The Climate Change Challenge and International Cooperation

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Abstract: Over the past two decades, the international community has struggled to deal constructively with the problem of mitigating climate change. This is considered by many to be the preeminent public policy challenge of our time, but real progress has been disappointingly slow. This essay provides an abbreviated narrative history of international policy in this domain, with a special emphasis on aspects of the problem, proposed solutions, and unresolved issues that are of interest to international economists and informed observers of the global economic system. We also discuss the potential conflict that could emerge between free trade principles on the one hand and environmental policy imperatives on the other.

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1. Introduction

As concern about greenhouse gas (GHG) emissions and possible human-induced climate change has intensified, the volume of economic research on prospective climate change, its negative economic impacts, and cost-effective methods of limiting those impacts has grown substantially. We will make no effort in this paper to offer a comprehensive review of the recent literature on the economics of climate change.[1] Instead, we focus in this paper on the particular challenge of international policy coordination to reduce emissions, the mechanisms by which this coordination might be achieved, and the implications of for international trade. Even in this narrower domain, there is a substantial and growing literature comprising important contributions from scholars working in multiple disciplines. Our aim is to summarize and place in context some of the lessons of this literature for economists interested in the general question of multilateral policy coordination in the 21st century. Because our intended audience is the general community of international economists and policymakers interested in international economic policy issues, rather than the community of climate specialists, our exposition will necessarily cover a broad range of topics, sometimes with limited depth.

In the view of the authors, the impressive collection of evidence documented by the successive reports of the Intergovernmental Panel on Climate Change (IPCC) leaves little doubt that anthropogenic GHG emissions are already changing the earth's climate system.[2] Unconstrained growth in GHG emissions is likely to intensify these changes in coming decades, raising the prospect of serious damage

[1] Readers interested in a recent, comprehensive survey are directed to Aldy et al., 2010.

[2] The IPCC is an international panel of scientific experts charged under the United Nations Framework Convention on Climate Change (UNFCC) to produce periodic reports on the scientific evidence for the existence and extent of anthropogenic global warming. The most recent IPCC assessment report was published in 2007 and can be accessed on-line at http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html. The drafting of the fifth assessment report is currently underway. In 2007, the IPCC shared the Nobel Peace Prize with former U.S. Vice President Albert Gore for its efforts to promote public understanding of climate change.

to ecological and economic systems worldwide.[3] Many scholars and political leaders view an effort to limit climate change as the preeminent policy challenge of our time.

But this effort carries with it special challenges that stem from the intrinsic characteristics of the climate change problem. The costs of global warming, while potentially significant, will only fully emerge over a time span of many decades -- even centuries -- making it difficult for democratic political systems with relatively short decision making time horizons to come to terms with the problem. Despite the remarkably strong consensus among physical scientists regarding the reality of anthropogenic climate change, significant uncertainties still exist around exactly how and when the earth's climate system might respond to increases in GHG concentrations. This uncertainty about the earth's future physical circumstances is further compounded by our general uncertainty about the impact of climate change on human systems, driven by the uncertain evolution of future economic growth, population expansion, and technological change. If our political systems find it difficult enough to reckon with long-run problems when the costs and benefits are well known, it is even more difficult when the economic costs of climate change (and therefore the economic benefit of mitigation) is highly uncertain.

But perhaps the most vexing aspect of the climate change problem is its global nature. Many conventional air pollutants are essentially local problems. Emissions inflict damage, but the intensity of that damage diminishes sharply with increasing geographic distance from the point of emissions. GHG emissions, by contrast, are a textbook case of a transnational environmental externality. GHG emissions have the same impact on the global climate system, regardless of where they are emitted. A molecule of CO_2 emerging from a cooking fire in rural India has the same impact as a molecule of CO_2 emerging from the tailpipe of an SUV in the Houston suburbs. Many GHGs, including CO_2, are characterized by

[3] A useful nontechnical summary of the basic physical science of climate change can be found in Collins et al., 2007.

extremely long residence times in the atmosphere -- time spans measured in centuries -- which implies that the externalities are not just transnational but transgenerational.

If all major emitting nations viewed the shared costs and benefits of curbing emissions in a similar light, the transnational nature of the problem might not be such a significant barrier to progress. Unfortunately, the preponderance of projected growth in GHG emissions over the next several decades will come in developing countries whose ongoing industrialization will bring in its train a rapid increase in per capita energy use and GHG emissions. These countries have made it clear in international negotiations that they view the continuation of rapid economic growth as a greater priority than the curbing of emissions, and they expect significant support from developed countries to finance emission mitigation. Meanwhile, developed countries outside of Europe have found it challenging to implement their own mitigation efforts, let alone finance those in developing countries. The international system has thus struggled to deal with the reality, on the one hand, that the greatest source of current and future emissions sees itself as having relatively little to gain from a strong commitment to climate change mitigation and, on the other hand, that other countries will have a hard time paying them to do so. However, recent progress in Copenhagen and Cancun suggest positive steps forward.

In this essay, we start by laying out some basic facts about the current and prospective future distribution of emissions across countries. We will also summarize what that the basic economic theory of environmental regulation would prescribe as the first-best solution to the problem of emissions reductions. Unfortunately, we shall see that the ability of current global institutions to practically implement anything like this first-best solution in the near term is practically zero. We will then summarize the recent major shift in the direction of global negotiation away from the top down, legally binding developed-country-only targets and timetables of the Kyoto Protocol, and towards a bottom up

set of mitigation commitments by all major economies, provisions for transparent review, and financial support – both public and private – for poorer countries.

Toward the end of the paper we also address an idea that many international economists may find controversial and unwelcome. As policies to mitigate emissions are strengthened in some countries – particularly through mechanisms that price emissions and effectively raise energy costs – pressure will build to shield domestic energy-intensive manufacturing industries from competition with producers based in other countries with weak or nonexistent carbon control policies. The existence of "carbon tariffs" or other border measures may be required, both to allow those countries seeking to strengthen their carbon control regimes and to convince other countries that some degree of global cooperation on carbon control is warranted. These ideas raise important legal and economic questions, which we will review.

2. The Global Distribution of GHG Emissions: Past, Present, and Future

Today, global negotiations on climate change policy are conducted primarily under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC). This is the legal framework under which the Kyoto Protocol was created. The recent Copenhagen and Cancun meetings, which we will discuss below, were international negotiating conferences among the parties to this convention. The UNFCCC was established in 1992 as an outcome of the Earth Summit in Rio de Janeiro, Brazil, and with 194 signatory nations, enjoys near universal participation among UN member states. In addition to the establishment of the UNFCCC, the participating developed-country nations made (nonbinding) pledges to reduce GHG emissions below 1990 levels by 2000.

It is worth reflecting on the economic context in which this organization first took shape. In the early 1990s, the developing world as a whole was slowly and fitfully emerging from the multiple recessions and financial collapses initially triggered by a severe recession in the developed world and

sustained by the Third World debt crisis of the 1980s. Throughout that decade, progress in terms of sustained growth in per capita income had been minimal, and many regions had witnessed substantial declines in the real purchasing power of the median worker. Developing nations in East and Southeast Asia were doing much better, but the growth miracles of China and, especially, India were still at an early stage, and were not yet recognized as such by the global community. The developed world had fared much better in the 1980s, with reasonably robust GDP expansion in Japan, Western Europe, and the U.S., and most forecasters looked forward to a short- and medium-term future that would resemble the recent past. This would be a world where wealth, prosperity, and energy consumption were disproportionately concentrated in the advanced industrial countries. Despite their relatively small collective share of the world's population, these countries accounted for the overwhelming majority of greenhouse gas emissions. As nations participating in the UNFCCC began to discuss the possibility of legally binding targets for emissions reductions, it made sense to concentrate this discussion on the advanced industrial countries as a first step, since they were both the primary source of the problem and the set of nations best suited to shoulder the economic costs of reducing emissions.

The treaty establishing the UNFCCC included a document listing the advanced industrial countries that could be expected to lead any global effort to reduce emissions. The so-called Annex I countries were divided into advanced Western economies and those in transition to a market economy. Asian nations like South Korea -- which would be invited to join the OECD within a few years -- were excluded, because the per capita GDP levels of these countries' recent past lay just below the thresholds for inclusion into Annex I.[4]

[4] Taiwan is -- and remains -- excluded from consideration because of largely successful efforts by the government in mainland China to deny Taiwan membership in international organizations on the grounds that it is not legally recognized as an independent state by most countries, including the U.S. Any effort to seriously engage Taiwan in a climate change debate would first have to contend with its legal nonexistence as a sovereign state, over the vociferous objections of mainland China. This may be one example of a case in which Taiwan's diplomatic isolation is actually advantageous for the country.

Legal scholars tell us that founding documents have enduring consequences. By the time serious negotiations surrounding the Kyoto Protocol were taking shape in the mid-to-late 1990s, observers of the world economy had begun to take industrial Asia much more seriously. But negotiations remained focused on legally binding targets for Annex I countries and no others. The diplomatic die had already been cast, and newly emerging economies were able to evade the efforts made to create legally binding emissions reduction targets that applied to them.[5]

As the rest of our essay will attest, this has been a significant omission. Even in the mid 1990s, observers understood that manufacturers in energy-intensive industries could face a strong incentive to relocate production from countries that imposed a cost of emissions to countries with weak or nonexistent carbon regulation regimes. The development of a high level of manufacturing capacity in East and Southeast Asian nations with no obligations to curb emissions raised the specter of "leakage" of carbon intensive industrial activity from the Western countries to this region. This leakage has an environmental angle – that emission reductions efforts in developed countries could be partially, wholly, or even more than wholly offset by increases in unregulated emerging economies. But equally important, it has an economic angle as jobs are pushed overseas, a concern faced by environmental regulations more generally (Cropper et al 1998).

As early as 1997, there were responses to this concern. Prior to the Kyoto meetings (where the Kyoto Protocol was negotiated), the United States Senate passed the Byrd-Hagel Resolution (by a vote of 95 to 0) stating the refusal of the Senate to ratify any climate change treaty that failed to impose meaningful constraints on developing countries. This meant, of course, that the Kyoto Protocol was effectively dead in the United States even before a final version had been agreed upon by international

[5] Interestingly, the goal of reducing emissions below 1990 levels, also originally embodied in the UNFCCC's founding documents, remained the salient benchmark for the Kyoto Protocol negotiations.

negotiators. President Clinton signed the agreement, but never submitted it to the Senate for ratification, and it therefore never became binding as U.S. law. After the election of President George W. Bush, the United States formally withdrew from the Kyoto Protocol altogether.

Even as resistance to a focus on obligations for Annex I countries only was building in the U.S. and elsewhere, economic developments worldwide were rendering the Annex I designations increasingly obsolete. The 1990s were a time of dramatically slower economic growth in Japan and in much of Western Europe, lowering the rate of growth of Annex I country emissions.[6] At the same time, the growth boom that had begun in China in the 1980s significantly accelerated in the 1990s and India's economy responded to the liberalization program of the 1990s with a significant growth acceleration of its own. Industrial Asia expanded throughout much of the decade. The global pattern of emissions was shifting away from Annex I countries and toward the set of countries for which no binding emissions limitations existed.

These trends accelerated in the 2000s. China's rapid and sustained growth during this decade led the Asian giant to displace the United States as the world's single largest emitter around 2006, and the gap between the two widened sharply in the wake of the global financial crisis. At the time of this writing, the near universal expectation among market forecasters is that growth in the developed world will continue to proceed at a relatively slow pace -- much slower than in the developed world. According to growth projections widely touted by Citigroup, China will exceed the United States in terms

[6] At the same time, economic sclerosis in Western Europe and Japan limited the growth in emissions in that decade, and made a reduction of emissions below 1990 levels, as eventually called for in the Kyoto Protocol, more feasible for these countries. Relatively robust economic growth in the U.S. in the 1990s pushed emissions well above 1990 levels by the end of the decade, which meant that the "Kyoto pledge" would be many times more economically costly for the U.S. to implement than for its European or Japanese trading partners. See Victor (2001), who lays out this contrast.

of total economic size by 2020, developing Asia will account for 44% of world GDP by 2030, and today's developing regions will collectively account for nearly 75% of world GDP by 2050.[7]

These growth trends have direct, immediate, and obvious implications for GHG emissions. Readers are encouraged to examine Figure 1, provided with other figures and tables at the end of the paper. This figure presents a "baseline" estimate of carbon emissions generated by various groups of countries in the global economy from the year 2000 through 2100. These estimates arise out of studies undertaken through the EMF 22 International Scenarios initiative. This initiative utilized ten of the world's leading integrated assessment models to predict rising levels of GHG emissions and atmospheric concentrations over time in the absence of serious efforts to mitigate global warming and the climactic and economic implications of various policy efforts to slow down or even reverse this trend.[8] Obviously, any exercise of this kind is speculative -- the models must incorporate assumptions about population growth, economic growth, technological progress, public policy, and other variables that are hard to forecast with any degree of accuracy. However, the general picture that emerges from this estimate is broadly in line with what many experts in the climate change community expect. While per capita income will continue to rise in the rich countries, slow population growth and a general transition to a post-industrial economy will limit emissions growth. In striking contrast, developing countries and especially the so-called BRICs will see rapid and substantial growth in emissions. These graphs make quite explicit that even large emissions reductions by the Annex I countries will be insufficient to fully offset increases in expected emissions by the developing countries over coming decades. Real reductions, at a global level, in emissions, will require that developing countries deviate from their

[7] See the forecasts contained in Global Economics View: Global Growth Generators, Moving beyond 'Emerging Markets' and 'BRICs', by Willem Buiter, available at http://www.nber.org/~wbuiter/3G.pdf. The forecasts of economic size are measured using (prospective) PPP exchange rates.

[8] Integrated assessment models are computer simulation tools which integrate models of the earth's physical environment with models of economic growth. Perhaps the best known model of this family for economists is William Nordhaus's DICE (Dynamic Integrated Model of Climate and the Economy) model, which he has used in numerous papers and in his recent book, Nordhaus (2007). They have become a central tool within the climate change community.

baseline. Depending on how aggressive we want to be, those deviations may need to occur within years rather than decades.

The necessity of developing country participation in meaningful efforts to slow climate change is also mandated by economic efficiency. Figure 2, taken from 4th assessment report of the IPCC, shows the carbon intensity of different regions of the global economy. What is immediately apparent is that developing countries tend to generate far more emissions per unit of GDP than do the developed countries. While part of this difference reflects the greater proportional role of heavy industry in some developing countries than in some post-industrial developed ones, a great part represents the higher levels of energy efficiency (and correspondingly lower levels of carbon intensity) achieved by Western firms operating with more advanced technology. If all regions of the global economy faced a common price of emissions, there would appear to be ample, relatively low cost opportunities in developing countries to reduce emissions simply by implementing in those contexts the higher efficiency technologies, machines, and practices that have already been developed in the West. Limiting the purview of the global search for relatively low cost emissions reduction opportunities to the already fairly energy (and carbon) efficient economies would substantially raise the cost of any given level of carbon emissions. Moreover, given the expected economic growth in developing countries, there are much cheaper ways to invest mitigation at the time when a factory or power plant is built versus retrofitting after the fact. Furthermore, as we have already mentioned, geographically mobile emitting activity would have strong incentive to relocate in a world of uneven carbon regulation. This would increase the cost further, as emissions reduction opportunities would progressively be localized in geographically immobile emitting sectors.

The common sense conclusion that economic efficiency requires global participation, in principle, enjoys universal support from the climate change modeling community. Table 1 presents

estimates from Nordhaus (2007) on the degree to which the costs of a particular level of global emissions reductions rise as one limits the set of participants to a smaller set of countries. These results are broadly representative of the kinds of results one obtains from the other major integrated assessment models.

3. Economic Logic Versus Political Reality

Unfortunately, this is one of the many real-world instances in which economic logic collides with overriding political considerations. The developing countries -- especially the big ones that really matter, including China and India -- harbor grave reservations about adopting mandatory emissions reduction targets. These countries understand that industrialization and economic growth will raise their emissions per capita. In fact, they see the current gap between their own emissions per capita and those of the industrialized West as a strong reason for them to refuse to make any concessions whatsoever. Figure 3 (a), based on the IPCC 4th assessment report, shows the dramatic and persistent gaps in emissions per capita across regions of the world economy. Figure 3 (b) presents these estimates for a few individual countries to make these very different levels of emissions per capita easier to associate with specific countries. Developing country delegations to international climate conferences can regularly be counted on to suggest that all the world's people have an equal right to emit and enjoy the economic benefits of emission. Rather than constraining the growth of the world's poor, delegates from developing countries often suggest that the West be willing to substantially lower its emissions first.

Of course, it is not just a matter of current emissions. What matters for climate change is not any one year's level of emissions, but the cumulative stock of GHG in the atmosphere. Because of its long history of industrialization, the industrial West still bears responsibility for a larger fraction of this stock than do developing countries, as Figure 4 illustrates. This reality has led some observers, including

Jagdish Bhagwati, to promote a focus of global climate change mitigation policy around an EPA "superfund model" in which Western countries contribute to a global fund to support climate mitigation efforts worldwide in the same way that polluting corporations in the United States are required to contribute financial support to environmental cleanup efforts that result from corporate pollution, even when the true extent of eventual environmental damage was unknown to the polluters at the time of emission.[9] Perhaps not surprisingly, developing country advocates have championed this as a model, suggesting that any effort made by developing countries to mitigate emissions growth should be primarily funded by the industrial West.

At the same time, there is a significant difference between the history of CO_2 emissions and superfund pollution. Emerging economies today benefit greatly from following on the shoulders of the developed countries – information technology, global trade, and advances in human health create advantages for developing countries today that allow faster, easier development. In this way, accumulated CO_2 emissions are simply one negative among a large number of positive spillovers from developed country industrialization. Compensation for historic emissions would make sense only if we insisted developing countries proceed without access to any developed country innovations and trade. Intellectual debates aside, anyone who has paid attention to the growth and fiscal challenges confronting Western countries right now, however, can appreciate the political resistance these ideas encounter in the parliaments and national legislatures of the beleaguered industrial world.

While it is certainly true that the industrial West bears responsibility for a larger portion of the current stock of GHGs than developing countries, the rapid rate at which the current emissions of developing countries are growing suggests that this gap will be completely eliminated and reversed within a few decades. Some studies suggest that China's share of the stock of GHGs in the atmosphere

[9] Bhagwati makes the case for this approach in Bhagwati (2004) and has elaborated the idea in a number of policy essays and op-ed articles published since then.

could exceed that of the United States within a couple of decades. From the perspective of emission necessity and economic efficiency, the need for developing country participation in a meaningful carbon control regime seems incontrovertible, even if the politics mitigate against it.

But economic models also drive home the difficulty of negotiating a mutually agreeable means of moving forward when large emitters have a limited interest in mitigation and the global system lacks legal mechanisms to compel participation in emissions reductions by reluctant nations. An extensive game theoretic literature illustrates these problems in theory. Carraro and Siniscalco (1993) and Barrett (1993) show that the presence of asymmetries across countries and the incentive to free ride make the existence of global self-enforcing agreements quite unlikely. When self-enforcing international agreements exist, they are signed by a limited number of countries (Hoel, 1992, 1994; Barrett, 1994). A grand coalition, in which all countries sign the same agreement, is unlikely to be an equilibrium (Finus and Rundshagen, 2003). The difficulties the international community has encountered in practice bear out these theoretical predictions, as can be seen in the history of the Kyoto Protocol. Of course, these same models would never predict why countries like the European Union would pursue a unilateral mitigation at exactly the moment the United States announces it is walking away from any commitment. This leaves open the question of what economic interest drives national commitments and action.

After the establishment of the UNFCCC, subsequent climate meetings sought to create a framework in which the Annex I countries would set legally binding targets for emissions reductions. A key meeting in Berlin in 1995 produced the so-called Berlin Mandate, an agreement to begin serious negotiations on legally binding reduction targets that would eventually become the Kyoto Protocol.

As already mentioned, the UNFCCC enshrined in its founding documents the aspirational goal for developed countries of a reduction of GHG emissions below 1990 levels by the year 2000. As international climate change diplomacy moved from nonbinding pledges to a binding treaty, this

remained the key benchmark around which negotiations coalesced. As already mentioned, robust economic expansion after 1990 made this benchmark far more costly for the U.S. to reach than for many other Annex I countries. By the time of the Kyoto negotiations 1990s, emissions had risen so much that the U.S. delegation expected to have to cut emissions by more than 30% relative to a no-control baseline in order to bring the U.S. into compliance over the course of the 2008-2012 "commitment period." If implemented solely through reductions in emissions within the borders of the U.S. itself, compliance would carry with it extremely high economic costs. Partly out of recognition of this, the U.S. delegation in Kyoto pushed hard for economic flexibility within the Kyoto framework.[10] The Kyoto targets involved multiple greenhouse gases and emissions from land-use changes, and allowed for trade-offs within this basket of targets. Importantly, international emissions trading was made a central feature of the protocol, over the initial reservations of the Europeans.[11] While only Annex 1 countries were required to reduce emissions, they were allowed to obtain credit against their targets through the funding of emissions reductions in developing countries (as well as through trading with each other). Since an international climate change treaty was seen as having little meaning without the participation of the U.S., the world's (then) largest emitter, the other delegations eventually endorsed these flexibility mechanisms.

Following the signing of the Kyoto Protocol in 1997, various countries began the ratification process – though the U.S. did not. It is also true that any party that had ratified the protocol and subsequently found its targets too onerous to meet could unilaterally withdraw from the agreement

[10] Prominent climate change economists, including Yale's William Nordhaus, publicly criticized the Kyoto Protocol on the grounds that it imposed unreasonably (and therefore politically unacceptable) costs of compliance on the United States.

[11] The U.S. team was a strong advocate of a global cap-and-trade style approach to regulating GHG emissions for another reason. The federal government has employed this tool with great success to combat acid rain in the Northeastern U.S. Sulfur dioxide emissions had declined more rapidly and at lower economic cost than either industry or environmentalists had anticipated. Interestingly, cap-and-trade was viewed in environmental circles at the time as a "conservative" idea, implemented under George H. W. Bush's Administration and championed by Pennsylvania's Republican Senator, Jack Heinz.

without penalty. Even parties who remained inside the protocol and failed to achieve their targets (as Canada is now likely to do) face little to no consequence. States that were not meeting their targets at the end of the 2008-2012 commitment period would have to reduce their emissions by an additional 30% in the next round of climate change negotiations -- but, of course, final negotiations on the Kyoto Protocol ended with no definitive arrangements for a next round.[12] And at the time of this writing, the prospects for a next round are extremely uncertain.

Even with the concessions made by its negotiating partners in the realm of economic flexibility mechanisms, full participation by the U.S. in the Kyoto enterprise would have been hard to achieve. With the passage of the Byrd-Hagel Amendment by the Senate in the late 1990s, it was evident to the Clinton Administration that no legally binding climate change treaty that excluded large, rapidly industrializing developing country emitters would survive a ratification vote in the U.S. Senate. President Clinton signed the treaty, but never submitted it for ratification, so that it never became legally binding under U.S. law. After defeating former Vice President Al Gore in the contentious 2000 election, President George W. Bush formally withdrew the United States from the protocol in 2001. By the late 2000s, despite a pronounced slowdown from the robust economic growth rates of the late 1990s, U.S. emissions were still 16% above 1990 emissions levels, rather than 6% below, as called for under the Kyoto targets.

Other Kyoto member states remained in the protocol, but did little to enact national policies that would effectively ensure compliance. Canada, Australia, New Zealand, and Switzerland have seen their emissions rise by 25% compared to the base year, reflecting the unwillingness of these countries to implement legislation reducing emissions.[13] Norway has seen emissions rise by 9% compared to the

[12] The additional 30%, referred to as the "restoration rate" is meant to be a form of interest (roughly 6% per year) to deter the economic incentive to put off emission reductions indefinitely.

[13] Like the United States, Australia participated in the Kyoto Protocol negotiations, but declined to ratify the treaty until national elections brought a new government to power in 2007. However, as of the time of this writing, the

base year, despite its participation in the EU cap-and-trade system and implementation of a carbon tax that preceded the Kyoto Protocol. Japan has lagged in meeting its Kyoto targets, despite two decades of poor economic growth and a population that is starting to shrink.[14] The Annex I countries are a group are likely to meet their Kyoto targets, but this is only because Annex I includes a large number of formerly socialist "economies-in-transition" (EITs) whose 1990 emissions levels reflect the legacy of socialist industry. Eastern Europe and the former Soviet states underwent a profound industrial collapse in the 1990s that lowered emissions well below 1990 levels even without the enactment of any specific policy to mitigate GHG emissions. While these states have seen their economies recover in more recent years, the recovery has not brought emissions anywhere close to their 1990s levels. By the mid-2000s, these economies' collective emissions level was still 35% below 1990 levels. Because of this, Annex I as a group is expected to meet the targets, despite the fact that the non-EIT members of Annex I had seen their collective emissions rise to 5-6% over the base year, rather than fall 6% below that level.[15] And, as we have already pointed out, the non-Annex I countries, which were increasingly the source of growth in the global economy, increased their emissions without constraint. The World Bank (2010) noted that since the negotiation of the Kyoto protocol in 1997, global energy related emissions had increased by 24%.

4. Is the Kyoto Protocol a Stepping Stone or a Stumbling Block?

Labor Government first elected in 2007 and narrowly re-elected (under different leadership) in 2010 has been unable to pass legislation that would effectively enforce Australia's treaty obligations.

[14] At the time of this writing, Japan appears likely to narrowly meet its targets largely through the purchase of international offsets and credits.

[15] There are individual EU economies that are on track to meet their Kyoto targets, even though the non-EIT Annex 1 countries that have acceded to the Protocol will not meet them as a group. In some cases, though, the individual economies benefitted from domestic economic transitions that had little to do with climate change. The UK's 1990s emissions levels reflected heavy use of coal that was phased out during the 1990s as the UK took increasing advantage of North Sea natural gas to replace coal. This transition largely accounts for the UK's success in meeting its target. Likewise, Germany benefitted from the fact that its 1990 emissions level includes the emissions of the Eastern Lander. Reunification coincided with a deep and persistent industrial collapse that left emissions in the states of the former East Germany well below 1990 levels even in the late 2000s. This largely accounts for German success at meeting its Kyoto targets.

Even before the Kyoto Protocol formerly came into legal force in the 2000s, it attracted strong criticism from an increasingly vocal faction within the climate change policy community.[16] This faction predicted that the Kyoto Protocol might very well collapse before the end of the 2008-2012 commitment period.[17] At best, the Protocol would prove ineffective at restraining emissions growth and that a completely different approach to policy was needed. A competing faction acknowledged the strains and imperfections of the Protocol, but viewed it as a "stepping stone" to a more complete and effective international framework that would include more emitters and stronger enforcement mechanisms.[18] While the failure of the international community to come up with a successor agreement to the Kyoto Protocol has been largely seen as a vindication of the former group, it is useful to review the arguments advanced by advocates of the Protocol.

One of the core propositions enshrined in the UNFCCC and the Kyoto Protocol is the often deeply held belief that any solution to the climate change issue has to be global in nature from its inception. There are powerful economic arguments that support this view of course, as we have noted in the preceding paragraphs. Political scientists and international legal scholars also point to the notion of "legitimacy" arising from a global agreement reached under UN auspices as something that could inspire greater compliance and cooperation than regional initiatives developed by *ad hoc* "coalitions of the willing."

But Victor and other critics have forcefully argued that the weakness of international law undermines these apparent virtues in significant ways. Under current international law and diplomatic practice, undertakings like the Kyoto Protocol are strictly voluntary. The mechanisms by which reluctant

[16] The points made in this section are drawn, in part, from Pizer (2009).

[17] David Victor's evocatively titled 2001 book, *The Collapse of the Kyoto Protocol*, forecasting the doom of the initiative before it had even come into force, is a well known critique written for the general audience. Goulder and Pizer (2006) survey economists' research on the Kyoto Protocol, much of it critical.

[18] One of the most eloquent examples of writing in this domain is the recent paper by Frankel (2009), which is all the more useful for economists because of the economic acumen (and effective writing style) of the author.

states could be coerced into joining an agreement that runs counter to their interests are weak and rarely used. States will consent to be bound by agreements only when it serves their interests. In practice, this means the least committed states exercise enormous *de facto* power over the terms of any agreement that seeks to be global in scope.

For those in the climate change community, the case of Russia's accession to the Kyoto Protocol speaks to this point in a particularly salient way. Russia's geography makes it likely to benefit from even fairly substantial degrees of global warming that might alarm the industrial states located in more temperate latitudes. This reality and its 1990s-era economic difficulties made Russia approach the Kyoto process with some skepticism. In the end, however, Russia was persuaded to sign onto the protocol because the other parties made it a deal it could not refuse. With the 1990 level of emissions set as a benchmark and the post-Soviet industrial collapse of Russia largely complete by the mid-to-late 1990s, it was clear that Russia would easily exceed its emissions "reduction" target during the 2008-2012 commitment period by an extremely wide margin, even if it did absolutely nothing to raise the energy efficiency or reduce the carbon intensity of the Russian economy.[19]

In fact, under a system with international emissions trading, Russia had effectively been handed an extremely valuable asset by the Kyoto process. It could sell its large stock of excess emissions (which it had done nothing to earn) to the Western European economies whose economic growth was likely to push their emissions levels well above their emissions targets, even if these economies took economically costly steps to restrain the growth of emissions. At some notional level, these transactions had the appearance of being a truly win-win scenario. Russians would receive valuable foreign currency they had done nothing to earn, Western European economies would obtain valuable credits against emissions reductions obligations that would otherwise be economically expensive to achieve, and the

[19] Victor (2001) provides a strong critique of the deal given to Russia. The writing in this section draws closely from his criticism.

Kyoto Protocol architects would be able to claim credit for a system that was meeting its targets. The artificiality of this potential transaction was, of course, apparent to all parties and ultimately prevented it from taking place on a large scale.[20]

After the U.S. withdrew from the Protocol, David Victor asserted that it was no longer binding in any meaningful sense. The excess credits handed to Russia and the other post-Socialist states -- often referred to in the literature as "hot air" --were almost certainly large enough to effectively cover the amount by which industrial Western Europe was expected to exceed its target. Politically, of course, the consummation of this transaction was highly problematic. Environmentalists decried the fictitious nature of the credits the ex-Soviet and Eastern European states were more than willing to trade. And, despite the post Cold War *rapprochement* between Russia and industrial Western Europe, European voters were not especially keen to see billions of dollars flowing from democratic Western European states to Vladimir Putin's Russia for the purchase of largely fictitious credits. Large scale purchases of "hot air" never took place. But official assessments of the success of the Kyoto Protocol often average the excess credit position of the EITs with the modest deficit position of the other participating Annex I countries to make the (somewhat specious) argument that the countries, "as a group," are meeting their targets.

In this case, the pursuit of the "legitimacy" acquired through Russian participation in the Protocol required the community of willing states to create such a good deal for the Russians that it helped undermine the legitimacy of the Kyoto Protocol even among those who might have believed very much in its ultimate principles and goals. Victor's general critique is that an insistence on universal participation will inevitably lead to weak agreements.

[20] Ultimately, the ratification of the Kyoto Protocol by Russia was brought about by another political deal – European support for Russian accession to the WTO.

The history of the Protocol has also highlighted the limited mechanisms states have under international law to punish states that fail to live up to the full letter and spirit of the agreement. Especially when valuable assets are changing hands across international borders, parties to the agreement want some basis for their belief that the state with whom they are trading will abide by the rules. The Western industrial democracies, as a group, are better able to trust each other than in this regard than they are able to trust developing countries or even some of the EITs. Victor (2001) refers to the Western industrial democracies as residing within a "zone of law" that provides a basis for the trust that must be present before any high level of asset exchange can take place. Under the rules of the EU international emissions trading system (ETS) set up to facilitate the international trading of emissions permits for the EU member states that have acceded to the Kyoto Protocol, the core industrial EU economies can engage in very high levels of emissions permits trading among themselves, but there are limits on the degree to which any EU core state can offset its emissions reductions obligations through the purchase of emissions permits from "outside the zone" -- either from the EITs or from developing countries.

These difficulties also highlight another core critique articulated by Victor (2001), Pizer (2009), and many others. For many environmentalists, the Kyoto Protocol represented a major leap forward, whatever its flaws, because it moved from the nonbinding "squishy" pledges contained in the UNFCCC founding documents to legally binding targets and timetables. And, for some states, notably including the United States, the legally binding targets and timetables embedded in the Protocol required significant emissions reductions over a short period of time -- something that could only be accomplished under fairly high economic cost. Of course, this was the very reason the U.S. ultimately walked away without ratifying the treaty. Other nations ratified the Protocol but did very little to force emissions down, implicitly anticipating (correctly) that the rather weak enforcement provisions in the Protocol would impose little cost on noncompliant states. In fact, the structure of the Protocol virtually

ensured this outcome. The penalty for a noncompliant state would be a 30% reduction in some (unspecified) reduction target that would be negotiated in an (unspecified) successor agreement. But, of course, any state that found itself in a position in which that 30% reduction was onerous could simply withdraw in the next round.[21]

Legally binding targets and timetables often make sense in the context of domestic laws and policies internal to the states that are part of the Western zone of law. Every day in these countries, reluctant firms, agencies, and consumers are forced to meet the provisions of laws passed over their objections but with which they must comply. However, the international legal environment is a completely different story -- in that context, the apparent strengths of the legally binding targets are compromised by the legal weakness of the international system.

5. From Kyoto to Cancun

In the much longer run, even Kyoto critics like Victor concede that a strong, broad-based agreement with legally binding targets of some kind will eventually be needed to mitigate climate change.[22] In the short run, though, the UNFCCC has demonstrated its inadequacy as a framework within which such an agreement could be built.

This has given rise to two views about how to proceed. Rather than pursue a "broad and shallow" strategy (the current UNFCCC approach) that seeks to engage the maximal number of states by only requiring commitments that they are willing to accept, Victor instead advocates a "narrow and

[21] In the absence of a successor agreement to the Kyoto Protocol that also features binding targets and timetables, member states like Canada, that ratified the protocol but did absolutely nothing to address their noncompliance, have been able to evade any sanction whatsoever.

[22] As Cooper (2009) and Nordhaus (2007) have argued, these international targets can take the form of commitments to specific carbon prices (enforced through taxes) rather than levels of emission reduction. Cooper (2009) points out several theoretical and practical reasons why a price target may be more easily implementable by the international system.

deep, then broad" strategy that first brings together the subset of states that are willing to engage in meaningful policy experimentation.

For Victor and other advocates of this strategy, there are interesting historical parallels, some of which are the focus of other chapters at this conference. One is the WTO itself. When it first began, as the GATT, it was narrow in focus and in membership. The original agreement's purview was restricted to trade in physical goods and focused almost solely on a gradual multilateral reduction in tariff rates. The initial membership excluded the Soviet bloc, and as decolonization proceeded in the 1950s and 1960s, many of the newly created states did not rush to join. Over the span of several decades, however, the GATT morphed into the WTO -- an international organization with a much broader purview (that extended to trade in services, intellectual property, and multinational investment), a near-universal membership, and much more powerful means of adjudicating disputes and punishing offending member states than had ever existed under the GATT. In fact, for Victor, the only current international body that possibly has the clout to enact and enforce a meaningful international agreement to limit climate change is the WTO.

In some ways, an even more intriguing parallel is the growth of the EU. What is now the EU originally started as the European Coal and Steel Community, an effort by six European states to coordinate policy and reconstruction in these two sectors. Over time, the depth of cooperation and the extent of policy coordination broadened. Eventually, of course, the European Union became something so important that the states of the post-Communist East and even Turkey were willing to make quite substantial changes and amendments to their own national laws, and engage in costly concessions in order to quality for membership.

In similar fashion, Victor and others foresee a near term future in which only a handful of (mostly Western, industrial, democratic) states are willing to undertake serious policy experiments to

combat global warming. Rather than constrain the progress of this group by forcing it to meet the objections of the least committed states, it is far better to permit this group (and other groups) to move forward, engage in policy experimentation that other states could learn from, and turn the zone of law, or at least part of it, into a zone of competence in climate mitigation policy. As climate change proceeds, climate science becomes more precise, "green technology" becomes more developed, and the successes (and failures) of policy experimentation within the zones of competence become manifest, the cost/benefit calculus of today's reluctant states may change, leading some to opt for accession into the zone of policy experimentation. At some point, the countries inside the zone become an important enough collective that other countries perceive a penalty for remaining outside. We will develop this point further in a few paragraphs, but even in a global economy that is paying increasing attention to China and India, a potential coalition that includes North America, industrial Western Europe, Australia, and Japan would be influential.

As a pre-requisite to even this narrow-and-deep approach, it may be necessary for countries to take initial steps unilaterally. While exercises like the GATT and the EU offered significant and immediate economic benefits (overall gains to trade) for each country to be weighed against the costs (those domestic industries hurt by freer trade), climate cooperation offers only near-term costs and long-term potential benefits. For this reason, it may be hard to negotiate something narrowly that leaders return home to implement within any kind of agreed window. Instead, it may be necessary to key countries to pursue mitigation on their own terms and *then* seek to weave together cooperation afterwards or as a second step.

Regardless of how such a narrow-and-deep model arises, all of the economic inefficiencies and leakage concerns that we discussed in earlier paragraphs arise in the context of a less-than-global agreements. If a small group of countries in the zone of cooperation begins to raise the price of carbon

emissions, that begins to create incentives for emitting activities to relocate outside the zone. And so long as the scope of search for emissions reductions opportunities is less than fully global, the marginal cost of those reductions will surely increase.

But in the early stages of the policy experimentation phase, it is extremely unlikely that the political equilibrium, even among the countries within the zone of cooperation, would support particularly high carbon prices or other forms of draconian regulation. Contemporary economic analysis strongly supports the notion that prices on emissions could be set to achieve moderate reductions without triggering en masse relocation of emitting industries or major internal economic dislocation. At some point, of course, the major developing country emitters will need to be brought on board. But Victor, and many others, argue that we are not at that point yet.

While simple economic logic might argue for a global unified approach, political reality points toward a less appealing, but more realistic future, over the short-to-medium run, of "fragmented carbon regimes" with little trading between them, and regional initiatives rather than global, multilateral ones. Victor coins an evocative phrase, "variable geometries of participation," to indicate the need for flexibility, multiple approaches, and the need to let the theoretically optimal not get in the way of the practically beneficial.

In essence, the overall tenor of global climate change negotiations since the Kyoto Protocol has validated Victor's critique. For much of the 2000s, the overall focus in international negotiations was on the unwillingness of the government of the United States to do anything about global warming. It was relatively easy for reluctant large scale developing country emitters to excuse their own disengagement with the process by pointing to the need for the U.S. to act first. By 2006, the pendulum of public opinion in the United States appeared to be swinging in the direction of doing something at the national level. By 2008, both presidential candidates were professing their support for a U.S. cap-and-trade

program, and by the summer of 2009, the U.S. House of Representatives had (narrowly) passed a cap-and-trade bill. The shift in the U.S. position brought renewed focus on the large developing country emitters. The U.S. consistently communicated that it was unwilling to participate in a successor to the Kyoto Protocol with legally binding commitments that completely excluded the large developing country emitters. By this time, scientific monitoring had concluded that China had become the largest emitter by a substantial margin and was on track to dramatically outstrip the emissions projected for the U.S or industrial Western Europe. The Chinese and Indian delegations made it just as clear that they were unwilling to accept any legally binding targets. It was on that rock of resistance that the last attempts to salvage an immediate successor to the Kyoto Protocol ultimately foundered.

While international media coverage portrayed the Copenhagen Summit as a surprising disappointment, the major actors in these negotiations understood that any real hope of fashioning a successor agreement to Kyoto was long gone by the time the planes were arriving in Denmark. So long as one understands that basic reality, it is possible to view the more recent Copenhagen and Cancun summits as modest successes in the sense that a broad cross-section of emitters have assented to a set of (nonbinding) targets and an agreement on basic principles that could guide future negotiations. This is more clearly seen in the official declarations that followed the Cancun Summit, since it was there that formal agreement to the basic principles first articulated in Copenhagen was finally conferred by all the UNFCCC member states.

6. The Cancun Commitments

At Cancun, all major emitters (including China) made (nonbinding) mitigation commitments. While all parties accept that absolute emission levels will continue to rise in countries like China, at least in the short run, the willingness of China to make mitigation commitments is a significant advance. Concrete mitigation commitments by China in an international venue, alongside commitments by other

major emitters, represents a huge success by the U.S. In his first day on the job, Special Envoy Todd Stern emphasized that this administration would not bring back an international agreement that could not be supported by the U.S. Congress, and this meant the agreement had to have comparable commitments by China and the U.S. An equally significant and important advance is that all the major emitters have accepted (in principle) provisions for measuring progress toward those mitigation commitments in a transparent and objective way. This was a domain in which the large developing country emitters had been dragging their feet, and this concession is another victory for the West.[23] In return for these concessions from the major developing country emitters, the developed countries agreed to provisions providing for financial support for developing country mitigation and, especially, adaptation.

The developed economies first committed to providing resources approaching $30 billion over the 2010-2012 period, a substantial short-run commitment offered up in return for the concessions on mitigation commitments and transparent monitoring. In the longer run, the developed countries committed to mobilizing $100 billion per year by 2020 to address the needs of developing countries. This latter sum includes public and private funding, bilateral aid, and multilateral development assistance. The Cancun Accord also establishes a committee to improve coherence and coordination of climate finance delivery.

Can the developed countries really come up with $100 billion per year? In March 2010, the UN Secretary General appointed a high-level advisory group to look at possible sources of finance to achieve this goal. One of us participated directly in this group and helped author a November 2010 report that concluded the goal was "challenging but feasible." The key to effective realization of this goal is the establishment of active carbon markets in the industrialized countries that effectively impose a price on

[23] For several years after international observers concluded that China had surpassed the United States as the world's largest emitter, China rebutted these claims in ways that looked increasingly awkward to external observers.

emissions in the neighborhood of $20-$25 per ton. These markets would generate private sector demand for offsets and credits that could supply a large portion of this total on an annual flow basis, leaving a much smaller role for direct aid. To the extent that the carbon markets in the industrial West could allow the purchase of offsets or credits in developing countries, this could generate annual flows on the order of $30-$50 billion. And the carbon markets would likely stimulate hundreds of billions of dollars in capital investments in developing countries over time.

The report also suggested that carbon markets, with a price of $20-$25 per ton, would generate substantial permit auction revenues. Earmarking just 10% of these revenues to international climate action could, in principle, generate annual flows on the order of $30 billion. The international transportation industry currently operates outside the purview of any country's domestic carbon regulation regime. Bringing this industry under global carbon regulation could generate additional revenue flows on the order of $10 billion per year. Effectively, this would involve taxing the carbon content of international transportation fuels through a carbon tax or some special cap-and-trade applied to international transport.

As is clear, the largest component by far of these flows will be private sector flows. Concessional resources will increasingly go to the poorest countries to fund adaptation. Mitigation in middle income developing countries (a group that includes many large emitters, like China) will need to be financed primarily through private flows, possibly incentivized by public policies (like carbon markets in the industrial West) and nonconcessional public finance.

The future of the Kyoto Protocol is highly uncertain, but it will certainly *not* include the United States and Japan (who made this announcement in Cancun). In the absence of a global framework of this character, the principle vehicle for mitigation will be policies implemented at the national or

regional level. For better or worse, the international community has swerved sharply in the direction long advocated by the critics of Kyoto.

7. Can We Afford to Wait for Coordinated Global Action?

For some in the environmental community, the effective abandonment of stringent, legally binding targets is tantamount to giving up. Catastrophic climate change is such a looming threat that a lengthy period of incremental advance that precedes real global efforts to substantially reduce emissions is unacceptable. Many climate change economists disagree, and the results of recent integrated assessment models would appear to provide some support for the economists' position.

Climate change mitigation targets are often expressed either in terms of levels of concentration of GHGs in the atmosphere or the prospective increases in mean global surface temperature associated with those concentration levels. With either form of target, there is a cumulative amount of allowable global emissions, after which emissions will need to decline essentially to zero because of the long residence times of GHGs in the atmosphere and the limited pace at which the earth's biological and geological systems can absorb anthropogenic GHGs. What is certainly true is that the abandonment, in the short run, of global binding targets makes it extremely unlikely that the most ambitious targets will be met. Many in the environmental community have suggested a concentrated level of 450 ppm as an appropriate target.[24] Such targets become steadily more difficult – if not impossible -- to achieve as one allows large emitters to continue with business as usual for several additional decades. ,

Under current technologies, of course, emissions cannot go negative. Some in the climate change modeling community have discussed the possibility of bioCCS technologies that could, in

[24] The early documents of the UNFCCC pronounced an intention to limit global warming to "safe" levels. Since then, the climate change community has struggled to define what that might mean. While it is likely that the probability of various catastrophic and sudden climate change scenarios rises along with global mean surface temperature, suggesting a convex global damage function, there is little hard science suggesting that any of these scenarios becomes dramatically more likely as atmospheric concentrations rise from 450 ppm to 452 or 453 ppm.

principle, generate negative emissions. BioCCS involves the use of biofuels that are created from photosynthesizing plants, so that the growth of the feedstock absorbs carbon dioxide from the atmosphere. When it is burned, the carbon dioxide is stripped out of the emissions stream, piped underground, and stored in geologic formations where it will remain trapped indefinitely. Although it is appealing for environmental reasons, the economic viability of this technological option is unclear.

Figure 5 presents results of the EMF 22 modeling initiative to provide some guidance to our thinking on this issue, based on 10 of the leading integrated assessment models. The modeling exercise considers three widely discussed potential atmospheric concentration targets for GHGs: 450 ppm, 550 ppm, and 650 ppm. The exercise also envisions two separate patterns of international participation. In the benchmark case, all nations participate in a global market-driven carbon regulation regime, starting in 2012. In the second, more realistic case, the developed countries as a group, with the exception of Russia, participate in an Annex I carbon regulation regime beginning in 2012. The so-called BRIC countries (Brazil, Russia, India, and China) do not begin climate change mitigation until 2030. When they do begin, they do is in a phased fashion such that the stringency of their carbon control regime does not converge with that of the advanced nations until 2050. The other developing countries do not engage in climate change mitigation until 2050, and do so in a gradual fashion, such that their carbon control regimes do not match those of the rest of the world, in terms of stringency, until 2070.

Two additional variants are considered in this modeling exercise. In some cases, the atmospheric concentration targets are considered "not to exceed" (NTE) hard targets. In others, the model is allowed to consider a case in which the target can be exceeded so long as global emissions fall enough in the later years to allow the global atmospheric concentration to reach the targeted level by 2100. To facilitate these latter, "overshooting" (OS) scenarios, a handful of these models incorporate bioCCS into the array of energy options.

As Figure 5 demonstrates, it will be very difficult to hit even the 550ppm targets under a scenario of delayed participation (and hard to hit 450 ppm even with full participation). On the other hand, more generous 650 ppm targets are certainly feasible. At 650 ppm, a 65% probability interval includes warming of 2-5 degrees Celsius. We take from this modeling exercise some measure of assurance that a phased in approach to climate change mitigation could feasibly limit global warming to levels that will reduce the negative economic impact of climate change, but still risk significant impacts including reduced agricultural productivity, water shortages, ecosystem loss and extinctions, increased coastal flooding, and increased health burdens (IPCC 2007). For better or worse, these may be targets the global community will have to live with.

8. The Unsetting World of Border Measures

Moving forward, those states and groups of states taking increasingly ambitious steps to mitigate climate change – whoever they are – will have to deal with slower moving states. The asymmetries of economic size among countries are such that the actions (or inactions) of a large number of developing countries are effectively ignorable. In the grand scheme of things, emissions from Mali or Honduras are and will be simply too small to matter. The real question for the industrial West is what to do about states like China that are large emitters and extremely important participants in the international trading and financial system. Or, what Europe will do about a lagging United States.

The unsettling answer we will suggest to this question is that the industrial West may be driven to use tariffs that tax the carbon content of tradable goods produced in reluctant countries. The literature has referred to these instruments as carbon tariffs or, more euphemistically, as "border measures," and we will use both terms in what follows. The good news is that modest differentials across trading states in terms of the stringency of their carbon control regimes is unlikely to warrant the use of these instruments. The bad news is that, the farther the West gets ahead of nations like China,

the more pressure will build to utilize them. We will deal in this section with three questions: 1) are carbon tariffs WTO-legal?, 2) can the West implement carbon control measures without employing carbon tariffs, 3) under what circumstances would carbon tariffs become hard to avoid. and 4) could carbon tariffs be implemented in practice.

8.1 Are Carbon Tariffs WTO-Legal?

The WTO-legality of carbon tariffs is an open question among legal scholars. Advocates see in the so-called "shrimp turtle" case a WTO affirmation of principles that could support carbon tariffs, and we offer here a brief review of that case. In the mid-1990s, environmental groups sued the U.S. federal government over inadequate enforcement of a U.S. law, Public Law 609, that was designed to protect sea turtles from shrimp trawlers. The nets of U.S. fleets were equipped with so-called turtle exclusion devices (TEDs) that allowed sea turtles caught in nets to escape through a trap door mechanism. By the mid-1990s, however, the U.S. was importing large quantities of shrimp from South and Southeast Asian nations that did not require the use of these devices. The U.S. imposed an import ban on these nations pending adoption of TEDs.

India, Malaysia, Thailand and several other countries launched a formal dispute against the United States, basing part of their legal argument on a longstanding principle in international trade law that prevents importing nations from discriminating against otherwise identical products on the basis of differences in the processes of production. In its final ruling, the WTO ruled against the United States for technical reasons, but the ruling explicitly upheld the right of the U.S., in principle, to apply trade measures against the shrimp exporters because sea turtles were an exhaustible natural resource as covered by Article 20 of the GATT, and the U.S. could prohibit imports, even if the sea turtles in Asia never migrated to U.S. waters.

Environmental advocates have seized on this ruling as creating a precedent for carbon tariffs. The atmosphere, they argue, is surely even more of an exhaustible natural resource than are migratory sea turtles. In fact, the extent of the precedent created by the shrimp turtle case is unclear. Chinese trade representatives have flatly declared carbon tariffs illegal under WTO rules and have vowed to launch an immediate case against any nation that enacts legislation requiring the imposition of carbon tariffs. The final legal status of this idea will likely be determined when the first attempt is made to implement it by a WTO member state.

Other advocates point to the way the international system has dealt with value-added taxes. China, for instance, obtains the largest portion of government revenue through a value-added tax (VAT) of 17%. When foreign goods are imported into China, the customs authority imposes this tax on the imports, in addition to import duties. If the VAT taxes were not imposed, the foreign goods would hold a commanding advantage in the marketplace over the domestically produced goods subject to the VAT. Since the tax is imposed on all goods, regardless of national origin, the tax meets the "national treatment" test. Exporters are entitled to value added tax rebates to avoid penalizing them in global competition with producers based in other countries without such taxes. In the eyes of some environmental advocates, carbon tariffs would function like a VAT and need pose no more of a threat to free trade than does China's practice with respect to levying its VAT on imported tradable goods.

8.2 Are Carbon Tariffs Necessary? Part 1: The Problem in Theory

The theoretical construct of costless international trade in a homogeneous commodity between two economies helps us make the case for carbon tariffs. Imagine the home country constructs a carbon regulation regime -- for simplicity, consider a carbon tax -- to contend with environmental externalities, but the foreign country does not. Imagine the home economy is large enough relative to the global economy that its policies can affect global prices. Consider a carbon-intensive good. The

carbon tax would tilt the home country supply curve up, but would not affect foreigners' export supply curve. Under these conditions, the primary impact of the carbon tax would be to shift home demand from (more expensive) domestic producers to (cheaper) foreign producers. The global price of the carbon-intensive good would rise, but only a little. Foreign supply would expand to meet home demand, and the ability of the domestic carbon tax to reduce emissions associated with the carbon intensive good would be largely undermined by international trade.

In this context, a carbon tariff that applies to imports of the carbon intensive good the same implicit price on emissions created by the home country's carbon tax would equalize the playing field for domestic producers, lead to a more substantial rise in the home market price of the carbon-intensive good, and a more substantial decline in emissions. The environmental externality would be better addressed. Home producers shrink less under this policy than under a policy of a unilateral carbon tax, and the home economy exploits its international market power to extract surplus from foreign producers. On the other hand, the carbon tariff would cause the foreign price of the carbon-intensive good to decline, as imports are pushed out of the home market. This would lead to a decline in foreign production but an increase in foreign consumption.

In simple cases, it is possible that the combination of a carbon tax and a carbon tariff on imports could bring domestic production and consumption of the carbon-intensive good in the home country to the same level that would obtain in a world of uniform global carbon taxes. It is obviously not possible for the combination of domestic carbon taxes and carbon tariffs to bring about the same outcome in the foreign country.

Moving away from our stylized example, in the real world quality and technology differences between domestic and foreign products could blunt the impact of initially smaller differences in production cost. On the other hand, to the extent that the foreign economy is open to foreign direct

investment, over time the advent of carbon regulation in only the home economy would confer upon home producers of carbon-intensive goods a powerful incentive to transfer their technologies, brand names, and quality-control methods to subsidiaries based in the foreign economy. Also over time, a general equilibrium setting blunts some of the negative impact of a shrinkage of domestic production in the home economy -- these resources would find employment elsewhere in the home economy, leading to an expansion of the non-carbon-intensive sectors. However, even a general equilibrium setting does not mitigate the problem of emission "leakage," with carbon intensive activity moving from the regulated jurisdiction to the unregulated jurisdiction.

8.3 Are Carbon Tariffs Necessary? Part 2: The Problem in Practice in the Short Run

To what extent are these concerns likely to arise in the context of advanced Western (post)industrial economies? Precisely because the U.S. government has long harbored concerns about the impact of adopting carbon regulation on U.S. competitiveness when developing countries were not also similarly constrained, there is a body of research -- some of it undertaken by the U.S. government at the behest of nervous legislators -- to which we can turn. The following paragraphs draw heavily from work by one of the authors (Aldy and Pizer, 2010) and from a U.S. government interagency report on the competitiveness effects of the Waxman-Markey bill (H.R. 2454, formally known as the American Clean Energy and Security Act of 2009) in which one of the authors was directly involved (hereafter, Interagency Report).

For those trade economists eager to avoid conflict between their free trade ideals and their environmental conscience, this work offers some good news. The primary impact of carbon regulation is to raise the price of fossil energy in the economy. The impact of such regulations on U.S. industrial competitiveness is bounded by the fact that on average, energy expenditures account for less than two percent of the value of U.S. manufacturing output. This means the vast majority of U.S. industry would

be largely unaffected by carbon regulation in the short-run, since even advocates of such policies suggest that carbon prices would remain relatively modest ($10 - $25 per ton CO2-e) in the near-term future, and would imply modest increases in fossil energy prices that would have very limited impact on the overall cost structures of U.S. manufacturers.

The second factor limiting impact is that some energy-intensive activities are not subject to much international competition. H.R. 2454 contained provisions for measures to mitigate the impact of the bill on U.S. industrial competitiveness. "Presumptive eligibility" for these provisions was based on an industry's energy intensity, greenhouse gas intensity, and trade intensity. The Interagency Report concluded that only 44 of about 500 manufacturing industries would be presumptively eligible for relief. Together, these energy-intensive and trade-exposed industries collectively account for only 12 percent of total manufacturing output and 6 percent of manufacturing employment -- and only half a percent of total U.S. non-farm employment. On the other hand, these industries account for almost half of manufacturing greenhouse gas emissions.[25] It is exactly this concentration of GHG emissions in a relatively small number of industries that allows a cap-and-trade approach to carbon regulation, such as that put forward in H.R. 2454, to compensate vulnerable industries without necessarily invoking carbon tariffs or blunting the overall impact of the regulatory regime on the gradual decarbonization of the U.S. economy.

Figure 6 illustrates the distribution of manufacturing activity in the U.S. across differential degrees of energy (and emissions) intensity. Figure 7 illustrates employment in the presumptively eligible industries relative to employment in industries that either do not meet the energy intensity or trade intensity thresholds. This helps illustrate the degree to which the competitiveness problem is

[25] See the Interagency Report, pp. 1-2.

highly concentrated in a small number of sectors and represents a relatively small number of current jobs.

There is an extensive economic literature on the "pollution haven" hypothesis that evaluates the impact of environmental regulation on the shift of polluting activity to less regulated environments. Important recent papers included Jaffe et al. (1995), Levinsohn and Taylor (2008), Antweiler et al. (2001), Ederington et al. (2005), and Jeppesen et al. (2002). The general findings in this literature suggest that the ability of industry to profitably relocate to less regulated jurisdictions is significantly constrained by factors which limit the "footlooseness" of polluting industry, and most studies find the negative impact of domestic environmental regulation on domestic production to be quite limited. Some economic studies reach similar conclusions in the case of U.S. carbon regulation, at least for relative low carbon prices (e.g., Aldy and Pizer, 2010) and this is even in the case in which no steps are taken to mitigate the impact of domestic carbon regulation on domestic firms.[26]

What is also true is that much of the international trade that takes place in "presumptively eligible" U.S. industries is with other advanced Western economies that are likely to adopt carbon regulation policies when the U.S. does, if not before. Figure 8 illustrates the distribution of U.S. imports and exports by origin and destination for these sectors.[27] America's Western European trading partners have, of course, already implemented carbon regulation, and none of several retrospective studies undertaken by European scholars and governments have yet found strong evidence of a negative impact on EU manufacturing as a consequence.

[26] This is not true of all studies of the potential impact of uneven carbon regulation on the U.S. economy, and the next version of this draft will include a broader investigation of the studies so far undertaken and the reasons for the wide range in their results.

[27] Of course, the role of developing countries in global manufacturing has been rising over time and reasonable long run projections of future trade flows in these commodity categories suggest that

To the extent that negative impacts do occur, they can be partially offset by the means through which emissions permits are provided to polluting industries. While most climate change economists would support a policy that allocates emissions permits by open auction in the long run, most climate change bills seriously entertained in the U.S. Congress provide some transition path along which a significant fraction of permits are provided at no charge to emitting industries on the basis of historical output. H.R. 2454 contained provisions that allowed for provision of these free allocations directly to polluting industries (on the basis of historical output) and to the local electric utilities from which they sourced electricity.

Figure 9 presents the results of modeling undertaken in the Interagency Report which estimates the impact of carbon regulation as envisioned under H.R. 2454 with and without the mitigating measures provided for in the report. This modeling exercise suggests that the mitigation policies can largely offset -- and sometimes more than offset -- any increase in marginal production costs engendered by the carbon regulation in the five broad categories of presumptively eligible industries. Of course, in principle, the reduction in economic pressure on the vulnerable industries could also lessen the overall incentive for emissions reductions in the U.S. economy. But the Interagency Report suggests that these effects are also small, at least in the short run and at relatively low carbon prices.

For international economists who understand the importance of protecting the world's open trading system, this is all good news. It suggests that the first steps toward carbon regulation could be taken by groups of advanced industrial countries without imposing on those countries serious competitiveness concerns, and a regulatory framework like a cap-and-trade system can be designed to compensate the most heavily affected sectors without generating a significant need for trade intervention

8.4 Are Carbon Tariffs Necessary? Part 3: The Problem in Practice in the Long Run

Unfortunately, the analysis above is limited to the case in which Western carbon prices are held to relatively low levels. Standard economic analysis suggests that this is where carbon prices have to start. Most Western economies are optimized for a carbon price of zero. An immediate shift to punishingly high carbon prices would instigate costly output contractions, slow growth, and high unemployment. A gradual shift over time to high carbon prices permits the economy time to gradually transition from our current carbon-intensive industrial structure to something far more sustainable in the long run. However, conventional analyses suggest that, in the longer run, those carbon prices have to rise to quite high levels.

Nordhaus (2008), drawing upon decades of work in the economic modeling of climate change policy, argues that by 2100, the global carbon price needs to be at least $202 in 2005 U.S. dollars. Limiting global mean surface temperature increase to 3 degrees (Celsius) or limiting global GHG atmospheric concentrations to twice pre-industrial levels, as some environmentalists suggest, would require substantially higher carbon prices by 2100 and a steeper trajectory of carbon price increases over the 20th century. A more recent interagency study (IWG 2009) suggests optimal prices could be as high as $136 by 2050, though the central estimate is $45.

Even economists who have undertaken studies demonstrating the limited import of competitiveness concerns at low carbon prices -- and this includes one of the authors -- understand that these concerns rise as carbon prices rise from the levels we might expect with unilateral or region-specific carbon control regimes in the near term toward the levels that will be required to prevent economically damaging levels of climate change. The higher carbon prices rise, the broader the zone of vulnerable industries becomes, and the more cumbersome and costly it becomes to attempt to offset the competitiveness impacts through mechanisms other than carbon tariffs. If, a couple of decades from now, the industrial West finds that it has moved as far out ahead of the developing world as it

comfortably can, the temptation to use global tariffs, either as a stick to compel developing country compliance with Western environmental goals or as a wall to defend against an onslaught of carbon intensive imports, may become too great to resist. At that point, the global system may face an uncomfortable choice between an adherence to free trade principles that has brought a greater measure of prosperity to billions, and preservation of the natural environment on which all of humanity ultimately depends.

8.5 C*ould carbon tariffs be implemented in practice?*

An important question raised in some of the literature is whether a carbon tariff could even be implemented in a meaningful way. Two particular issues arise: supply chain and production technology. Carbon tariffs would presumably focus on the country of importation. However, many supply chains involve components manufactured and assembled in a multiple countries. Ascertaining where production and emission occur, and which emission occur in countries without appropriate emission regulations could be quite hard. In addition, if one country in a coalition of carbon-regulating countries fails to enact carbon tariffs, it would be possible for non-regulating countries to ship goods to that country for final assembly. The final product could then be imported to other carbon-regulating countries without being subject to carbon tariffs.

Distinct from supply chain issues is how one could practically address the differences in production technology and energy supply. Carbon taxes and cap-and-trade are relatively simple policies in that it focuses on emissions or fossil fuel use, where emissions are easy to measure, and allows product prices to adjust based on the market. In contrast, carbon tariffs would have to estimate the carbon content of a product, including indirect emissions from all sub-components. These emissions would need to be based on the foreign production technology and emission rates – and should be

different for each country of importation. This kind of data and analysis suggests an entire government agency might be necessary to implement carbon tariffs, depending on how broad they were.

9 Conclusion

This essay has reviewed the history of international efforts to curb global warming. Despite more than two decades of international engagement on this issue, the international community has made surprisingly little progress toward the goal of substantially reducing GHG emissions. We have argued that the evolution of the Kyoto Protocol, its problems, and the difficulty key nations have had negotiating a successor agreement that broadens and extends its binding targets and timetables points to several lessons for policymakers and social scientists. Of particular concern for economists is the degree to which the kinds of policies prescribed by straightforward application of economic theory often conflict with political reality.

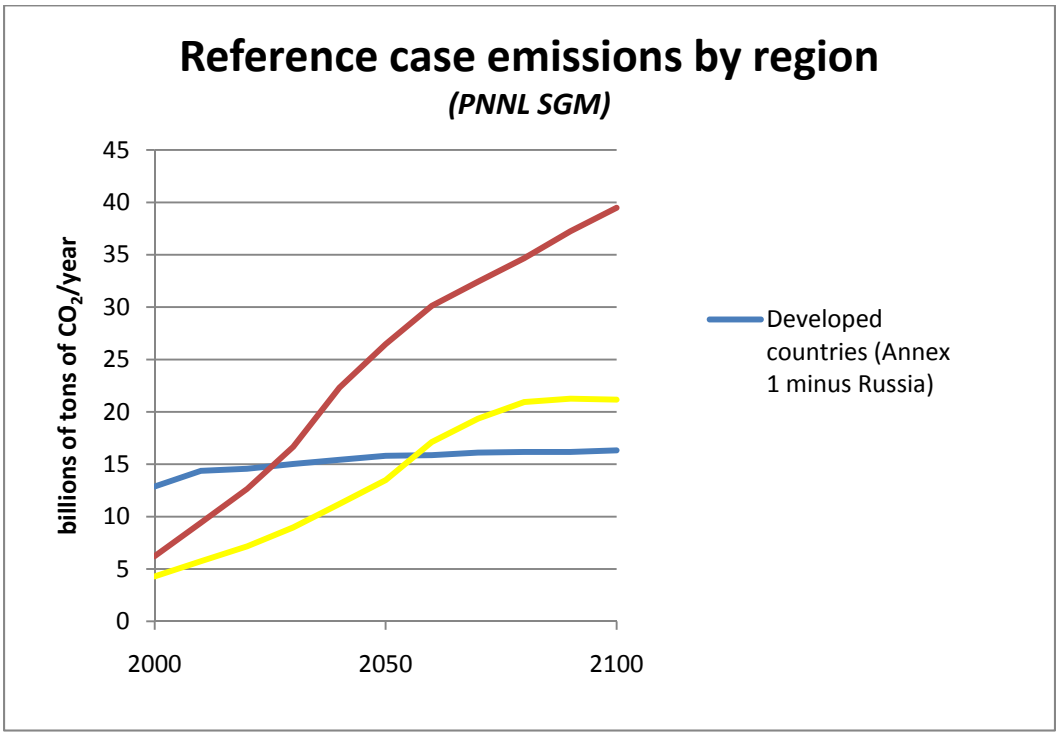
Economic theory suggests that the most efficient approach to reducing emissions is a global, integrated approach that equalizes carbon prices across countries. It is particularly important to bring developing countries into this system, since that is where most emissions growth will occur over the next century. Recent modeling efforts suggest that even if the developed Annex I nations reduce their emissions to zero after 2050, growth in developing country emissions will make it all but impossible to hit even modest targets for atmospheric stabilization of GHG emissions.

Unfortunately, the reluctance of developing countries (and, at the moment, the United States) to accept binding emissions reduction targets of any kind and the inability of the international system to compel a reluctant state to accede to a global climate change agreement makes the theoretically optimal approach impractical in the short-to-medium run. Given that, this essay has suggested that progress in the short-to-medium run is likely to take place at the national or regional level through unilateral or regional policies that are not globally enforced. We have suggested that the

implementation of modest carbon prices would result in limited emissions reductions (relative to a no control baseline) and that nations or groups of nations could engage in meaningful and useful policy experimentation without substantially harming their competitiveness. The international agreements reached at Copenhagen and in Cancun have moved away from top-down, Kyoto-style global agreements with binding targets and instead have embraced a more bottom up, pluralistic approach along these lines. Current agreements also point to the mobilization of significant financial flows – public and private – to developing countries to promote climate change mitigation and adaptation. We have argued that the implementation of modest carbon regulation regimes in the Western countries could generate private capital flows that would go a long way toward meeting these commitments.

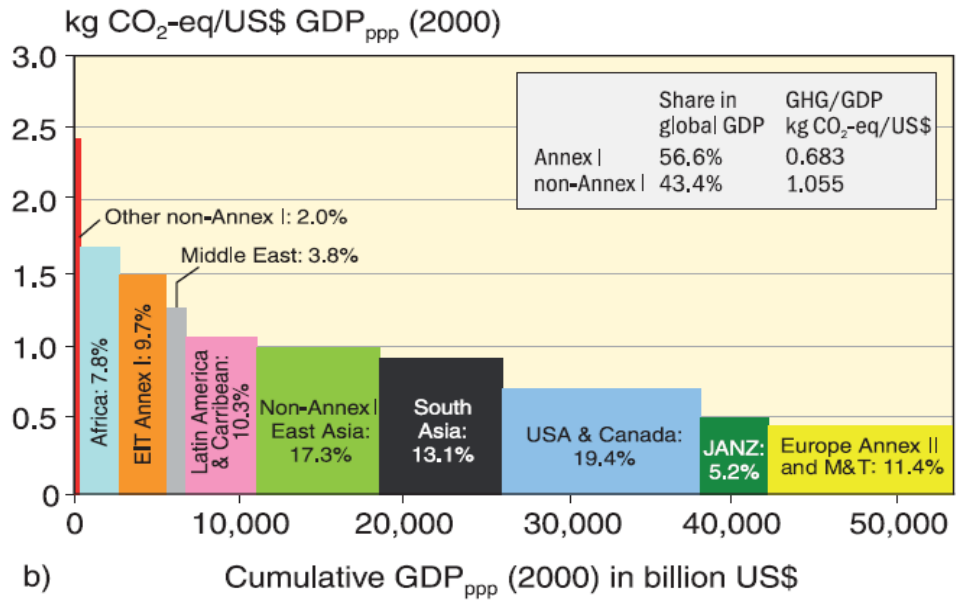
As nations willing to engage in meaningful carbon regulation proceed down this path, however, they will eventually reach the point where it will become costly for them to advance further without the use of "border measures" to prevent the leakage of carbon-intensive activity out of these countries and into more lightly regulated jurisdictions. There may be a point at which the goals of trade openness and effective mitigation of climate change come into conflict.

Figure 1 Most Emissions Growth Will Come from Developing Countries



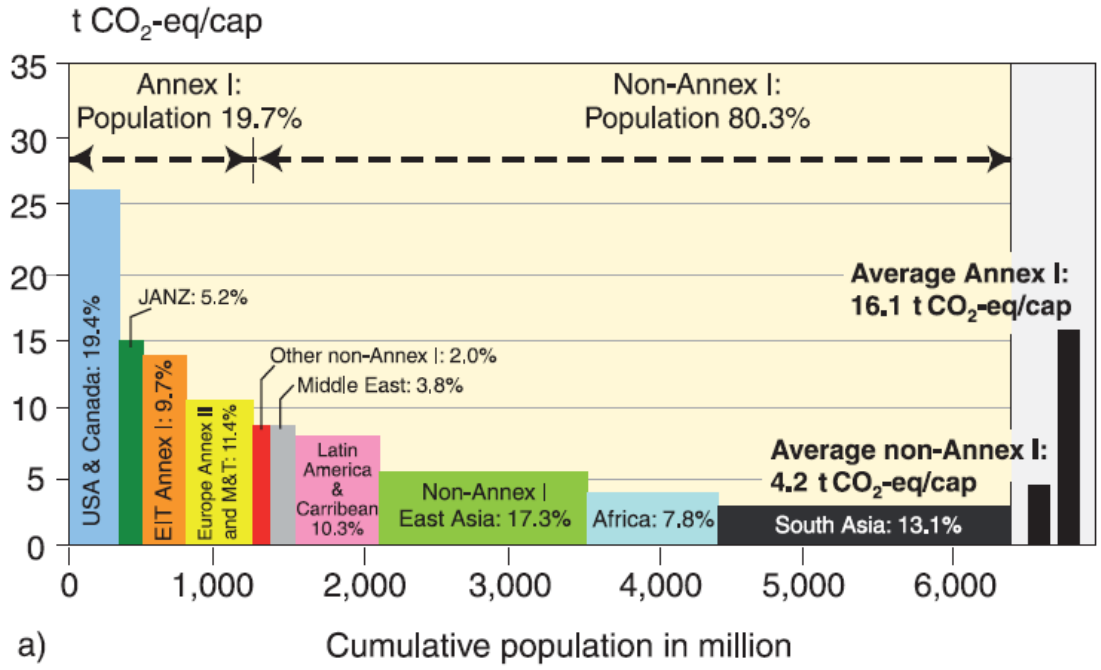
Source: Energy Modeling Forum No. 22

Figure 2 **Carbon Intensity of GDP, by Region (2000)**



Source: IPCC 4th Assessment Report

Figure 3a Per Capita Emissions in Developed Countries are Much Higher than in Developing Countries



Source: IPCC 4th Assessment Report, 2007

Figure 3b Per Capita Emissions, 2004

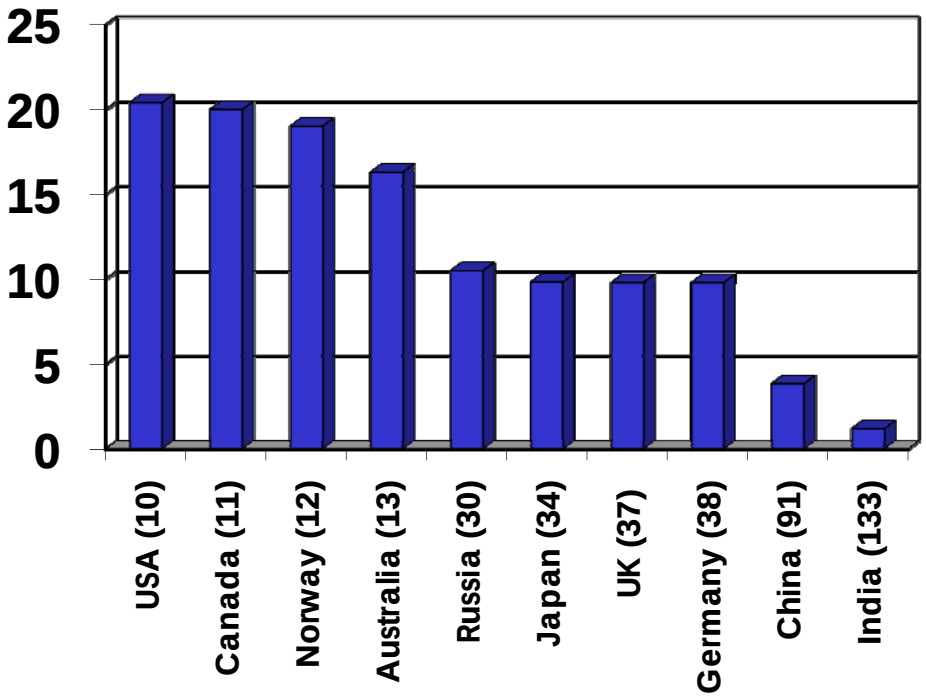


Figure 4 **Historical Contributions to the Stock of Atmospheric CO_2, 1900-1999**

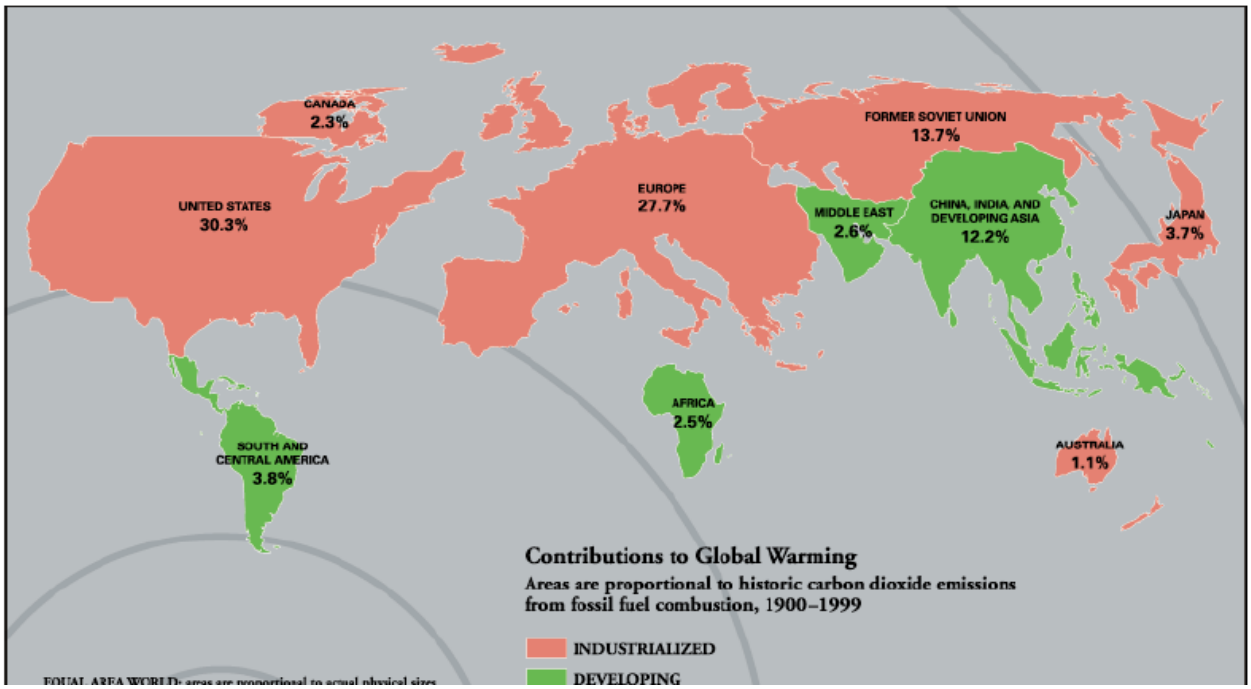


Figure 5 **The EMF 22 Scenarios**

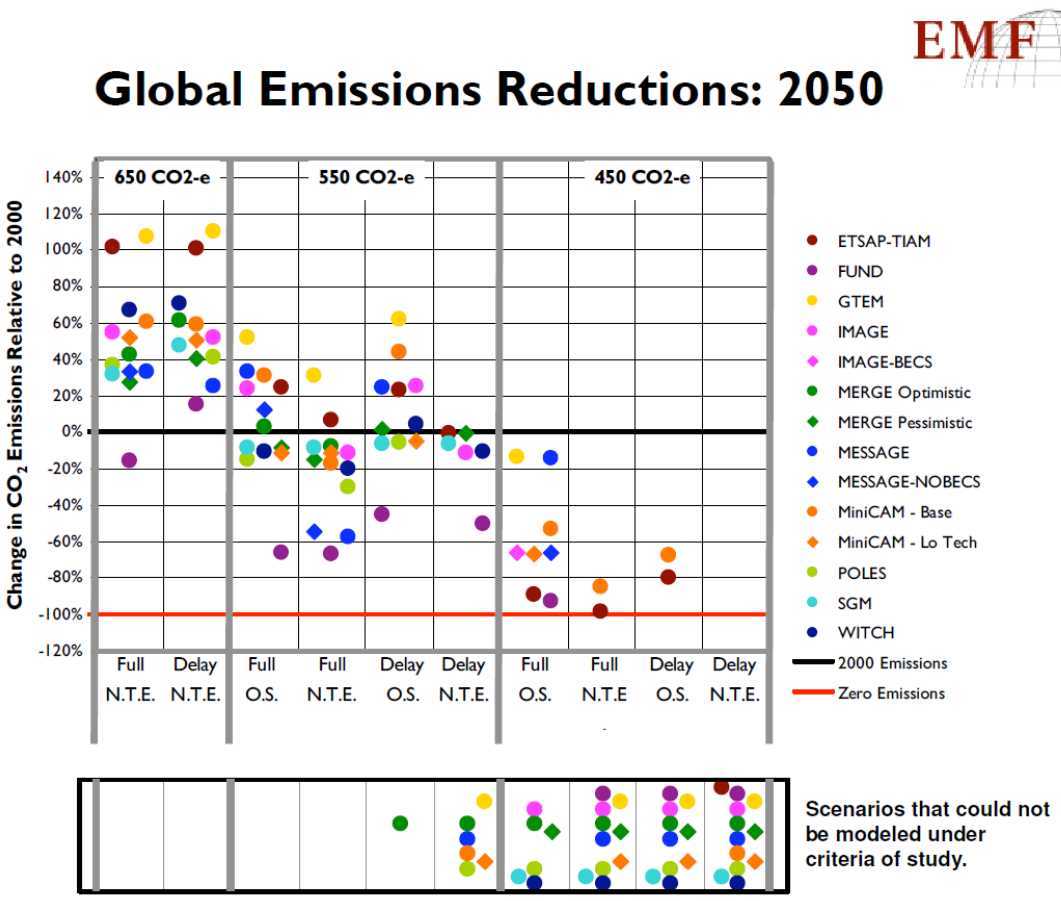
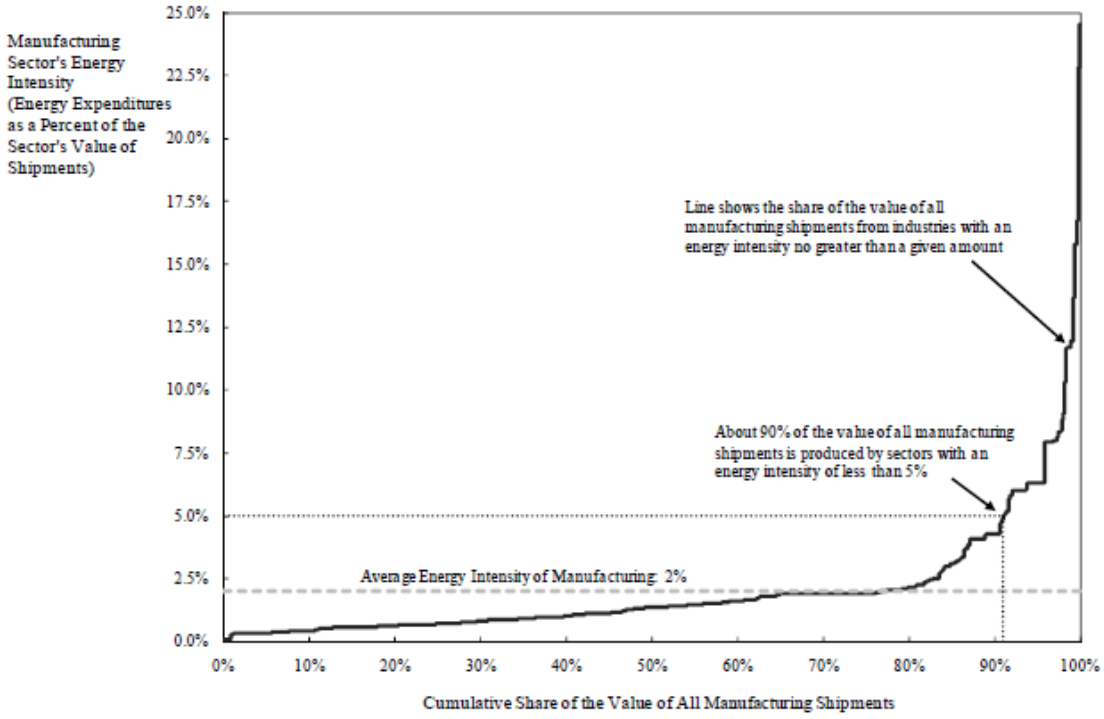


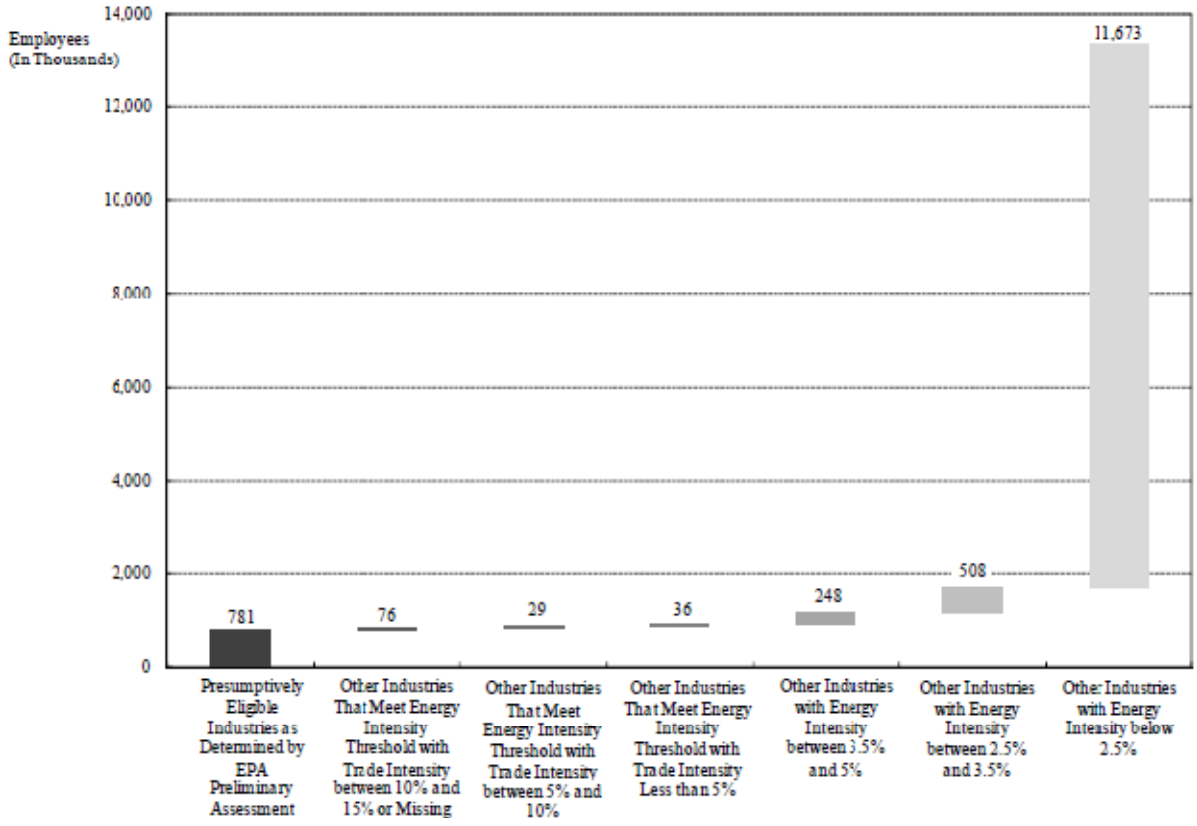
Figure 6 **Only a Few Sectors are Really Susceptible to Competitiveness Concerns**



Note: This chart does not account for 14 (of 471) manufacturing sectors for which data on energy expenditures were withheld in the Economic Census to maintain confidentiality of individual companies' data. However, these sectors account for only 2 percent of the value of all manufacturing shipments.
Source: 2007 Economic Census.

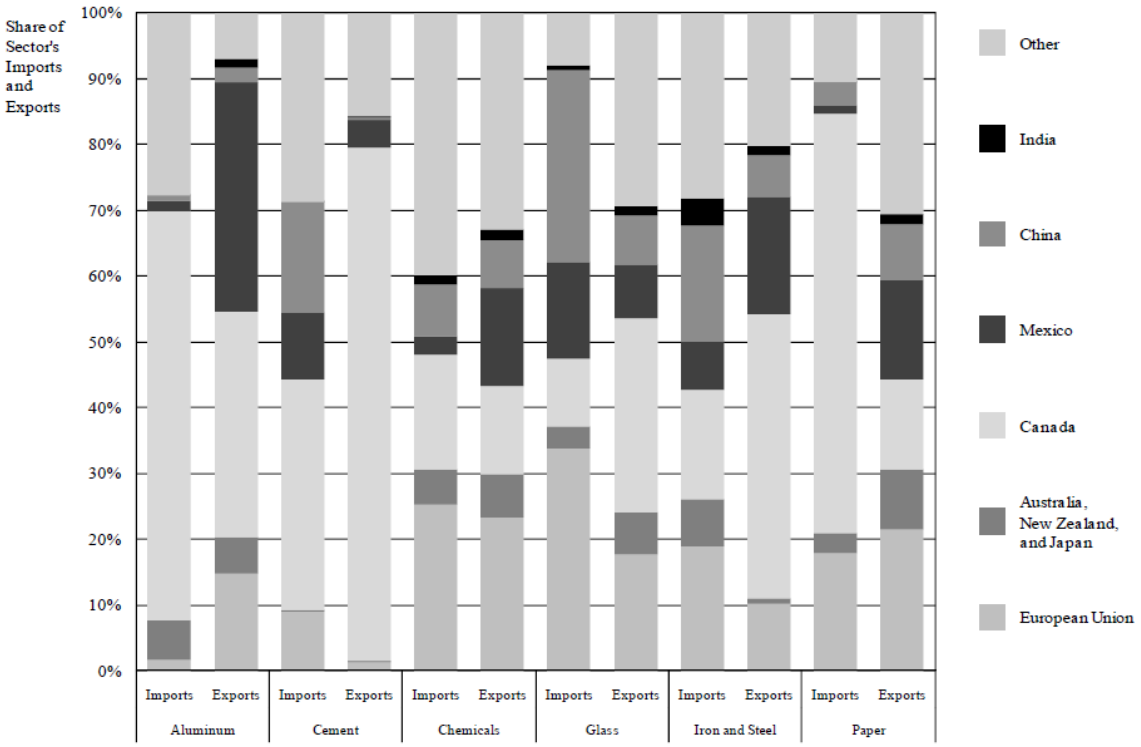
Source: Interagency Report

Figure 7 **2007 Employment in "Presumptively Eligible" Industries and in Remaining Six-Digit Manufacturing Industries with Various Energy and Trade Intensities**



Source: EPA analysis and 2007 Economic Census.

Figure 8 Distribution of U.S. Imports and Exports by Origin and Destination in 2008 for Various "Presumptively Eligible" Industries



Note: Six-digit presumptively eligible sectors included in industry categories depicted above are: Aluminum (Alumina Refining and Primary Aluminum Production); Cement (Cement Manufacturing); Chemicals (Petrochemical Manufacturing, Inorganic Dye and Pigment Manufacturing, Alkalies and Chlorine Manufacturing, Carbon Black Manufacturing, All Other Basic Inorganic Chemical Manufacturing, Cyclic Crude and Intermediate Manufacturing, All Other Basic Organic Chemical Manufacturing, Plastics Material and Resin Manufacturing, Synthetic Rubber Manufacturing, Cellulosic Organic Fiber Manufacturing, Noncellulosic Organic Fiber Manufacturing, and Nitrogenous Fertilizer Manufacturing); Glass (Flat Glass Manufacturing, Other Pressed and Blown Glass and Glassware Manufacturing, and Glass Container Manufacturing); Iron and Steel (Iron and Steel Mills); and Paper (Pulp Mills, Paper Mills, Newsprint Mills, and Paperboard Mills).
Source: U.S. International Trade Commission data.

Figure 9 **Effect of Domestic Cap-and-Trade Program on Marginal Production Costs of Energy-Intensive Trade-Exposed Industries without and with Allocations to Local Distribution Companies and Output-Based Allocations to "Trade-Vulnerable" Industries**

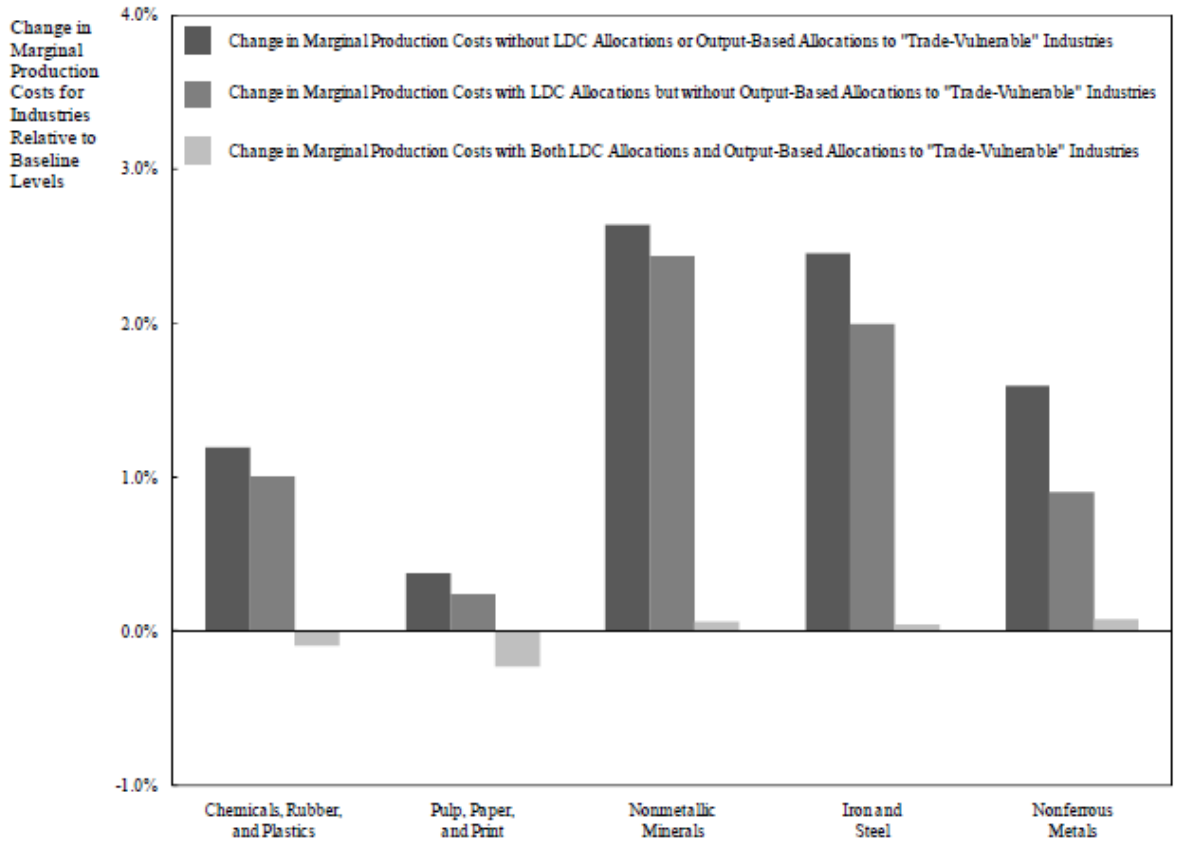


Table 1 Penalty from Limiting Agreements to Large Countries

A. Fraction of global emissions	
Big five countries	0.528
Big four countries plus WE	0.632
All major (EU plus big nine)	0.749
B. Cost penalty (ratio to complete participation)	
Big five countries	3.16
Big four countries plus WE	2.29
All major (EU plus big nine)	1.68

Note: Big five are United States, China, Russia, India, and Germany. Big four are United States, China, Russia, and India. WE includes only Western European members of EU. Big nine includes big four plus Brazil, Canada, Japan, Mexico, and South Africa. Part A of the table shows the fraction of 2005 global CO_2 emissions that come from the different groups. Part B shows the cost penalty associated with partial participation. For example, if only the big five countries are included, this would cover 53 percent of emissions, and the cost penalty for attaining a given global emissions reduction would be a factor of 3.16.

Source: Nordhaus, 2007

Table 2 Mitigation Commitments Under Copenhagen

Impact of Mitigation Pledges under the Copenhagen Accord

Source[9]	Temperature or GHG concentration pathway	Global emission reductions in 2020 below BAU	Global emission reductions below BAU needed in 2020 to achieve a 2-degree pathway
Project Catalyst	550 ppm	9-16%*	24%*
Climate Action Tracker	3.2 to 3.5 degrees Celsius by 2100	4-16%*	26%*
Houser	Peaking at 487-490 ppm in 2020	7-13%	21%*
Climate Interactive	3.9 degrees Celsius by 2100		

* Calculated by the Pew Center on the basis of data contained in the respective analyses.

Bibliography

To Be Completed