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Trade and Climate Change: An Analytical Review of Key Issues

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The last decade has witnessed an increasing global awareness of human impact on the planet's climate and its likely consequences. However, strategic and structural complexities hinder further compliance and participation in efforts to establish a global agreement for climate change mitigation. This induces economists and environmentalists to further investigate the two-way relationship between trade and climate change, that is, climate-related consequences of liberalized trade and possible benefits of using trade policy for climate change mitigation.

The Impact of Trade on Climate

There has been a rapid expansion of international trade and deepened trade liberalization among countries within the last few decades. The volume of world trade is nearly 32 times greater than the 1950 level. The ratio of merchandise trade to gross domestic product (GDP) has increased from less than 20 percent to more than 50 percent in less than half a century (figure 1). This was partly facilitated by reductions in average world tariffs at major export destinations; that is, tariffs were reduced from 18 percent in Europe and 15 percent in North America in the late 1950s to about 4 percent in North Atlantic countries by the end of the 20th century (Baldwin 2006). In parallel, there has been a drastic increase in the carbon dioxide (CO_2) concentrations in the atmosphere, from about 310 ppm (parts per million) in the 1950s to about 390 ppm by the end of the century (World Bank 2010). The simultaneous expansion of trade, greater trade liberalization and higher pollution intensities, therefore, raise questions about the climate impacts of trade and trade liberalization.

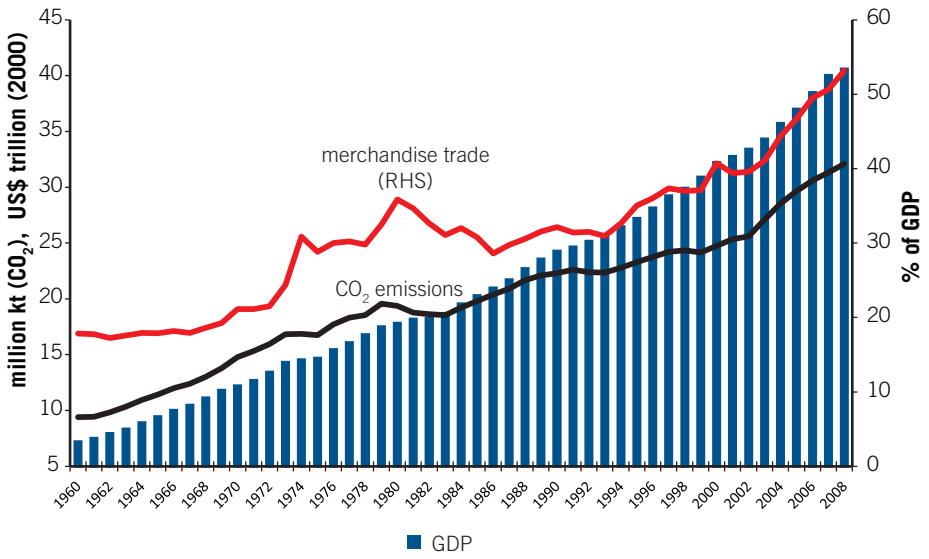
Do Emissions Rise When Countries Trade More?

Emissions of green house gases (GHGs) do not necessarily rise when countries trade more. Trade theory suggests that the impact of a marginal change in trade on the emission level in a given economy can be decomposed into three major channels: scale effect, composition effect, and technique effect.[1] The net change in aggregate emissions in this particular economy will be determined by the interaction of these effects.

The *scale effect* refers to an increase in the emissions due to increasing level of economic activity, holding all other factors constant. In a simple case without any other structural change in the economy, trade opening will increase the level of production, transportation, and consumption of goods. This will, in turn, drive up the level of pollution through greater emissions during these processes. Therefore, the sign of the scale effect is generally positive when isolated, because higher trade level is usually associated with higher levels of economic activity. Analogously, a reduction in trade between countries due to a hike in trade barriers would cause a contraction in economic activities and decrease the level of emissions through the scale effect.

The *composition effect*, on the other hand, refers to a change in the emission level because of a change in the relative shares of different goods in the aggregate production of a country. Other things being equal, a marginal change in trade barriers will alter the relative prices of the goods produced in an econ-

Figure 1. Trends in Output, Openness, and Emissions: Correlation or Causality?



Source: World Development Indicators Database.

omy. This will, in turn, change the quantities of production in equilibrium. When goods have different degrees of carbon intensity, a change in the composition of production will affect the overall emission level. The sign of the composition effect is determined by the comparative advantage of the economy. A reduction in trade barriers will increase the domestic price of the exported good. Therefore, more of the national resources will be devoted to the production of the exported good. If the exported good is relatively GHG intensive, then the overall emission will increase, hence the composition effect will be positive. If the country has a comparative advantage in the "clean" industries, however, trade liberalization will cause a further expansion of the clean industries and reduce the level of aggregate pollution. Therefore, the scale and composition effects work against each other in the case of "clean" good exporters, whereas they enhance each other to increase the level of pollution in the case of "dirty" good exporters.

Finally, the *technique effect* refers to the impact of an increase in trade on emission level due to a change in production methods. Other things being equal, this effect represents the variation in the derived demand for the polluting input per unit of the final good or service. There are two major channels through which trade reduces emissions per unit of output: first, trade facilitates technology transfer, hence, cleaner technologies become available for adoption by domestic producers. Developing countries might benefit significantly from increased access to modern technology embodied in imports. Second, trade can reduce the emission per unit of output through consumer preferences and political processes. Since environmental quality is considered to be a normal good, the demand for it will increase when trade raises income. If politicians are responsive to public demand, then necessary fiscal and regulatory measures will be implemented to induce the producers to reduce the GHG intensity per unit of output in the production process.

This analytical approach has proven most useful in a single country case to investigate the marginal impact of a reduction in trade costs on aggregate emissions. The sign of overall impact depends on relative magnitudes of these three effects, which, in turn, depend on country characteristics such as emission policies and comparative advantages. A cross-country comparison, therefore, does not necessarily reflect the causality between openness and emissions unless it accounts for country-specific factors. Nevertheless, it may provide some intuition without claiming such causality. Figure 2 shows an application where openness is positively correlated with aggregate emissions, higher per capita GDP, higher share of industry in the economy, and higher emission intensity per unit of energy use. More careful case studies reveal mixed results for the sign and magnitude of trade's impact on aggregate pollution (box 1).

The methodology introduced here has been proven useful in investigating seemingly simple but inherently complex problems. An important one in this case is the impact on global pollution when countries with different income and production characteristics trade more with each other. The following sections will analyze this and elaborate on how to employ the decomposition tool to answer important questions on the climate change mitigation policy agenda.

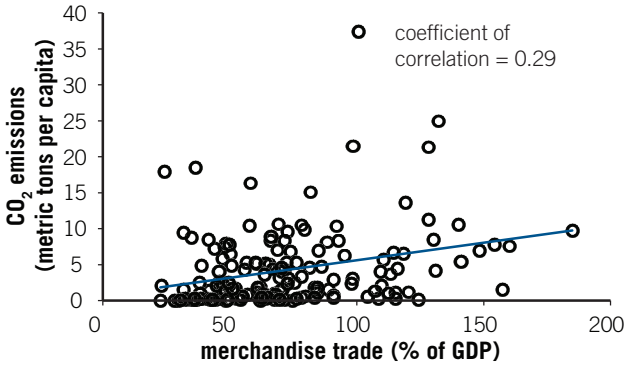
Do Countries Pollute More or Pollute Less When They Become Richer?

Countries may emit more GHGs as they become richer, or they may emit less. It is also possible that they emit more GHGs as they get richer in the earlier stages, and emit less later. The latter case, if correct, could provide a basis for the arguments that support the strategic delay in developing country mitigation policies.

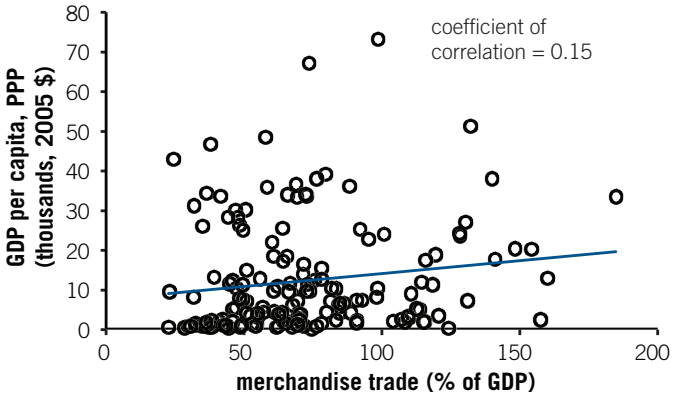
The Environmental Kuznets Curve (EKC) is a hypothesis that emphasizes the non-monotonicity of the relationship between income and pollution. Accordingly, the aggregate level of pollution exhibits an inverted U shape when graphed against GDP: the level of pollution rises when a poor country takes off, and eventually goes down after a threshold level of income. Figure 3 shows a cross-country correlation of GDP per capita and CO_2 emissions per capita. The emissions exhibit a partial inverted U shape; however, this does not neces-

Figure 2. A Cross-Country Analogy of the Decomposition Methodology

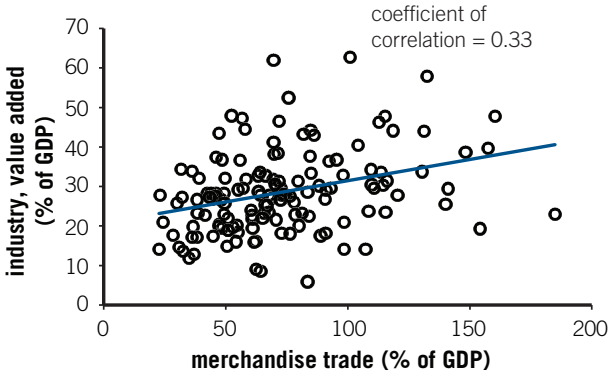
Open economies emit more CO_2 per person…



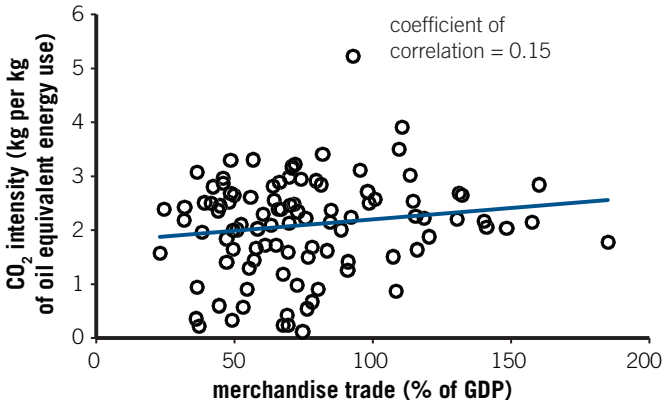
…one reason is because they produce and consume more…



…another reason is because they produce more energy-intensive goods relative to other goods…



…and finally, because they employ more polluting technologies and/or inputs.



Source: WDI Database.

Notes: The top two panels include 161 sample countries, the bottom left quadrant includes 141 countries, and the bottom right quadrant includes 102 countries. The main criteria for country selection were data availability in each category. Moreover, oil-rich countries (countries with oil rents greater than 30 percent of GDP) were also excluded. Two outliers (Singapore and Hong Kong SAR, China) with too high trade openness were also excluded without a significant impact on correlations presented here.

Box 1. Measuring the Impact of Trade

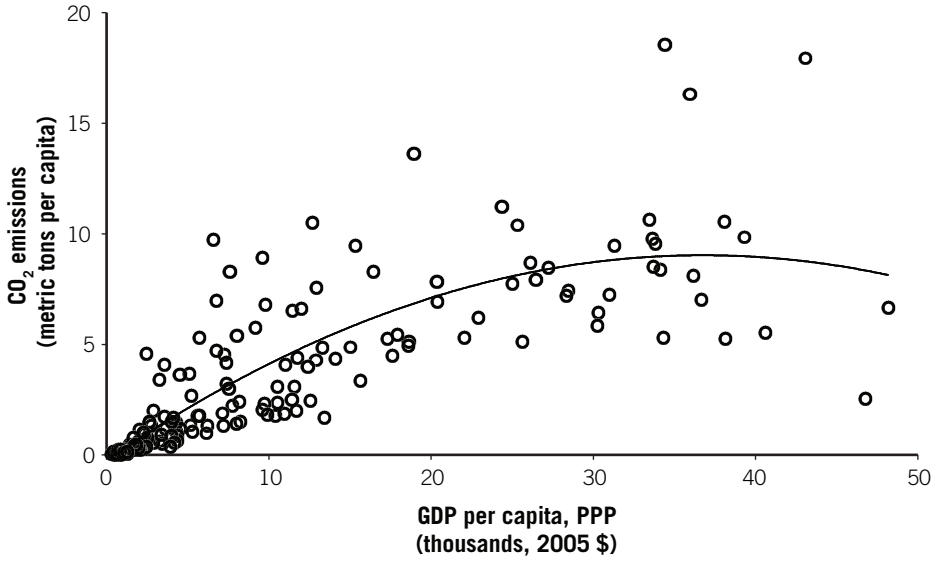
The empirical evidence on the net effect of trade on aggregate emissions is mixed. In an attempt to evaluate the environmental implications of the North American Free Trade Agreement (NAFTA), Grossman and Krueger (1992) find that the sulfur dioxide (SO_2) in the air increases with per capita GDP at low levels of national income, and decreases at high levels across nations: the turning point comes around US$5,000 (1985 values). In the case of Mexico, this implies that overall emissions may decrease after the trade agreement, because trade liberalization was expected to increase the national income beyond the specified threshold, and because the lower trade costs would induce production to shift toward labor-intensive and cleaner industries in which Mexico has a comparative advantage. However, Grossman and Krueger do not provide a decomposed estimate of the scale and technique effects.

Antweiler, Copeland, and Taylor (2001) find that a 1 percent increase in GDP per capita due to trade liberalization decreases SO_2 by about 1 percent by estimating the effects separately. This result is driven mainly by the technique effect always dominating the scale effect. A 1 percent increase in the economic activity raises SO_2 concentration by 0.25 to 0.5 percent for an average country, whereas the emission concentration is driven down by 1.25 to 1.5 percent by the technique effect. The composition effect is reported to be country specific and relatively small, hence not affecting the result.

Mani and Cunha (2011), on the other hand, estimate that the scale effect, which drives pollution intensities up, dominates the composition and technique effects in the case of the Dominican Republic–Central America Trade Agreement with the United States, albeit by a small margin.

Sources: Antweiler, Copeland, and Taylor (2001); Grossman and Krueger (1992); Mani and Cunha (2011).

Figure 3. Is There a Kuznets Curve for CO_2 Emissions?



Source: World Development Indicators Database.
Note: The sample covers 167 countries, excluding the countries with missing data, main oil and natural gas exporters, and two outliers (Luxembourg and Trinidad and Tobago). Best fitting line assumes a quadratic functional form, where the R^2 is 0.67 (the R^2 in the case of a linear fit is equal to 0.60).

sarily prove the existence of an EKC. An important caveat here is that other country-specific characteristics that may potentially explain both GDP per capita and emissions per capita are unaccounted for.

A possible explanation for why there might be an EKC could be the changing composition of production in the course of growth.[2] Suppose the emission policy is fixed, the polluting sector is capital intensive, and countries grow primarily via capital accumulation in the earlier phases of development and via human capital improvement later. As capital becomes more abundant relative to the effective labor in the earlier stages, the economy will produce more of the polluting good relative to the clean good. Therefore, both the scale effect and composition effect reinforce each other in increasing the aggregate pollution during the capital-augmented growth. Subsequently, as effective labor becomes more abundant through human capital accumulation, more of the clean good is produced in the economy. At this stage, the pollution will increase because of the scale effect and decrease because of the composition effect. If the transition from capital-augmented growth to human capital–augmented growth is substantial, then the composition effect will dominate and the aggregate pollution will decrease.

Other factors that could generate the EKC are consumer preferences along with responsive emission policies. Suppose income grows because of factor neutral technological change, and governments set the environmental policy to maximize domestic welfare.[3] Then, a marginal increase in income will generate a small technique effect in the earlier stages and a large one in the later stages, if income elasticity of marginal damage due to pollution is increasing in income. This condition is essentially true when the willingness to pay for climate quality increases as income rises. And if this willingness is sufficiently strong, the technique effect will dominate the scale effect in rich economies. In the absence of a composition effect due to neutral growth, the aggregate pollution will increase in the beginning of the growth process, but will decrease later.

The mechanisms above can generate the EKC without considering the impact of trade. However, autarkic explanations of the EKC lack some important strategic interactions between countries. When trade links economies in different stages of their development, what is true for one country may not be true for others anymore; in others words, there might be a fallacy of composition. The next section discusses this possibility.

Does Trade Enable Rich Countries to Become Cleaner at the Expense of Poorer Countries?

It is theoretically possible that both countries reduce their emissions, hence global pollution is reduced, when trade is liberalized. Therefore, trade may provide an alternative abatement mechanism. However, the impact of trade liberalization on the aggregate pollution level in an economy depends on the comparative advantage of the country. A marginal reduction in trade barriers increases the international and domestic prices of the good in which the country's comparative advantage lies. Therefore, a greater share of national resources is devoted to production of the exported good.

In an open economy, the comparative advantage is shaped by two forces: the *pollution haven effect* and the *factor endowment effect*, where the former refers to policy aspects of comparative advantage and the latter is related to the relative resource abundance (De Melo and Mathys 2010). If the polluting sector is capital intensive, then, all else being equal, a capital-abundant country with relatively loose pollution regulations will have a comparative advantage in the dirty industry. Suppose the emission intensities are fixed by regulation, then trade liberalization increases the aggregate emissions in a dirty-good-exporting country since both the scale effect and the composition effect work in favor of it. However, it might reduce the aggregate pollution in the clean-good-exporting country if the composition effect is strong enough.

Pollution haven and factor endowment effects do not always reinforce each other. Developed countries are both capital abundant and more likely to have stricter climate policies. In this case, if the relative capital abundance in the developed country is smaller in comparison to the relative differences in income effects on pollution regulation, then the reductions in pollution (pollution haven effect) are greater in magnitude than the increments in it (factor endowment effect). Therefore the developed country exports the clean good. In contrast, when the developed country is sufficiently capital abundant, the factor endowment effect will dominate the pollution haven effect, and trade will cause an increase in the aggregate pollution in the developed country. Moreover, if the consumer preferences are such that the pollution policy is very responsive to income changes, then trade can reduce the aggregate pollution both in developed and in developing countries.[4]

The bottom line of the analysis is that different countries are affected differently by increased trade and greater trade liberalization based on their relative factor endowments, policy choices, and the rigidity of these policies.

The Role of Trade Policy in Mitigating Climate Change

Current multilateral efforts to reduce GHG emissions are considered to be ineffective because of insufficient participation and lack of enforcement (Barrett 2008). Governments differ in their willingness to impose limitations on activities with harmful climate impacts due to major complexities: first, projected harmful impacts of climate change and mitigation and adaptation costs differ across countries. Second, global climate is a public good; therefore, there is a free-riding opportunity for each country when others pay for it. Third, there may be disadvantages for the first movers; that is, the impact of efforts in one country may be undone fully or partly by others if they do not participate. Fourth, any restriction on current economic activity imposes definite instant costs, whereas the benefits may be realized in the future and are subject to stochastic variations.

Trade policy is, therefore, suggested as a mechanism to facilitate compliance and participation in global mitigation and also supplement domestic measures to internalize the cost of climate distortions. In particular, trade policy is considered to have four roles under a global climate regime (De Melo and Mathys 2010): address leakage and competitiveness issues; generate sanctions against nonparticipation and noncompliance; help reach global efficiency in mitigation policies by facilitating the separation of abatement location and the bearer of the cost of abatement; and, finally, maintain a free trade regime that is crucial for technology transfers. The following sections investigate these roles.

Can Trade Policy "Level the Playing Field"?

Taxing GHG emissions is one of the most preferred options in implementing domestic mitigation policies.[5] Typically such a tax is based on the content of fossil fuels embodied in production. Therefore, the greater the fossil fuel dependency, the higher the tax burden on a given sector in the domestic economy. In the absence of global compliance, however, unilateral taxation raises concerns on leakage and competitiveness.

Leakage refers to an increase in GHG emissions in nonparticipating countries caused by an increase in the restrictions of emissions in participating countries. This can happen through several channels: firms in regulated economies might shrink, while the ones in unregulated economies expand; firms might relocate from regulated to unregulated economies; taxes in regulated economies decrease the international and domestic prices of energy-intensive goods in unregulated economies, boosting the domestic demand. Even though the estimates of leakage magnitudes based on different computerized general equilibrium algorithms vary, and there are significant results showing that the magnitude of leakage might be negligible, the concerns about leakage persist (Krishna 2010). Competitiveness, on the other hand, refers to a reduction in market access for the firms in regulated economies compared to the firms from unregulated countries. This is mainly driven by the cost disadvantages for the firms in participating countries because of the higher emission taxes.

Border tax measures (BTMs) are proposed as a mechanism to address the leakage and competitiveness concerns by *leveling the playing field*. BTMs might be implemented through a carbon-based tax on imports and subsidy on exports.[6] Trade theory suggests that a uniform tax on both domestic and imported goods is trade neutral if exporters are reimbursed (Grossman 1980; Lockwood and Whalley 2008). However, when domestic goods and imported goods have different carbon content because of different production processes, then the neutrality is no longer valid, and policy makers face a dilemma. A BTM that is calculated using the carbon content of domestic production methods will not be as effective as a BTM based on actual (foreign) carbon content in reducing the emissions. However, the latter method has several problems, and it is not clear whether it would be compatible with prevailing multilateral rules under World Trade Organization (WTO) legislation or not.[7] Moreover, the implementation of this method may not be feasible because many imported goods are composite goods with many different inputs produced in different locations under different mitigation policies. Mattoo et al. (2009) show that the latter policy would have significantly worse impacts on developing country manufacturing and exports than the former. This result is magnified for countries with higher export shares in GDP and higher fossil fuel dependency.

In light of these observations, trade measures at the border may be a costly and highly inefficient tool for leveling the playing field in the case of pollution policies. However, another option on the desk, which avoids some of the above mentioned implementation issues, is using border measures only in the case of noncompliance in mitigation policies. The next section will consider this alternative.

Can Trade Sanctions Facilitate Compliance in Multilateral Efforts for Climate Change Mitigation?

Using trade sanctions against nonmembers and noncompliers in multilateral climate change mitigation agreements is essentially equivalent to linking the two agreements. The main purpose is to transfer enforcement power from the trade agreement to the climate change mitigation agreement. However, this method has not been tested for WTO compatibility. Moreover, trade sanctions might not have the desired impact hoped for on nonmembers.[8]

The Kyoto Protocol is considered to have inadequate participation and compliance because of missing enforcement mechanisms. Even though the commitments are legally binding, any sanctions against a noncompliant party are required to be approved by the same party, as in the General Agreement on Tariffs and Trade (GATT). In comparison, the Montreal Protocol enabled trade sanctions among the parties and against the nonparties to the protocol, which have received credit in ensuring the success of the protocol (Barrett 2008). However, it is not obvious how the trade sanction threat actually functioned in altering the incentives in the latter case. There are significant differences between a comprehensive climate change mitigation agreement and a relatively modest attempt at addressing ozone depletion in terms of scale, costs, and composition of the impact on economies. Moreover, the trade sanctions were never implemented thanks to a broad participation in and compliance with the Montreal Protocol. Therefore, the legitimacy of the measures has not been tested under current WTO legislation.[9]

A further ambiguity regarding the efficiency of trade sanctions in promoting participation and compliance concerns the net impact of particular implementation mechanisms on nonmembers. A carbon-based tariff on imports from nonmembers would affect the exporting country significantly. However, this cost might be small in comparison to the loss of GDP growth had the exporter ratified the mitigation agreement and employed the entailed mitigation policies.[10] Obviously, this would be less of an issue if the exporter is export dependent or its exports more carbon intensive, because the impact of sanctions would then be greater. On the other hand, the opportunity cost of compliance in climate change mitigation policies will also be higher when the economy is more carbon (energy) intensive and loses a greater share of GDP growth because of the climate-motivated regulations. As a result, the unilaterally optimal policies are to be determined by the projected costs of adopting mitigation policies and not adopting the policies but facing trade sanctions.

How Can Trade Policy Help Separate the Location of Abatement and Bearer of the Cost?

Trade policy can ensure tradability of emission allowances and clean development types of mechanisms, which are crucial for the global efficiency of climate change mitigation. The World Development Report (World Bank 2010) on climate change suggests "acting now, acting together, and acting differently." An important rationale behind acting together but differently is the need to separate the location of abatement and the bearer of the cost of abatement. Obviously, the marginal cost of abatement would be different among countries depending on the current emission intensities and availability of alternatives. Moreover, given that capital investments are irreversible to a certain extent, saving future emissions might cost less than reducing the current emissions as the "no-regret" development idea suggests. This approach emphasizes the importance of mitigation efforts in developing countries. However, global efficiency does not necessarily imply equity. Unilaterally optimal mitigation efforts in developing countries would be different than globally efficient levels. Therefore, they would need to be compensated for the difference.

Trade policy can help provide the necessary financing for developing country mitigation through international tradability of carbon allowances and technology transfers. The Kyoto Protocol introduced the Clean Development Mechanism (CDM) for catalyzing mitigation in developing countries: the signatories are allowed to meet their commitment targets by investing in emission reduction projects in other countries. From the developing country perspective, this serves both the financing of mitigation and the adoption of cleaner technology.[11] Eliminating the tariff and nontariff barriers against imports and foreign direct investment (FDI) inflow might significantly improve the transfer of technology through the CDM and similar mechanisms.

However, Mattoo et al. (2009) point to an important caveat regarding the climate-motivated financial transfers from developed countries to developing countries. Transfers with carbon tradability can induce a decline in developing country manufacturing output and exports via Dutch disease–type mechanisms. Therefore, it is important to establish mechanisms that would foster the efficient use of financial inflows. In particular, the diminishing productive capacity in developing countries because of the narrowing scope for traditional technologies should be replaced with climate-friendly productive capacity. The following role for trade policy addresses this issue.

Will Trade Be Free After All?

Trade measures carry a significant risk of triggering waves of protectionist policies. Therefore, implementation procedures need to be well defined under a multilateral framework. It is

very likely that possible trade measures will be challenged at the WTO. However, if the climate-motivated trade measures are not ruled out by the WTO panel, then the developing countries would be tempted to increase their current tariff rates on imports from the respective partners to the bound rates without facing any legal restraint. Even when trade measures emanate from a multilateral agreement that developing countries themselves ratify, this will not exempt them from the risk of initiating a trade war. There are many technical complexities in the implementation of trade measures that may be observed imperfectly and misinterpreted. Among these complexities are the difficulty in assessing product-specific emissions and unobservable technical regulations in the country of origin that would affect the imported goods' qualification for a border measure (WTO-UNEP 2009). Any of these problems might induce a government to take retaliatory action when it mistakenly believes that the partner is pursuing a protectionist policy.[12]

Hence, multilateral investigations are necessary for jointly accepted trade and climate policies. Careful and detailed definitions of implementation tools and procedures are crucial in preventing the undesired protectionist consequences of trade policies.

Concluding Remarks

This note summarized a methodology that is particularly useful in considering the impact of further trade liberalization on pollution and answering questions on how trade policy can be used to address the challenges in global efforts to mitigate climate change.

The main points highlighted in this note are: first, the impacts of trade on GHG emissions are not uniform across countries, but are mainly driven by the differences in country characteristics such as underlying comparative advantages. Second, the same country characteristics will also determine whether GHG emissions would increase or decrease in an economy as it grows. Therefore, delaying mitigation in a given country may not necessarily lead to higher income and lower emissions in that economy after the strategic delay. Third, noncompliance by a country in climate change mitigation does not automatically create a "pollution haven." Other factors, such as the factor endowment effect, may dominate the pollution haven effect to reduce emissions in that country when trade barriers are lowered. Fourth, BTMs can successfully level the playing field by addressing the leakage and competitiveness issues; however, there are nearly prohibitive challenges in the implementation process and the measures themselves may fail to facilitate compliance. Finally, trade policy can effectively enable developing countries to have access to clean technologies and finance for mitigation efforts.

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Notes

1. For a detailed analysis, see Grossman and Krueger (1992) and Copeland and Taylor (2003).
2. This helps eliminate the technique effect; for a detailed analysis of alternative cases, see Copeland and Taylor (2003).
3. This might be a regulation that determines the optimal pollution intensity per unit of output. A technology change is factor neutral (or Hicks neutral) when the ratio of marginal productivities of factors do not change for a given ratio of factors.
4. See Copeland and Taylor (2003) for model details.
5. Alternatively, the same outcome can be reached by cap-and-trade policies, where a fixed amount of emission allowances are traded in the market (Mattoo et al. 2009). However, a tax system has advantages over cap-and-trade policy, such as verifiability (De Melo and Mathys 2010).
6. In the case of cap-and-trade policies, importers would be required to submit emission allowances.
7. GATT has ruled against U.S. barriers based on the processes and production methods in the United States–Mexico dolphin–tuna case; however, a WTO panel ruled that measures can target processes and production methods in the United States–India shrimp–turtle case.
8. Chisik and Onder (2012) show that enabling cross retaliation by linking the agreements may actually reduce the cooperation between governments if the policy actions are strategic substitutes and the limited punishment understanding of the GATT XXVIII rule prevails.
9. Sampson (2000) suggests that trade sanctions cannot be used against nonparties under the WTO legislation.
10. Panagariya (2010) anticipates a loss of US$2.1 trillion in net present value terms in 2020 for India, if ratification causes a 1 percentage point of loss in the current 8 percent growth rate.
11. Thirty-three percent of Clean Development Mechanism projects have claimed technology transfer (WTO-UNEP 2009).
12. Chisik (2010) shows that when degrees of information asymmetry differ across the issues, then using a policy tool in

one area to punish a violation in the other reduces the welfare of the parties by initiating a trade war, which would not occur if the issues were kept separated.

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WTO (World Trade Organization), and UNEP (United Nations Environmental Programme). 2009. *Trade and Climate Change Report.* World Trade Organization, Geneva.

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