; Brussels, Jan. 2008.

as to give them a cash subsidy. According to simple microeconomic theory, these subsidies would do nothing to address leakage; while it reduces the *average cost* to these firms' operations inside European borders, it does not reduce the *marginal* cost, which is the more relevant concept. Because carbon-intensive production is cheaper in non-participating countries, the European firms in theory would simply "take the money and run." They could sell the permits they receive and pocket the money, with the carbon-intensive production still moving from Europe to the non-participants. Perhaps these firms would use the money to buy plants in unregulated countries, or develop such subsidiaries themselves.[63]

Admittedly in practice there might be some effects from free allocations to affected industries; for example, an infusion of liquidity might keep in operation a firm that otherwise would go bankrupt. But there would probably be almost as much leakage as if there had been no policy response at all. Presumably the purpose behind the subsidies option is not to minimize leakage, for which it would be the wrong remedy, nor to punish non-participating countries, but simply to buy off domestic interests so that they will not oppose action on climate change politically. But in this case it is important to make sure that the politicians understand that this is what they are doing, because the rhetoric is different and the economic logic is subtle.

Would penalties against carbon-intensive imports be compatible with the WTO?

Would measures that are directed against CO2 emissions in other countries, as embodied in electricity or in goods produced with it, be acceptable under international law? Not many years ago, most international experts would have said that import barriers against carbon-intensive goods, whether tariffs or quantitative restrictions, would necessarily violate international agreements. But, as noted above, things have changed.

The WTO (World Trade Organization) came into existence, succeeding the GATT, at roughly the same time as the Kyoto Protocol. The drafters of each treaty showed more consideration for the other than do the rank and file among environmentalists and free traders, respectively. The WTO regime is more respectful of the environment than was its predecessor. Article XX allows exceptions to Articles I and III for purposes of health and conservation. The Kyoto Protocol text is equally solicitous of the trade regime. It says that the Parties should "strive to implement policies and measures...to minimize adverse effects...on international trade..." Similar language is featured in the United National Framework Convention on Climate Change (UNFCCC), which was the parent to the Kyoto Protocol.

Under the GATT, although countries could use import barriers to protect themselves against environmental damage that would otherwise occur within their own borders, they could not use import barriers in efforts to affect how goods are produced in foreign countries, PPMs (Processes and Production Methods). GHG emissions are PPMs. Is

[63] One important study, Hauser et al (2008) tends to favor such domestic subsidies, and opposes border measures, in part because the latter are judged to be more likely to run afoul of the WTO. I come to the opposite conclusion, for the reasons stated and because subsidies to sectors facing international competition run contrary to the WTO as much as import tariffs do.

this an obstacle to the application measures against them at the border? I don't see why it has to be. As argued above, two precedents can be cited: sea turtles and stratospheric ozone.

In case there is any doubt that the phrase "health and conservation" in Article XX applies to environmental concerns such as climate change, a third precedent is relevant. In 2007, a new WTO Appellate Body decision regarding Brazilian restrictions on imports of retreaded tires confirmed the applicability of Article XX(b) to trade measures in pursuit of GHG abatement: Rulings "accord considerable flexibility to WTO Member governments when they take trade-restrictive measures to protect life or health… [and] apply equally to issues related to trade and environmental protection…including measures taken to combat global warming."[64]

I personally have come to believe that the Kyoto Protocol could have followed the Montreal Protocol by incorporating well-designed trade controls aimed at non-participants. One aspect that strengthens the applicability of the precedent is that we are not talking about targeting practices in other countries that harm solely the local environment, where the country can make the case that this is nobody else's business. Depletion of stratospheric ozone depletion and endangerment of sea turtles are global externalities. (It helped that these are turtles that migrate globally.) So is climate change from GHG emissions. Carbon emissions hurt all residents of the planet.

One can speculate that views are evolving even among those WTO officials and other trade experts who believed that the Montreal Protocol was not legally consistent with the GATT. Given the precedents mentioned, and the extent of popular support internationally for action on global climate change, it seems unlikely that either panel jurists or staff members at the WTO would want to commit institutional suicide by ruling against trade sanctions if they were adopted multilaterally under a successor to the Kyoto Protocol and were applied without unnecessary discrimination. On the other hand, if one country unilaterally adopted arbitrary and unnecessarily discriminatory barriers against imports from another [especially if the latter had ratified Kyoto and the former had not], it seems likely that a WTO panel would uphold a complaint from the sanction victim.

Some principles for design of legitimate carbon-intensive import penalties

While the shrimp-turtle case and the Montreal Protocol help establish the principle that well-designed trade measures can legitimately target PPMs, at the same time they suggest principles that should help guide drafters as to what is good design.

First, the existence of a multilaterally negotiated international treaty such as the Kyoto Protocol conditions the legitimacy of trade controls. On the one hand, that leakage to non-members could negate the goal of the Protocol strengthens the case for (the right sort of) trade controls. It is stronger, for example, than in the shrimp-turtle case, which was primarily a unilateral US measure. On the other hand, the case is weaker than it was for the Montreal Protocol. (Multilateral initiatives like the latter are on firmer ground than unilateral initiatives.) The Kyoto Protocol could have made explicit allowance for multilateral trade controls, and chose not to. The case would be especially weak for American measures if the US has still not ratified the Kyoto Protocol or a successor agreement. The Europeans have a relatively good case against the United States, until

[64] Source: Brendan McGivern, 12 Dec., 2007.

such time as the US ratifies. But the case would be stronger still if a future multilateral agreement, for example under the Framework Convention on Climate Change (UNFCCC), agreed on the legitimacy of trade controls and on guidelines for their design.

Second, there is the question of the sorts of goods or services to be made subject to penalty. It would certainly be legitimate to apply tariffs against coal itself, assuming domestic taxation of coal or a domestic system of tradable permits were in place. It is probably also legitimate when applied to the carbon content of electricity, though this requires acceptance of the PPM principle. The big question is the carbon/energy content of manufactures. Trade sanctions would probably not be legitimate when applied solely as punishment for free riding, against unrelated products of a non-member or, in a more extreme case, on clean inputs, e.g., a ban on US turbines used for low-carbon projects (unless perhaps economy-wide sanctions were multilaterally agreed by UNFCCC members, an unlikely prospect).

Paradoxically, the need to keep out coal-generated electricity or aluminum from non-members of the Kyoto Protocol is greater than the need to keep out coal itself. The reason is that the Protocol already puts limits on within-country emissions. If one assumes the limits are enforced, then the world community has no particular interest in how the country goes about cutting its emissions. But if the country imports coal-generated electricity or aluminum from non-members, the emissions occur outside its borders and the environmental objective is undermined.

But it is hard to determine carbon content of manufactures. [65] The best would be to stay with the half-dozen biggest-scale, most energy-intensive industries – probably including aluminum, cement, steel, paper, and glass. Even here there are difficult questions. What if the energy used to smelt aluminum in another country is cleaner than in the importing country (Iceland's energy comes from hydro and geothermal) or dirtier (much of China's energy comes from coal)? How can one distinguish the marginal carbon content of the energy used for a particular aluminum shipment from the average carbon content of energy in the country of origin? These are questions that will have to be answered. But as soon as one goes beyond a half dozen big industries, it becomes too difficult for even a good-faith investigator to discern the effective carbon content. It is also too liable to abuse. One would not want to levy tariffs against the car parts that are made with the metal that was produced in a carbon-intensive way, or against the automobiles that used those car parts (they could be low-mileage hybrids !) or against the products of the firms that bought the cars, etc.

The big danger

Just because a government measure is given an environmental label, does not necessarily mean that it is motivated primarily -- or even at all -- by bona fide environmental objectives,. To see the point one has only to look at the massive mistake of American subsidies of ethanol (and protection against competing bio-fuels imports from Brazil). If each country on its own imposes border adjustments for imports in whatever way suits national politics, they will be poorly targeted, discriminatory, and often covertly protectionist. When reading the language in the US Congressional bills or the EU decision, it is not hard to imagine that special interests could take over for

[65] Hoel (1996), for example, analyzes the difficulty of computing taxes differentiated by sector.

protectionist purposes the process whereby each government decides whether other countries are doing their share, and what foreign competitors merit penalties.[66] This has been the historical pattern.[67] Thus the competitiveness provisions will indeed run afoul of the WTO, and they will deserve to.

It is important who makes the determinations regarding what countries are abiding by carbon-reduction commitments, who can retaliate against the non-compliers, what sectors are fair game, and what sort of barriers are appropriate. One policy conclusion is that these decisions should be delegated to independent panels of experts, rather than made by politicians.

The most important policy conclusion is that we need a multilateral regime to guide such measures. Ideally the regime would be negotiated along with a successor to the Kyoto Protocol that set targets for future periods and brought the United States and developing countries inside. But if that process takes too long, it might be useful in the shorter run for the US and EU to enter negotiations to harmonize guidelines for border penalties, ideally in association with the secretariats of the UNFCCC and the WTO.[68]

Why approach the problem multilaterally?

Some say the most promising path for addressing the problem of climate change is for each country to take measures on its own. But GHG emissions are inherently a global externality. No single country can address the problem on its own, due to the free rider problem. While there is a role for unilateral actions on climate change, in the long term multilateral action offers the only hope of addressing the problem.

The multilateral institutions are already in place -- specifically the UNFCCC, its child the Kyoto Protocol, and the WTO -- and the basic designs and operations of these institutions happen to be relatively sensible, taking political realities as given. They are more sensible than most critics of the international institutions and their alleged violations of national sovereignty believe. This applies whether the critics are on the left or right, and whether their main concern is the environment or the economy.[69] One can place very heavy weight on economic goals, and yet realize the desirability of addressing externalities, minimizing leakage, dealing with competitiveness concerns, and so forth. One can place very heavy weight on environmental goals, and yet realize the virtues of market mechanisms, non-discrimination, reciprocity, addressing international

[66] The Congressional language imposing penalties on imports from countries that do not tax carbon was apparently influenced by the International Brotherhood of Electrical Workers, which regularly lobbies for protection of American workers from foreign competition. Alan Beattie, *FT*, Jan 24, 2008. Simultaneously, the European Trade Union Confederation urged the EU Commission to tax imports from countries refusing to reduce emissions. "Unions back carbon tax on big polluting nations," AP and *Wall Street Journal*, Jan. 16, 2008.

[67] Ekens and Speck (1999) find that exemptions granted by European governments to environmental taxes "usually run counter to the environmental economic logic of using environmental taxes to internalise social costs… and they are likely to increase the costs of achieving a given level of emission reduction."

[68] Sampson (1999).

[69] I have addressed elsewhere *other* ways in which the climate regime (Kyoto) could come into conflict with the trade regime (WTO), and the more general questions of whether free trade and environmental protection need be in conflict. Frankel (2004, 2005a,b, 2008).

externalities *cooperatively*, preventing special interests from hijacking environmental language for their own financial gain, and so forth.

Concluding recommendations regarding trade penalties in climate legislation

The central message of this section of the report is that border measures to address leakage need not necessarily violate the WTO or sensible trade principles, but that there is a very great danger in practice that they will.

I conclude with some subjective judgments as to some principles that could guide a country's border measures if its goal were indeed to reduce leakage and avoid artificially tilting the playing field toward carbon-intensive imports of non-participating countries. I classify characteristics of possible border measures into two categories, which I will name by color (for lack of better labels):
(1) the "Black" category: those that seem to me very dangerous, in that they are likely to become an excuse for protectionism; and
(2) the "White" category: those that seem to me reasonable and appropriate.

The Black (inappropriate) border measures include:

- Unilateral measures applied by countries that are not participating in the Kyoto Protocol or its successors.
- Judgments as to findings of fact that are made by politicians, vulnerable to political pressure from interest groups for special protection.
- Unilateral measures that seek to sanction an entire country, rather than targeting narrowly defined energy-intensive sectors.
- Import barriers against products that are further removed from the carbon-intensive activity, such as firms that use inputs that are produced in an energy-intensive process.
- Subsidies – whether in the form of money or extra permit allocations -- to domestic sectors that are considered to have been put at a competitive disadvantage.

The White (appropriate) border measures could be either tariffs or (equivalently) a requirement for importers to surrender tradable permits. The principles include:

- Measures should follow some multilaterally-agreed set of guidelines among countries participating in the emission targets of the Kyoto Protocol and/or its successors.
- Judgments as to findings of fact -- what countries are complying or not, what industries are involved and what is their carbon content, what countries are entitled to respond with border measures, or the nature of the response – should be made by independent panels of experts.
- Measures should only applied by countries that are reducing their emissions in line with the Kyoto Protocol and/or its successors, against countries that are not, either due to refusal to join or to failure to comply.
- Import penalties should target fossil fuels, and a few of the most energy-intensive major industries: aluminum, cement, steel, paper, glass, and perhaps iron and chemicals.

If countries follow these guidelines in enacting border penalties, they may be consistent with the avowed goals of preventing leakage and undue loss of competitiveness and are unlikely to fall afoul of the WTO. If they do not follow these guidelines – the more likely outcome – they can be inconsistent with these goals, and with the WTO as well.

References

Aldy, Joseph, and Jeffrey Frankel, 2004, "Designing a Regime of Emission Commitments for Developing Countries that is Cost-Effective and Equitable," *G20 Leaders and Climate Change*, Council on Foreign Relations.

Aldy, Joseph, Scott Barrett, and Robert Stavins (2003), "Thirteen Plus One: A Comparison of Global Climate Architectures," *Climate Policy*, 3, no. 4, 373-97.

Antweiler, Werner, Brian Copeland and Scott Taylor, 2001, "Is Free Trade Good for the Environment?" *American Economic Review*, 91, no. 4, September, 877-908.

Arrow, K., R. Bolin, P. Costanza, P. Dasgupta, C. Folke, C.S.Holling, B.O. Jansson, S.Levin, K.G. Maler, C.Perrings, and D.Pimentel, 1995, "Economic Growth, Carrying Capacity, and the Environment," *Science* 268, 520-521, April 28.

Barrett, Scott, 1994, "Strategic Environmental Policy and International Trade," *Journal of Public Economics*, 54, 325-338.

Barrett, Scott, 1997, "The Strategy of Trade Sanctions in International Environmental Agreements," *Resource and Energy Economics* 19, 345-361.

Barrett, Scott, 2003, "Trade Leakage and Trade Linkage," Chapter 12 of Environment and Statecraft: The Strategy of Environmental Treaty-Making (Oxford University Press, UK)

Barrett, Scott, and Kathryn Graddy, 2000, "Freedom, Growth, and the Environment," *Environment and Development Economics* 5, 433-456.

Benedick, R.E. 1991, Ozone Diplomacy, (Harvard University Press: Cambridge MA).

Bhagwati, Jadgish, 2000, "On Thinking Clearly About the Linkage Between Trade and the Environment," The Wind of the Hundred Days: How Washington Mismanaged Globalization (MIT Press: Cambridge).

Bierman, F., and R. Brohm, 2005, "Implementing the Kyoto Protocol Without the United States: The Strategic Role of Energy Tax Adjustments at the Border," *Climate Policy* 4, no. 3.

Bimonte, Salvatore, 2001, "Model of Growth and Environmental Quality, A New Evidence of the Environmental Kuznets Curve," Universita degli Studi di Siena, Quaderni, no. 321, April.

Bordoff, Jason, 2008, "International Trade Law and the Economics of Climate Policy: Evaluating the Legality and Effectiveness of Proposals to Address Competitiveness and Leakage Concerns," *Climate Change, Trade and Investment Conference: Is a Collision Inevitable?*, Brookings Institution: Washington DC.

Brack, Duncan, 1996, International Trade and the Montreal Protocol (The Royal Institute of International Affairs and Earthscan Publications, Ltd.: London).

Bradford, David, Rebecca Fender, Stephen Shore and Martin Wagner, 2005. "The Environmental Kuznets Curve: Exploring a Fresh Specification," *Contributions to Economic Analysis & Policy*, Berkeley Electronic Press, 4 (1), 1073-1073. Revised version of David Bradford, Rebecca

Schlieckert and Stephen Shore, 2000, "The Environmental Kuznets Curve: Exploring a Fresh Specification," *NBER Working Paper* no. 8001.

Braithwaite, John, and Peter Drahos, Global Business Regulation, Cambridge University Press, UK.

Brander, James, and Paul Krugman, 1983, "A Reciprocal Dumping Model of International Trade" *Journal of International Economics*, 15, 313-323.

Brathen, Nils Axen, 2008, "Carbon-Related Border Tax Adjustments," Comments at conference *on Climate Change, Trade and Investment: Is a Collision Inevitable?*, June 9, 2008, Brookings Institution, Washington, DC, organized by Lael Brainard.

Brewer, T.L. "The Trade Regime and the Climate Regime: Institutional Evolution and Adaptation," *Climate Policy* 3, no. 4 (2003): 329-341.

Brewer, T.L., 2004, "Multinationals, the Environment and the WTO: Issues in the Environmental Goods and Services Industry and in Climate Change Mitigation," in S. Lundan, A. Rugman and A. Verbecke, eds., *Multinationals, the Environment and Global Competition* (Elsevier).

Brewer, T.L. "The WTO and the Kyoto Protocol: Interaction Issues," *Climate Policy* 4, no. 1 (Sept. 2004).

[Candia, Lizzie, 2003, "Does the Environmental Kuznets Curve Explain How a Growing Economy Can Achieve Better Environmental Qualityi?" *Dundee Yearbook of International Natural Resources and Energy Law and Policy*, Vol. 7 (University of Dundee, UK).]

Carraro, Carlo, and D. Siniscalco, 1994, "R and D Cooperation and the Stability of Interanational Environmental Agreements," Nota di Lavoro 65/94, Fondanzione Eni Enrico Mattei, Milan.

Charnovitz, Stephen, 2003a, "The Law of Environmental 'PPMs' in the WTO: Debunking the Myth of Illegality," *The Yale Journal of International Law* 27, no. 1 (Winter): 59-110.

Charnovitz, Stephen, 2003b, "Trade and Climate: Potential Conflicts and Synergies," in *Beyond Kyoto: Advancing the International Effort Against Climate Change* (Pew Center on Global Climate Change): 141-167.

Charnovitz, Steve, and Michael Weinstein, 2001, "The Greening of the WTO," *Foreign Affairs* 80, no. 6, 147-156.

Chaudhuri, Shubham, and Alexander Pfaff, 2002, "Economic Growth and the Environment: What Can We Learn from Household Data?" Columbia University, February.

Chintrakarn, Pandej and Daniel Millimet. 2006. "The Environmental Consequences of Trade: Evidence from Subnational Trade Flows," *Journal of Environmental Economics and Management*, 52, 430-453.

Chua, Swee. 2003. "Does Tighter Environmental Policy Lead to a Comparative Advantage in Less Polluting Goods?" *Oxford Economic Papers* 55: 25-35 (Oxford University Press).

Copeland, Brian, and Scott Taylor, 2001, "International Trade and the Environment: A Framework for Analysis," *NBER Working Paper* No. 8540, Oct.

Copeland, Brian, and Scott Taylor, 2003, Trade and the Environment: Theory and Evidence (Princeton University Press: Princeton).

Copeland, Brian, and Scott Taylor, 2004, "Trade, Growth and the Environment," *Journal of Economic Literature* 42(1): 7-71. NBER Working Paper No. 9823, July 2003.

[Costello, Christopher and Carol McAusland. 2003. "Protectionism, Trade, and Measures of Damage from Exotic Species Introductions, " *American Journal of Agricultural Economics*, 85(4) 2003: 964-975.

Costello, Christopher, Mike Springborn, Carol McAusland and Andy Solow. 2006. "Unintended biological invasions: Does risk vary by trading partner?" *Journal of Environmental Economics and Management* 54(3) 2007: 262-276.]

Cropper, Maureen, and Charles Griffiths, 1994, "The Interaction of Population Growth and Evironmental Quality," *American Economic Review* 84, no. 2, May, 250-254.

Daly, Herman, 1993, "The Perils of Free Trade," Scientific American, Nov., 51-55.

Dasgupta, Susmita, Benoit Laplante, Hua Wang and David Wheeler, 2002, "Confronting the Environmental Kuznets Curve," *Journal of Economic Perspectives*, 16, no. 1, Winter: 147-168.

Dean, Judy, 1992, "Trade and the Environment: A Survey of the Literature," in Patrick Low, ed., *International Trade and the Environment*, World Bank Discussion Paper No. 159.

Dean, Judy, 2001, "Overview," in International Trade and the Environment, J. Dean, ed., *International Library of Environmental Economics and Policy Series*, (Ashgate Publishing: UK).

Dean, Judy, 2002, "Does Trade Liberalization Harm the Environment? A New Test," *Canadian Journal of Economics* 35, no. 4, November: 819-842.

Dua, Andre, and Daniel Esty, 1997, *Sustaining the Asia Pacific Miracle: Environmental Protection and Economic Integration*, Institute for International Economics: Washington DC.

Ederington, Josh, Arik Levinson and Jenny Minier, 2005, "Footloose and Pollution-Free," *Review of Economics and Statistics* 87: 92-99. NBER Working Paper No. 9718, May 2003.

Eiras, Ana, and Brett Schaefer, 2001, "Trade: The Best Way to Protect the Environment," *Backgrounder*, The Heritage Foundation no. 1480, September 27.

Ekins, Paul, and Stefan Speck, 1999, "Competitiveness and Exemptions From Environmental Taxes in Europe," *Environmental and Resource Economics* (Springer Netherlands), Volume 13, Number 4 / June, 1999: 369-396

Eskeland, Gunnar S. and Ann E. Harrison. 2003. "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis," *Journal of Development Economics.* 70(1):1-23.

Esty, Daniel, 1994, Greening the GATT: Trade, Environment, and the Future, Institute for International Economics, Washington DC.

Esty, Daniel, 2001, "Bridging the Trade-Environment Divide," Journal of Economic Perspectives, Summer 15, no. 3, 113-130.

Esty, Daniel, and Bradford Gentry, 1997, "Foreign Investment, Globalisation, and the Environment," Globalization and the Environment, edited by Tom Jones (Organization for Economic Cooperation and Development: Paris).

Esty, Daniel, and Michael Porter, 2001, "Measuring National Environmental Performance and Its Determinants," Yale Law School and Harvard Business School, April.

Foster, Andrew, and Mark Rosenzweig, 2003, "Economic Growth and the Rise of Forests," *Quarterly Journal of Economics*, 118, issue 2, May 601-638.

Frankel, Jeffrey, 2004, "Kyoto and Geneva: Linkage of the Climate Change Regime and the Trade Regime" for *Broadening Climate Discussion: The Linkage of Climate Change to Other Policy Areas*, FEEM/MIT conference, Venice.

Frankel, Jeffrey, 2005a, "Climate and Trade: Links Between the Kyoto Protocol and WTO," in *Environmen*t, vol. 47, no. 7, September 2005: 8-19.

Frankel, Jeffrey, 2005b, "The Environment and Globalization" in *Globalization: What's New* edited by Michael Weinstein (Columbia University Press: New York): 129-169. Reprinted in Economics of the Environment: Selected Readings, Fifth Edition, R.Stavins, editor (W.W.Norton: New York), 2005.

Frankel, Jeffrey, 2007, "Formulas for Quantitative Emission Targets," in *Architectures for Agreement: Addressing Global Climate Change in the Post Kyoto World*, Joe Aldy and Robert Stavins, editors, Cambridge University Press, p. 32-56.

Frankel, Jeffrey, 2008, "Addressing the Leakage/Competitiveness Issue In Climate Change Policy Proposals," *Climate Change, Trade and Investment: Is a Collision Inevitable?*, Brookings Institution, Washington, DC, organized by Lael Brainard.

Frankel, Jeffrey, and Andrew Rose, "Is Trade Good or Bad for the Environment? Sorting out the Causality" *Review of Economics and Statistics*, 87, no. 1, 2005.

Fredriksson, Per G. and Muthukumara Mani, 2004, "Trade Integration and Political Turbulence: Environmental Policy Consequences," *Advances in Economic Analysis & Policy*: Vol. 4 : Iss. 2, Article 1.

Goulder, Lawrence, and Robert Stavins, 2002, "An Eye on the Future," *Nature*, 419, Oct. 17, 673-74.

Government of Sweden, Kommerskollegium, 2004, *Climate and Trade Rules – Harmony or Conflict?*.

Grossman, Gene, and Alan Krueger, 1993, "Environmental Impacts of a North American Free Trade Agreement," in The U.S.-Mexico Free Trade Agreement, Peter Garber, editor, MIT Press.

Grossman, Gene, and Alan Krueger, 1995, "Economic Growth and the Environment," *Quarterly Journal of Economics*, 110, no. 2, May: 353-77.

Hanley, Nick, Jason Shogren, and Ben White, Environmental Economics in Theory and Practice, (Oxford: New York), 1997.

Harbaugh, Willaim, Arik Levinson, and David Molloy Wilson 2001, "Reexaming the Empirical Evidence for an Environmental Kuznets Curve," National Bureau of Economic Research, February 27.

Hauser, Trevor; Rob Bradley; Britt Childs; Jacob Werksman; and Robert Heilmayr, 2008, Leveling the Carbon Playing Field: International Competition and US Climate Policy Design, (Peterson Institute for International Economics: Washington DC.

Hilton, F.G. Hank, and Arik Levinson, 1998, "Factoring theEnvironmental Kuznets Curve: Evidence from Automotive Lead Emissions," *Journal of Environmental Economics and Management* 35, 126-141.

Hoel, M. 1992, "International Environment Conventions: The Case of Uniform Reductions of Emissions," *Environmental Research* Economics 2, 141-159.

Hoel, M., 1996, "Should a Carbon Tax Be Differentiated Across Sectors?" *Journal of Public Economics*, 59, 17-32.

Holtz-Eakin and T. Selden, 1995, "Stoking the Fires? CO2 Emissions and Economic Growth," *Journal of Public Economics*, vol. 57, May, 85-101.

Hufbauer, Gary, Daniel Esty, Diana Orejas, Luis Rubio, and Jeffrey Schott, 2000, NAFTA and the Environment: Seven Years Later, *Policy Analyses in International Economics* No. 61, Institute for International Economics: Washington DC.

International Panel on Climate Change (2001), *Third Assessment Report -- Climate Change 2001*, Working Group III.

Jaffe, Adam, S.R. Peterson, Paul Portney and Robert Stavins, 1995, "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic Literature* 33, 132-63.

Kahn, Matthew E. and Yutaka Yoshino, 2004, "Testing for Pollution Havens Inside and Outside of Regional Trading Blocs," *Advances in Economic Analysis & Policy* 4(2).

Kander, Astrid, and Magnus Lindmark, 2006, "Foreign trade and declining pollution in Sweden : a decomposition analysis of long-term structural and technological effects," *Energy policy* , vol. 34, n°13, pp. 1590-1599

Kellenberg, Derek, 2008, "A reexamination of the role of income for the trade and environment debate," *Ecological Economics* 68, issue 1-2: 106-115

Kennedy, P. W., 1994, "Equilibrium Pollution Taxes in Open Economics with Imperfect Competition," *Journal of Environmental Economics Management*, 27, 141-159.

Levinson, Arik, and Scott Taylor, 2008, "Trade and the Environment: Unmasking the Pollution Haven Effect," *International Economic Review*, 49 (1), 223-254.

List, John A. and Daniel Millimet. 2004. "The Case of the Missing Pollution Haven Hypothesis," *Journal of Regulatory Economics*, 2004, 26, 239-262.

Low, P., and A. Yeats, 1992, "Do 'Dirty' Industries Migrate?" in P. Low, editor, International Trade and the Environment (The World Bank), 89-104.

Lucas, Robert E.B., David Wheeler, and Hememala Hettige, 1992, "Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960-1988," in Patrick Low, editor, International Trade and the Environment, World Bank Discussion Papers no. 159 (The World Bank: Washington DC).

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

McAusland, Carol. 2008, "Trade, Politics, and the Environment: Tailpipe vs. Smokestack" *Journal of Environmental Economics and Management* 55(1): 52-71.

McKibbin, Warwick, and Peter Wilcoxen, 2008, "The Economic and Environmental Effects of Border Adjustments for Climate Policy," Brookings Conference on *Climate Change, Trade and Competitiveness: Is a Collision Inevitable?*, Washington, DC.

Mulatu, Abay, Raymond J.G.M. Florax, and Cees Withagen, 2004, "Environmental Regulation and International Trade: Empirical Results for Germany, the Netherlands and the US, 1977-1992" *Contributions to Economic Analysis & Policy* 3(2).

Neumayer, Eric, 2002, "Does Trade Openness Promote Multilateral Environmental Cooperation?" *The World Economy* 25, no. 6, 812-832.

Panayotou, Theo, 1993, "Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Development," Working Paper WP238, Technology and Employment Programme (International Labor Office: Geneva).

Panayotou, Theo, 2000, "Economic Growth and the Environment," Center for International Development Working Paper No. 56, Harvard University.

Regibeau, Pierre M. and Alberto Gallegos. 2004. "Managed Trade, Trade Liberalisation and Local Pollution," *Advances in Economic Analysis & Policy* 4(2).

Ruggie, John, 2002, "Trade, Sustainability and Global Governance," *Columbia Journal of Environmental Law*, vol 27, 297-307.

Sampson, Gary, Trade, Environment, and the WTO: The Post-Seattle Agenda, Johns Hopkins University Press (Baltimore), 2000.

Sampson, Gary, 1999, "WTO Rules and Climate Change: The Need for Policy Coherence," in Bradnee Chambers, editor, Global Climate Governance: A Report on the Inter-Linkages Between the Kyoto Protocol and Other Multilateral Regimes (Tokyo: United Nations University).

Schleich, Joachim. 1999, "Environmental Quality with Endogenous Domestic and Trade Policies," *European Journal of Political Economy* 15, no. 1, March: 53-71.

Schulze, Gunther G. and Heinrich W. Ursprung, eds. 2001. *International Environmental Economics: A survey of the issues* (Oxford University Press: Oxford), Chapter 4.

Seidman, Laurence, and Kenneth Lewis, 2008, "Compensation and Contributions Under an International Carbon Treaty," University of Delaware, February.

Selden, Thomas, and Daqing Song, 1994, "Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions," *Journal of Environmental Economics and Management* 27, 147-162.

Shafik, Nemat, 1994, "Economic Development and Environmental Quality: An Econometric Analysis," *Oxford Economic Papers* 46, 757-773.

Smarzynska-Javorcik, Beata, and Shang-Jin Wei, 2004, "Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth? *Contributions to Economic Analysis & Policy* 3(2). *NBER Working Paper* No. 8465, September 2004.

Smulders, Sjak. Daan van Soest, Cees Withagen. 2004. "International trade, species diversity, and habitat conservation," *Journal of Environmental Economics and Management*.

Stern, David, and Michael Common, 2001, "Is There an Environmental Kuznets Curve for Sulfur?" *Journal of Environmental Economics and Management, 41, 162-178*

Suri, Vivek, and Duane Chapman, 1998, "Economic Growth, Trade and Energy: Implications for the Environmental Kuznets Curve," *Ecological Economics* 25, 2, May, 147-160.

Tobey, James, 1990, "The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test," *Kyklos* 43, 191-209.

Ulph, A., 1994 , "Environmental Policy and International Trade: A Survey of Recent Economic Analysis," Fondazione ENI Enrico Mattei Discussion Paper No. 53/94.

Vogel, David, 1995, Trading Up: Consumer and Environmental Regulation in a Global Economy, Harvard University Press.

World Bank, 1992, *Development and the Environment,* World Development Report .

Xing, Y. and C. Kolstad, 1996, "Environment and Trade: A Review of Theory and Issues" Economics Department Working Paper 2-96, University of California, Santa Barbara.

Appendix 1:
Addressing a critique of of the use of the trade/GDP measure in environmental equations

Squalli (2008) argues that the measure of "openness" that is used in Frankel-Rose (2003) and Kellenberg (2008) and these other studies is not the appropriate variable. The word "openness" seems to connote deliberate policy decisions, such as removal of tariffs. Squalli points out, correctly, that trade/GDP ratios don't capture this notion of openness, and in particular that large countries such as the United States, Japan, China and Germany rank very low on the list by this measure, even though they are among the more liberalized of countries. He wants to modify the trade/GDP ratio by multiplying it by the country's share of world trade, with the result that large countries are not penalized, and only then put the resulting variable ("composite trade share") into the environmental equation. But he appears to have wandered astray.

It is well-known that countries' trade/GDP ratios depend inversely on their size (smaller countries are more dependent on trade because they lack both a large enough internal market to exploit economies of scale and diverse enough factor endowments to manage without comparative-advantage-based trade). It is also well-known that countries' trade/GDP ratios depend on geographic determinants such as landlockedness, remoteness from the world's major economies, and so forth. One could try to adjust for all these factors if one truly wanted a measure of overall trade policy. But recall that the debate is between the hypothesis that high-trade countries experience downward pressure on environmental regulation due to competitiveness concerns (race to the bottom) and the hypothesis that high-trade countries enjoy positive environmental benefits such as innovation (gains from trade). It does not matter for this purpose whether the level of trade is the way it is due to country size, geography, or deliberate free-trade policy.

Appendix 5:
Estimation of Determinants of Environmental Degradation for 1995, 2000 and 2004

Table 5: Determination of Environmental Degradation, OLS and IV, 1995

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO2**	(6) **SO2**	(7)**PM10**	(8) **Water**
	OLS				**IV**			
Trade/GDP	0.003*	0.000	-0.000	0.002	0.020**	0.005	-0.000	0.009
	(0.002)	(0.002)	(0.001)	(0.002)	(0.008)	(0.007)	(0.005)	(0.008)
Log real GDP per capita	2.544*	0.390	0.394	2.569***	2.545*	-0.144	0.423	2.324**
	(1.291)	(0.839)	(0.525)	(0.896)	(1.341)	(1.109)	(0.768)	(0.884)
Log real GDP p/c squared	-0.074	0.032	-0.039	-0.113**	-0.078	0.060	-0.040	-0.106**
	(0.077)	(0.050)	(0.032)	(0.052)	(0.079)	(0.066)	(0.045)	(0.052)
Polity (democracy)	0.000	-0.005	0.001	0.019**	0.005	0.004	-0.003	0.059***
	(0.009)	(0.006)	(0.003)	(0.009)	(0.008)	(0.006)	(0.004)	(0.019)
Log of Area per capita	-0.002	0.142***	-0.015	-0.086*	0.108	0.182***	-0.015	-0.025
	(0.067)	(0.054)	(0.041)	(0.049)	(0.077)	(0.065)	(0.045)	(0.090)
Observations	152	153	152	91	131	132	131	84

*** p<0.01, ** p<0.05, * p<0.1

Notes: Robust standard errors in parentheses.

1. F-R'04: the Frankel & Rose (2004) result
2. F-R'08: update with Penn World Table 6.2, and new environmental data:
3. New CO2 country emission data from WB WDI ---- National CO2 emissions (metric tons per capita)
4. New SO2 country emission data: from WRI and EDGAR ---- National SO2 emissions (metric tons p.c.)
5. New PM10 country level data: from WB WDI ---- PM10 country level (micrograms per cubic meter)
6. Water Pollution: from WB WDI Organic water pollutant emissions (kg per day per capita)

Table 6: Determination of Environmental Degradation, 2000

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO2**	(6) **CO2**	(7) **SO2**	(8) **PM10**
	OLS				**IV**			
Trade/GDP	0.002	0.001	-0.002	0.002	0.006	0.002	-0.002	0.013
	(0.001)	(0.002)	(0.001)	(0.002)	(0.004)	(0.005)	(0.003)	(0.009)
Log real GDP per capita	3.084***	0.057	0.239	5.719***	2.895***	-0.483	0.466	5.373***
	(0.753)	(0.972)	(0.561)	(1.633)	(0.837)	(1.002)	(0.650)	(1.484)
Log real GDP p/c squared	-0.105**	0.045	-0.027	-0.283***	-0.095*	0.076	-0.040	-0.271***
	(0.044)	(0.057)	(0.034)	(0.089)	(0.049)	(0.059)	(0.038)	(0.084)
Polity (democracy)	-0.005	0.000	0.000	0.021*	-0.001	0.003	-0.001	0.037*
	(0.004)	(0.006)	(0.002)	(0.012)	(0.004)	(0.004)	(0.003)	(0.021)
Log of Area per capita	0.019	0.139**	-0.002	-0.095*	0.050	0.163***	-0.007	0.073
	(0.055)	(0.060)	(0.040)	(0.050)	(0.050)	(0.060)	(0.039)	(0.150)
Observations	153	156	156	68	149	152	152	68

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses

Table 7: Determination of Environmental Degradation, OLS and IV, 2004

VARIABLES	(1) **CO2**	(2) **PM10**	(3) **CO2**	(4) **PM10**
	OLS		IV	
Trade/GDP	0.001	-0.001	0.001	-0.005
	(0.001)	(0.002)	(0.007)	(0.007)
Log real GDP per capita	2.242*	0.286	2.591**	0.450
	(1.148)	(0.981)	(1.122)	(1.043)
Log real GDP p/c squared	-0.062	-0.036	-0.081	-0.043
	(0.065)	(0.055)	(0.064)	(0.059)
Polity (democracy)	0.007	0.005	0.006	0.004
	(0.007)	(0.005)	(0.009)	(0.006)
Log of Area per capita	-0.039	-0.064	-0.034	-0.137
	(0.068)	(0.073)	(0.145)	(0.145)
Observations	68	69	67	68

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses

Appendix 3 : Estimation of Determinants of Environmental Degradation Allowing Cubic Income

Table 1A: Cubic-Income Determinants of Environmental Degradation, OLS, 1990

VARIABLES	(1) **CO2,'04**	(2) **CO2,'08**	(3) **SO2, '04**	(4) **SO2,'08**	(5) **PM, '04**	(6) **PM10,'08**	(7) **Water Emis'08**
Trade/GDP	0.017**	-0.001	-0.306***	0.002	-0.374	0.001	-0.000
	(0.008)	(0.002)	(0.079)	(0.002)	(0.337)	(0.001)	(0.001)
Log real GDP per capita	-17.879***	0.133	287.250**	-11.086	566.651	9.667	-10.848
	(4.365)	(12.909)	(118.806)	(11.659)	(336.189)	(7.509)	(9.997)
Log real GDP p/c squared	1.329***	0.232	-16.584**	1.418	-35.566*	-1.144	1.430
	(0.284)	(1.576)	(6.781)	(1.435)	(19.056)	(0.920)	(1.226)
Log real GDP p/c cubic		-0.012		-0.055		0.043	-0.058
		(0.063)		(0.058)		(0.037)	(0.049)
Polity (democracy)	-0.016*	-0.011**	-6.579***	0.002	-6.697*	-0.001	0.013***
	(0.009)	(0.005)	(2.049)	(0.003)	(3.416)	(0.005)	(0.005)
Log of Area per capita	0.155	-0.091	-2.921**	0.154**	-13.024**	-0.015	-0.093
	(0.155)	(0.101)	(1.394)	(0.067)	(6.292)	(0.039)	(0.076)
Observations	102	130	41	132	38	131	86

*** p<0.01, ** p<0.05, * p<0.1

Notes: Robust standard errors in parentheses.

1. F-R'04: the Frankel & Rose (2004) result
2. F-R'08: update with Penn World Table 6.2, and new environmental data:
3. New CO2 country emission data from WB WDI ---- National CO2 emissions (metric tons per capita)
4. New SO2 country emission data: from WRI and EDGAR ---- National SO2 emissions (metric tons p.c.)
5. New PM10 country level data: from WB WDI ---- PM10 country level (micrograms per cubic meter)
6. Water Pollution: from WB WDI Organic water pollutant emissions (kg per day per capita)

Table 2A: Cubic-Income Determinants of Environmental Degradation, 1990, Trade IV

VARIABLES	(1) **CO2,'04**	(2) **CO2,'08**	(3) **SO2,'04**	(4) **SO2,'08**	(5) **PM, '04**	(6) **PM10,'08**	(7) **Water Emis'08**
Trade/GDP	-0.011	0.025**	-0.220	0.007	-1.311	0.004	-0.003
	(0.022)	(0.012)	(0.394)	(0.008)	(1.012)	(0.006)	(0.007)
Log real GDP per capita	-15.201***	0.010	245.369	-22.864	578.784**	12.040	-10.796
	(3.462)	(23.716)	(186.551)	(14.525)	(251.316)	(10.170)	(12.969)
Log real GDP p/c squared	1.165***	0.084	-14.335	2.790	-35.826**	-1.460	1.460
	(0.215)	(2.898)	(10.287)	(1.774)	(14.590)	(1.242)	(1.584)
Log real GDP p/c cubic		-0.001		-0.108		0.057	-0.061
		(0.117)		(0.071)		(0.050)	(0.064)
Polity (democracy)	-0.022	0.004	-6.265***	0.003	-7.242**	0.000	0.019*
	(0.018)	(0.011)	(2.148)	(0.007)	(2.674)	(0.005)	(0.011)
Log of Area per capita	0.032	0.069	-0.748	0.209***	-16.548*	0.012	-0.137
	(0.234)	(0.109)	(7.760)	(0.070)	(9.447)	(0.049)	(0.085)
Observations	97	117	38	118	35	118	80

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3A: Cubic-Income Determinants of Environmental Degradation, OLS and IV, 1995

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO2,IV**	(6) **SO2,IV**	(7) **PM10,IV**	(8) **Water,IV**
			OLS				**IV**	
Trade/GDP	0.003*	0.000	-0.000	0.002	0.020**	0.007	-0.001	0.009
	(0.002)	(0.002)	(0.001)	(0.002)	(0.008)	(0.007)	(0.005)	(0.008)
Log real GDP per capita	-15.904*	-14.543**	9.730**	-1.891	-1.683	-42.327***	16.805*	7.106
	(8.856)	(6.326)	(4.229)	(12.066)	(16.704)	(13.227)	(9.317)	(11.320)
Log real GDP p/c squared	2.234**	1.899**	-1.206**	0.425	0.434	5.172***	-2.025*	-0.682
	(1.091)	(0.793)	(0.540)	(1.436)	(2.023)	(1.601)	(1.128)	(1.361)
Log real GDP p/c cubic	-0.095**	-0.077**	0.048**	-0.021	-0.020	-0.204***	0.079*	0.023
	(0.044)	(0.033)	(0.023)	(0.056)	(0.081)	(0.064)	(0.045)	(0.054)
Polity (democracy)	0.003	-0.004	-0.000	0.018*	0.005	0.005	-0.004	0.059***
	(0.009)	(0.006)	(0.003)	(0.010)	(0.008)	(0.006)	(0.004)	(0.019)
Log of Area per capita	-0.015	0.131**	-0.008	-0.089*	0.107	0.175***	-0.013	-0.026
	(0.068)	(0.054)	(0.041)	(0.050)	(0.078)	(0.064)	(0.045)	(0.089)
Observations	152	153	152	91	131	132	131	84

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses

Table 4A: Cubic-Income Determinants of Environmental Degradation, OLS and IV, 2000

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO2,IV**	(6) **SO2,IV**	(7) **PM10,IV**	(8) **Water,IV**
			OLS				**IV**	
Trade/GDP	0.002	0.001	-0.002	0.002	0.006	0.002	-0.002	0.014
	(0.001)	(0.002)	(0.001)	(0.002)	(0.004)	(0.005)	(0.003)	(0.009)
Log real GDP per capita	4.041	-13.188	12.560**	13.854	0.698	-20.389*	13.847**	26.492
	(8.882)	(10.973)	(6.169)	(18.493)	(9.262)	(10.796)	(7.000)	(23.528)
Log real GDP p/c squared	-0.221	1.651	-1.521**	-1.240	0.171	2.488*	-1.661*	-2.757
	(1.077)	(1.330)	(0.760)	(2.116)	(1.116)	(1.302)	(0.844)	(2.774)
Log real GDP p/c cubic	0.005	-0.064	0.060*	0.037	-0.011	-0.096*	0.065*	0.096
	(0.043)	(0.053)	(0.031)	(0.080)	(0.044)	(0.052)	(0.034)	(0.108)
Polity (democracy)	-0.005	0.001	-0.000	0.023**	-0.001	0.004	-0.001	0.043*
	(0.004)	(0.006)	(0.002)	(0.012)	(0.004)	(0.004)	(0.003)	(0.024)
Log of Area per capita	0.019	0.133**	0.003	-0.092*	0.049	0.154**	-0.001	0.090
	(0.055)	(0.061)	(0.039)	(0.047)	(0.050)	(0.060)	(0.039)	(0.162)
Observations	153	156	156	68	149	152	152	68

*** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses

Table 5A: Cubic-Income Determinants of Environmental Degradation, 2004

VARIABLES	(1) **CO2**	(2) **PM10**	(3) **CO2**	(4) **PM10**
	OLS		**IV**	
Trade/GDP	0.001	-0.001	0.000	-0.005
	(0.001)	(0.002)	(0.007)	(0.007)
Log real GDP per capita	-11.709	7.967	-7.801	7.782
	(16.796)	(10.527)	(15.219)	(13.826)
Log real GDP p/c squared	1.592	-0.948	1.148	-0.911
	(1.989)	(1.253)	(1.795)	(1.635)
Log real GDP p/c cubic	-0.065	0.036	-0.048	0.034
	(0.078)	(0.049)	(0.070)	(0.064)
Polity (democracy)	0.012	0.003	0.010	0.002
	(0.009)	(0.006)	(0.010)	(0.007)
Log of Area per capita	-0.046	-0.060	-0.047	-0.130
	(0.072)	(0.073)	(0.146)	(0.148)
Observations	68	69	67	68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6A: Cubic-Income Determinants of Environmental Degradation, Panel

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO2,FE**	(6) **SO2**	(7) **PM10**	(8) **Water**
	Random Effects				Fixed Effects, Time			
Trade/GDP	0.002***	-0.000	-0.000	-0.001	0.002***	-0.000	0.001***	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
Log real GDP per capita	-2.518***	-4.950	0.833	-16.761***	-0.438	3.994	1.669**	-12.169***
	(0.913)	(4.038)	(0.832)	(2.552)	(0.899)	(4.524)	(0.653)	(2.579)
Log real GDP p/c squared	0.475***	0.655	-0.064	2.215***	0.181	-0.572	-0.245***	1.538***
	(0.112)	(0.505)	(0.104)	(0.304)	(0.111)	(0.579)	(0.082)	(0.307)
Log real GDP p/c cubic	-0.022***	-0.025	-0.000	-0.093***	-0.009*	0.026	0.011***	-0.061***
	(0.005)	(0.021)	(0.004)	(0.012)	(0.005)	(0.024)	(0.003)	(0.012)
Polity (democracy)	0.000	0.002	-0.000	-0.001	0.001	0.002	0.000	-0.000
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)	(0.001)
Log of Area per capita	-0.341***	0.101*	0.500***	-0.003	-0.669***	-1.088**	-0.105**	-0.684***
	(0.020)	(0.052)	(0.027)	(0.035)	(0.050)	(0.434)	(0.053)	(0.098)
Observations	5369	441	2147	1951	5369	441	2147	1951
Number of cid	157	158	158	136	157	158	158	136

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

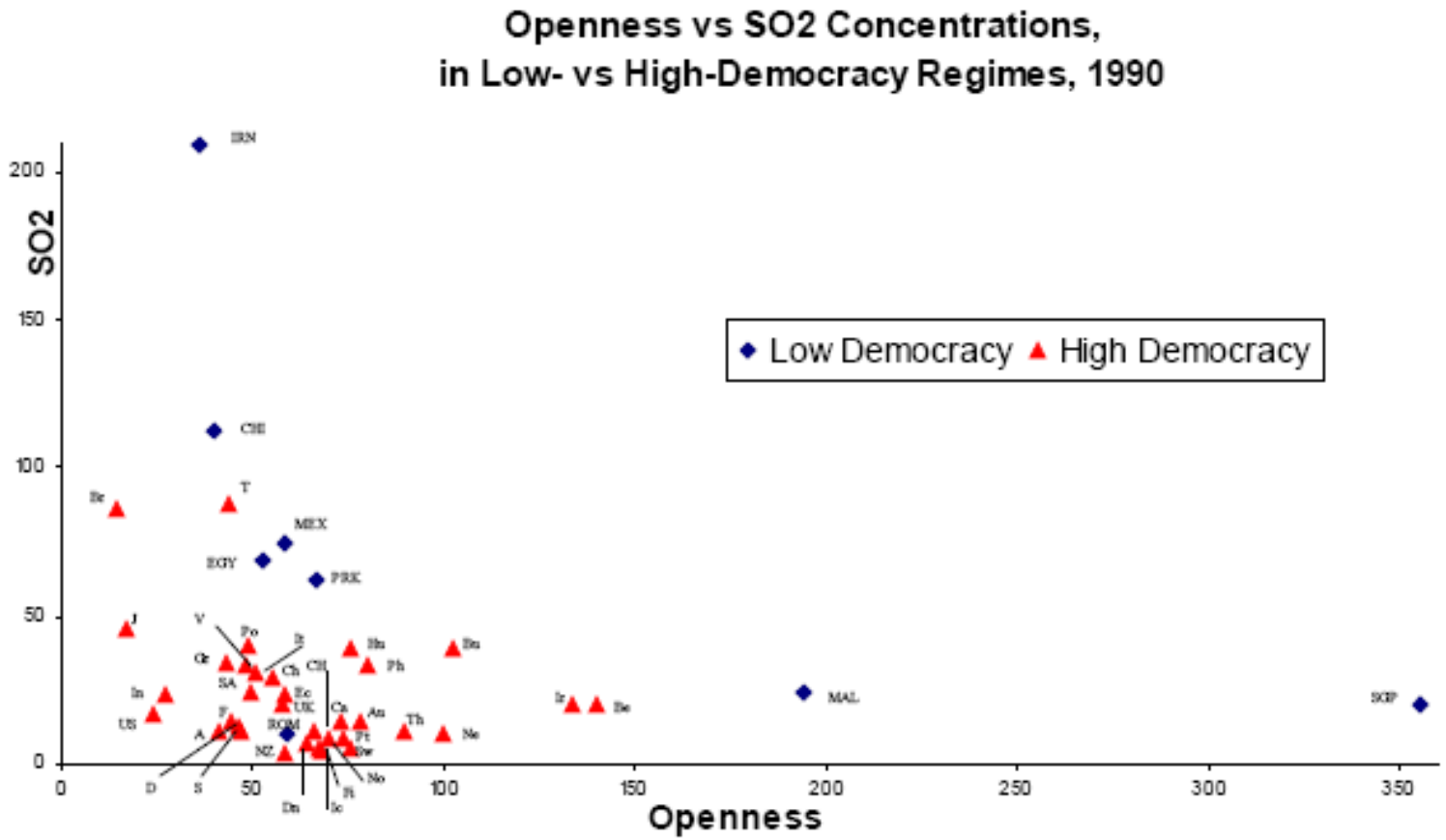
Table 7A: Cubic-Income Determinants of Environmental Degradation, 5 year Panel

VARIABLES	(1) **CO2**	(2) **SO2**	(3) **PM10**	(4) **Water**	(5) **CO**	(6) **SO2**	(7) **PM10**	(8) **Water**
	Random Effects				Fixed Effects, Time			
Trade/GDP	0.002***	0.001	-0.001	-0.000	0.003***	0.001	0.001*	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.001)
Log real GDP per capita	-5.870***	-4.080	2.177	-19.306***	-1.167	8.532	2.026	-15.108**
	(2.184)	(6.517)	(2.877)	(5.216)	(2.197)	(7.679)	(2.057)	(5.879)
Log real GDP p/c squared	0.923***	0.604	-0.228	2.536***	0.281	-0.992	-0.292	1.803***
	(0.267)	(0.793)	(0.351)	(0.621)	(0.270)	(0.938)	(0.251)	(0.694)
Log real GDP p/c cubic	-0.040***	-0.025	0.006	-0.106***	-0.013	0.038	0.014	-0.069**
	(0.011)	(0.032)	(0.014)	(0.024)	(0.011)	(0.038)	(0.010)	(0.027)
Polity (democracy)	0.001	0.002	-0.001	-0.001	0.003*	0.004	0.000	-0.000
	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.002)
Log of Area per capita	-0.174***	0.107**	0.123***	-0.074*	-0.663***	-1.911***	-0.425***	-0.774***
	(0.035)	(0.053)	(0.037)	(0.043)	(0.110)	(0.429)	(0.115)	(0.208)
Observations	1118	463	463	494	1118	463	463	494
Number of cid	157	158	158	136	157	158	158	136

*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parentheses

Figure 1: An inverse relationship between the total trade/GDP ratio and sulphur dioxide



Source: Frankel (2005b, Figure 1).

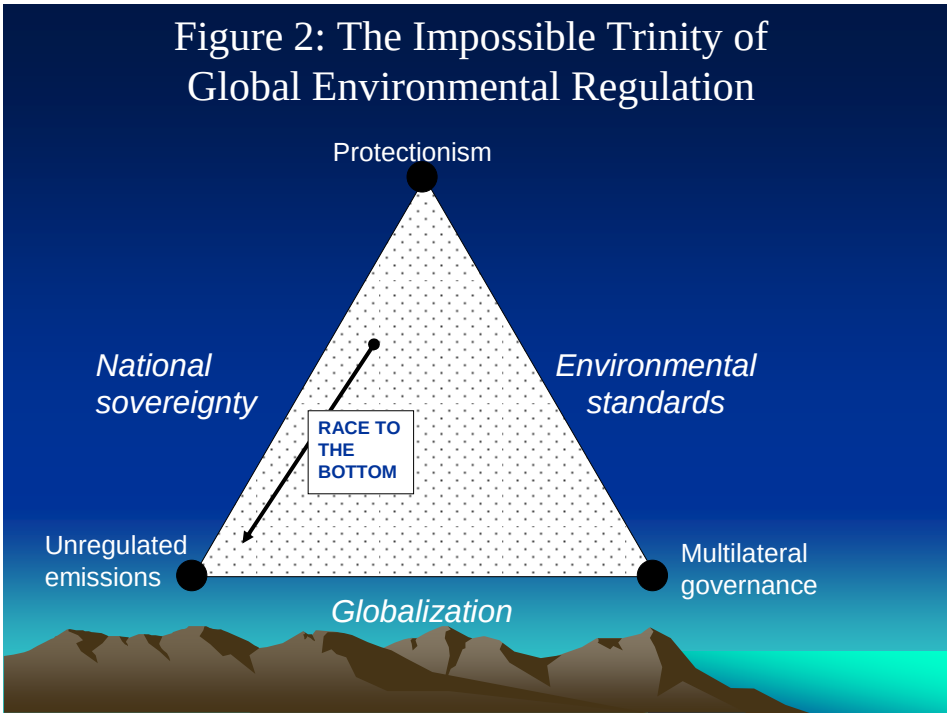


Figure 2: The Impossible Trinity of Global Environmental Regulation
Protectionism
National sovereignty
Environmental standards
RACE TO THE BOTTOM
Unregulated emissions
Multilateral governance
Globalization