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From Kyoto to Copenhagen: Meeting the Climate Change Challenge*

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In spite of some superficial success in achieving its overall global target, there has been much disillusionment with the progress on climate change since the Kyoto Protocol was negotiated in 1997. The key problems in addressing GHG emissions under the Kyoto Protocol have been the incomplete coverage across countries and lack of credibility. While significantly more onerous reduction commitments should be expected and required of developed countries in the name of economic fairness, GHG emissions must also be capped effectively in developing countries.

Keywords: Clean Development Mechanism, Copenhagen Accord, greenhouse gas emissions, Kyoto Protocol.

1. Introduction: Mounting Challenge! Shirking Commitments?

Reducing global greenhouse gas emissions has become one of the most serious challenges ever to face the international community. In spite of a small number of dissenting views, which frequently attract media attention, there is a robust scientific consensus that climate change represents an extraordinarily serious environmental threat and that human economic activity is significantly compounding the problem. In the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and, subsequently, the 1997 Kyoto Protocol, the so-called Annex B countries aimed first to stabilize and then to reduce greenhouse gas (GHG) emissions relative to a base year of 1990. Annex B of the Kyoto Protocol is comprised of a group of 25 developed countries and a group of 13 transition countries from Central Europe and the former Soviet Union.[1] The collective target of the Annex B countries was a reduction in emissions of 5.1 percent by 2008-2012. In 2007, on the eve of the target period, the GHG emissions of the Annex B countries inclusive of the effects of changes in land use and forestry practices were 6.0 percent below their 1990 level, and even excluding the effects of changes in land use and forestry practices, emissions were 4.8 percent below the 1990 level.[2] With the aid of the recent recession to suppress economic growth and emissions, therefore, the prospects for meeting the overall target of the Kyoto Protocol are reasonably good.

In spite of the superficial success, there has been much disillusionment with the progress on climate change since the Kyoto Protocol was negotiated in 1997. The reasons are clear to see. The United States did not ratify the Kyoto Protocol. Canada ratified the agreement and then largely ignored it, while Australia first refused to ratify the agreement and then, belatedly, with a change in government, changed its mind. In terms of performance, while Western European countries are on track, Australia, Canada, New Zealand, the United States and Japan are significantly over their targets. If the overall target is met, it will be predominantly because of the decline in emissions in Russia and other transition countries, associated with their economic collapse in the 1990s.[3] With recovery in the transition countries over the period since 1998, there is a strong sense that the overall Kyoto emissions reductions are not sustainable in the long term. The controversy has widened, with the United States and China as the key protagonists in a debate as to whether and to what extent the major developing countries should also face binding emission targets. At the recent Copenhagen Conference, amid suspicion, finger pointing, recrimination and public protest, countries meekly agreed that "the Conference of the Parties [t]akes note of the

Copenhagen Accord …" (United Nations, 2009). Given the scientific imperative for collective action on climate Change, it is important to explore how and why the situation has become so bogged down.

2. Assessing and Moving Beyond the Kyoto Legacy

The important greenhouse gasses (GHGs) associated with human activity that contribute to climate change include carbon dioxide, methane, nitrous oxide, hydroflurocarbons, sulphur hexafluoride and perfluorocarbons. The latter four GHGs have a much greater warming potential than carbon dioxide (CO_2), but their concentrations in the atmosphere are lower and, aside from methane, their emissions tend to be roughly proportional to CO_2 (Pancoast, 2003). While data on overall GHG emissions is generally available for developed countries and countries with economies in transition, it will frequently be necessary to resort to data on CO_2 emissions so as to include developing countries in the discussion.

Forestry and land use practices more generally affect the natural carbon cycle and, thus the extent of GHG release into the atmosphere and methane emissions from agriculture are an important secondary source of GHG emissions. Most GHG emissions that result from human economic activity, however, are attributable to the consumption of fossil fuels. The GHGs generated by combustion are in approximately fixed proportion to fossil fuel consumption in accordance with underlying scientific principles. Further, while abatement technologies such as carbon-capture and storage are on the horizon, to date emission reductions related to fossil-fuel use have been almost entirely through fuel saving rather than abatement. This implies that there is a relatively simple economic litmus test for determining how GHG emissions are affected by changes in economic policy and economic circumstances more generally. To a first approximation, changes in global emissions are proportional to the changes in world fossil fuel consumption.

The overall news is not good. During the Kyoto period from 1998 to 2007, world fossil-fuel consumption increased by 28%. Developed Countries increased fossil-fuel consumption by 15.8%, Transition Countries increased consumption by 11.5 %, and Developing Countries increased consumption by 60.4%.[4] The lack of success in curbing global fossil-fuel consumption suggests the need for a closer examination. Consequently, the legacy of the Kyoto Protocol is assessed across several important dimensions starting with international fairness as a precursor to considering a more effective international regime for reducing fossil-fuel use and GHG emissions.

2.1 How Equitable?

A key fairness feature of the Kyoto Protocol was its incomplete coverage. Only the Developed Countries and Transition Countries of Annex B made commitments to reduce their GHG emissions. The remaining mainly Developing Countries outside of Annex B were not required to make any emission reductions and, *de facto*, were free to increase their emissions. In 1998 as countries began ratifying the Kyoto Protocol, the Annex-B Countries accounted for 59.3% of world CO_2 emissions, which was down from 65.9% in 1990.[5] The Clean Development Mechanism (CDM) is another prominent feature of the Kyoto Protocol, which advances international equity. The CDM aims at promoting economic development in the non-Annex-B countries while restraining emissions. Firms or other economic players from the Annex-B countries can participate in projects with their counterparts in host Developing countries to reduce emissions below business-as-usual baselines. Since the firms from Developed Countries receive emission credits in return for their investment in such projects, in effect they purchase emissions credits. Meanwhile, there is a transfer of income and net benefit to the Developing Country.

There are at least three compelling reasons that suggest that Developed Countries should be expected to shoulder the largest burden in global efforts to reduce GHG emissions. First, the Developed Countries industrialized earlier and, thus, have been contributing to the problem of excessive greenhouse gasses for a much longer period. Second, the per capita emissions of Developed Countries tend to be much higher than those of Developing Countries. In 1998 the Developed Countries in Annex B emitted 13.1 metric tons of CO_2 per person, the Economies in Transition as a group emitted 11.9 tons per person and the non-Annex-B Developing Countries as a group emitted only 2.0 tons per person.[6] Third, the Developed Countries are considerably richer. Consequently, they should bear and are more able to bear a larger share of the costs of reducing GHG emissions. In 1998 the Developed Countries had a per-capita GDP of $30.2 thousand (in 2005 international dollars using purchasing power parity exchange rates), the Transition Countries had a per-capita GDP of $7.8 thousand and the Developing Countries had a per-capita GDP of $3.3 thousand.[7]

There, thus, appears to be a strong international equity or fairness rationale for the incomplete coverage of the Kyoto Protocol itself and for its Clean Development Mechanism. While these provisions may have been politically expedient means of achieving equity, there were other possibilities. If countries had come to a politically more difficult agreement to tax fossil fuel use, for example, there could have been revenue-sharing arrangements involving net transfers to Developing Countries. Similarly, under a global "cap and trade" system, net purchases of emission permits by

Developed Countries could have generated a substantive revenue flow into Developing Countries. Further, while the overall structure of the Kyoto Protocol may have been broadly equitable, there are also some awkward anomalies. For example, in 1998 Australia's per capita GDP of $27.0 thousand was close to the Developed Country average of $30.2 thousand and its per-capita emissions of 18.2 metric tones of CO_2 per person vastly exceeded the Developed Country average of 13.1 tons per person. Nevertheless, far from a commitment to reduce its emissions, Australia simply committed to restrict its increase in emissions to 8%. (See Figures 1, 2, 6 and 8 in the Technical Appendix.) In any case, equity is just one of the important yardsticks for assessing the Kyoto Protocol.

2.2 How Effective?

Basic arithmetic has significantly undermined the effectiveness of Kyoto Protocol due to its incomplete coverage. The collective commitment of the Annex-B Countries was to reduce GHG emissions 5.1% below 1990 levels. The GHG emissions of these countries as a group had already *fallen* by 7.6% over the interval from 1990 to 1995 owing primarily to the steep recession in the transition countries.[8] Consequently, if all Kyoto-commitments were exactly met, the GHG emissions of the Annex-B Countries as a group over the 2008-2012 period would actually be 2.5% *higher* than their 1995 level. To expand the discussion to include Developing Countries, it is helpful to focus on CO_2 emissions data, which is more widely available. The CO_2 emissions of the Annex-B countries had already *fallen* by 3.9% over the interval from 1990 to 1998, and so that only a further 1.3% reduction below the 1998 level would have been required to meet the Kyoto target. Given that the Annex-B countries produced only 59.3% of world carbon dioxide emissions in 1998, world CO_2 emissions over the 2008-2012 period would have been a mere 0.8% below the 1998 level in the best-case scenario where the CO_2 emissions of the unconstrained group of Developing Countries remained constant.[9]

Over the period from 1998 to 2006, however, CO_2 emissions in the unconstrained Developing Countries increased by a massive 53.9%. Meanwhile, CO_2 emissions also rose by 6.9% in the supposedly constrained Annex-B Countries and, thus world emissions were 26.1% higher. On an overall basis, Developing Countries accounted for 85% of the increase in CO_2 emissions between 1998 and 2006. Looked at another way, if the Annex-B Countries had reduced CO_2 emissions by 1.3% instead of increasing them by 6.9% between 1998 and 2006, world CO_2 emissions would "only" have risen by 21.1% rather than 26.1%.[10]

Excluding Developing countries, which accounted for 40.7% of world emissions in 1998, was a problematic feature of the Kyoto Protocol from the start. Given the rapid growth in emissions by the Developing Countries, this became a fatal flaw. With a 49.7% and rising share of world CO_2 emissions attributable to Developing Countries by 2006 (see Figure 5 in the Technical Annex), any arguments that might have been made in favour of the incomplete coverage of the Kyoto Protocol should now have been totally discredited. While the political process has been painful to watch, this lesson may have been partially learned by the end of the Copenhagen Conference. The Copenhagen Accord does call for "Nationally appropriate mitigating actions" by Developing Countries, but the parameters are much looser than for the "Quantified economy-wide emission targets for 2020" that are expected of the Annex-B Countries (United Nations, 2009, Appendix I and II respectively).

2.3 How Much GHG Leakage?

Basic economics has exacerbated the problem of incomplete coverage, which was built into the Kyoto Protocol. The 53.9% increase in CO_2 emissions by Developing Countries discussed above was clearly far from the best-case scenario of constant emissions, which advocates and some of the famers of the Kyoto Protocol might have imagined. Indeed, more careful consideration of this best-case emissions scenario suggests that it unrealistically presupposes no economic growth and no trade linkages between countries.

The main reason for the dramatic increase in emissions by Developing Countries is clearly economic growth. For the Developing Countries as a group, GDP was 48.8% higher in 2006 than in 1998. Consequently, there was only a small increase in their average CO_2 emissions intensity from 1.38 to 1.42 kilograms of carbon dioxide per constant US dollar of GDP between 1998 and 2006 and the emissions intensity actually fell slightly between 1990 and 2006. While China's emissions almost doubled between 1998 and 2006, its emissions intensity actually declined slightly from 2.95 to 2.85 kilograms of carbon dioxide per constant US dollar of GDP.[11] Overall, the impressive economic growth in many Developing Countries is very closely linked with the world's dramatic lack of progress in curbing the growth of CO_2 emissions under the Kyoto Protocol. While the evidence is now incontrovertible that there cannot be significant progress on reducing GHG emissions without commitments from major Developing Countries, this evidence also points to a concern that significant emissions reductions may come at the cost of slower economic growth at least in the short to medium term while the world economy adjusts to lower GHG emissions and higher effective prices for energy use. This apparent dilemma continues

to significantly affect the stance of Developing Countries in current negotiations and very rightly so.

With the rapid economic growth in Developing Countries, it might be tempting to think that world GHG emissions would have even worse but for the presence of the restraints on the Annex-B Countries. Sadly, this too is a dubious proposition. Under a state of autarky or no trade, emission reductions by the Annex-B Countries would have no repercussions on the emissions of the unconstrained Developing Countries. In a trading world, however, as production of the most emissions-intensive goods and services is reduced in the Annex-B Countries, these activities will tend to be displaced to Developing Countries, which do not face emissions constraints. This production displacement is associated with an increase in GHG emissions in unconstrained countries.

It has generally been assumed that such GHG "leakage" or "crowding out" will result in increases in emissions in unconstrained countries being of smaller magnitude than the initial reductions by constraining countries. Nevertheless, it is easy to envisage situations where there is a larger, not smaller, increase in GHG emissions by Developing Countries than the initial reduction by Annex-B Countries. In the worst-case scenario for the world environment, the decrease in production of emission-intensive goods and services by the Annex-B Countries would be matched by a one-for-one increase in the production of those goods and services in Developing Countries. Interestingly, full production displacement of this type occurs in some of the simplest possible international-trade models addressing GHG emissions.[12] If, for each good and service, Developed and Developing countries used similar production techniques and had similar emission intensities, then with full production displacement the increase in emissions by Developing Countries would, to a first approximation, nullify the reduction by Developed Countries.

The empirical evidence shown in Figure 14 in the Technical Annex, however, suggests a statistically significant inverse relation of large magnitude between a country's level of economic development measured by per capita income and CO_2 emission intensities of its production techniques. For each thousand-dollar increment in real GDP, CO_2 emissions intensity would fall by 6.4% for a country that was comprised of the world average shares of services, manufacturing, other industry and agriculture. This implies that, in terms of GHG emissions, there are not only "cleaner" and "dirtier" goods and services in terms of GHG emissions, but that Developed Countries are "cleaner" than Developing Countries in the production of similar goods and services. One possible reason is that the fuel-saving activity, which underlies lower emissions, tends to be highly capital intensive and capital tends to more

abundant and, thus, cheaper in high-income Developed Countries. In any case, in a worst-case scenario with full production displacement of emission-intensive activity from "cleaner" Developed Countries to "dirtier" Developing Countries, there would be a "GHG reversal" where a net increase in world GHG emissions arises from a Kyoto-type agreement.

Even more paradoxically, consider the fact that the US declined to ratify its participation and countries such as Canada chose to ignore their commitments. In the worst case scenario of full production displacement, such opting out would reduce the extent of displacement of emissions-intensive activity to Developing Countries leading to a smaller GHG reversal and, thereby a smaller increase in world GHG emissions. This implies that the flaws in the structure of the Kyoto Protocol are sufficiently serious that the impact on the global environment might have been worse with a wholehearted commitment by more of the Annex-B countries.

2.4 How Efficient?

Whether the production displacement that would have arisen if the Annex-B Countries met their Kyoto commitments would merely have caused partial GHG leakage or would have caused a more serious GHG reversal remains an open empirical question. In either case, however, the analysis exposes an important structural flaw in the Kyoto framework; it displaces production of the "dirtiest" or most GHG intensive goods and services to the "dirtiest" or most GHG intensive countries. Rather than restricting emissions in the most developed countries that accounted for 60% of world emissions at the time, it actually would have been better for the world environment to restrict the GHG emissions of the least developed countries that accounted for 60% of world emissions. Production would be then have been displaced to less emission-intensive Developed Countries resulting in an overall reduction in emissions even if there was full trade displacement of emissions-intensive activities from Developing to Developed Countries. Of course, restricting the emissions of all countries would still have represented an improvement over either "60% solution."

For efficiency, reductions in GHG emissions should be achieved at the lowest possible cost. This is particularly important given that the ultimate goal is very substantive reductions in GHG emissions. Although the incomplete coverage of Kyoto Protocol is highly problematic from an efficiency perspective, it was intended that the Clean Development Mechanism would at least partially address this deficiency. As discussed previously, firms from Developed Countries can receive emission credits in return for their investment in emission-reduction projects in Developing Countries under the CDM in the Kyoto Protocol. When emissions can be reduced at lower cost

through a project in host Developing Countries than in their regular operations at home, it is in the private interest of firms to pursue this option. Thus, the CDM opens the door to greater efficiency in goods markets by allowing greater output to be produced with the same level of overall emissions. In a similar vein to the CDM, the Kyoto Protocol also allows projects where the host country is form Annex B under the heading of Joint Implementation and direct Emissions Trading between pairs of countries in Annex B (United Nations, 1998).

Superimposing the CDM on the proposed reductions in emissions by the Annex-B Countries, however, may have a detrimental impact on world GHG emissions. At the initial prices, emission-intensive activities would increase in both Developed and Developing Countries alike. Firms and other economic players in Developed Countries benefit from the cost-saving opportunities while indirect subsidies attributable to CDM projects accrue to their counterparts in Developing Countries. Of course, the increase emissions in Developed Countries stemming from CDM credits is exactly offset by the emission reductions in Developing Countries resulting from the associated CDM projects. In Developing Countries, where the increase in emission-intensive activity is not subject to an overall emission cap, the impact of the CDM depends both on the change in output for emission-intensive activities and on the change in emissions per unit of output. The effect on global GHG emissions from the drop in emissions per unit output in Developing Countries, as we have just discussed, is exactly offset by the increase in emissions in Developed Countries. Consequently, the increase in emission intensive outputs stimulated by the indirect subsidy would lead to greater world emissions at the initial prices. Subsequent market equilibration in the face of likely excess supply, however, will typically lead to lower prices for emission-intensive goods and services. This, in turn, will at least moderate and may reverse the increase in emission-intensive output in Developing Countries and, thus, world emissions. Nevertheless, with emissions in Developing Countries unconstrained, world emissions could either rise or fall due the inclusion of the CDM in the Kyoto Protocol.

The problem, once again is the lack of constraints on emissions by Developing Countries. If such constraints were present, the CDM would lead to greater efficiency by providing an avenue for emissions trading while leaving world emissions unchanged. Indeed, with all countries constrained, a streamlined emission-trading regime between Developed and Developing Countries is vital to achieving any overall reduction in world emissions at the lowest possible economic cost.

2.5 How Credible?

There have been obvious compliance problems with the Kyoto Protocol. Excess Greenhouse Gasses in the atmosphere represent a negative global public good, which is harmful to all countries. Consequently, there is an incentive for each country to "free ride" on the reductions in GHG emissions by all other countries and thereby receive benefits without bearing costs. Consequently, in the absence of serious consequences for non-compliance, it is hardly surprising that compliance has been a problem.

Figures 1 and 2 in the Technical Annex to this paper suggest that, in 2007, the only countries on track to meet their Kyoto commitments were Western European and Transition countries, with the latter "succeeding" only because of steep recessions through the 1990s. Australia initially declined to ratify the Kyoto Protocol but recently, with a change in government, did ratify it. Canada by contrast initially ratified the Protocol but with its change in government acknowledged that it would not meet its target. Between 1990 and 2007, Australia's GHG emissions increased by 30.0% and Canada's emissions increased by 26.2% according to Figure 2 in the Technical Annex. In 2007, this left Australia 22.0% above its Kyoto target of an 8% increase in emissions and Canada 32.2% above its considerably more ambitious target of a 6% reduction in emissions. Although the US participated in the Kyoto negotiations and made a provisional commitment to reduce its emissions by 7%, with difficulties in Congress and a change in presidents and priorities, it eventually decided against ratifying the Kyoto Protocol. In spite of this, it is interesting to note that the 16.8% increase in US GHG emissions compares favourably to countries such as Australia, Canada and New Zealand. It is noteworthy that Japan has also failed to reduce its emissions. Japan, which has a very low emission intensity of 0.245 kilograms of CO2 per constant US dollar of GDP, experienced an 8.2% increase in GHG emissions from 1990 to 2007 whereas it had targeted a 6% reduction.[13]

It would be difficult to escape the conclusion that there were few if any consequences for to countries that engaged in political posturing rather than action in relation to their Kyoto commitments or chose to ignore or back out of their commitments entirely. This poses significant credibility issues for the Copenhagen Accord and any future agreements. In the wake of the credibility issue exposed by the Kyoto Protocol, there is a growing sense that there need to be trade-consequences for countries that do not make or follow through with commitments. To forestall a likely drift toward a free-for-all of retaliation for non-compliance and counter-retaliation, there is a strong case to be made for World Trade Organization (WTO) oversight of trade penalties.

Since failure to implicitly or explicitly "price" emissions *per se* or the underlying external effect of fossil fuel use could be seen as an "unfair" subsidy, one avenue would be to adapt the WTO's Agreement on Subsidies and Countervailing Measures to codify allowable trade penalties. Even this would represent no small change. Under the current agreement, actionable subsidies and countervailing measures are, for the most, part industry specific whereas the implicit subsidies on fossil-fuel use or emissions would be generally available. While all goods and services from non-compliant or non participating countries would be subject to countervailing measures, the rates of duty across sectors would vary depending on the emissions or fossil fuel intensities as determined by input-output tables. Of course, this is not to trivialize the substantive difficulties in agreeing upon and then calculating the degree to which fossil fuel or emissions are under priced. Nevertheless, it appears to be a given that if countries agree to significant GHG reductions under the Copenhagen Accord, then trade penalties will be imposed on those that do not follow through by those that do. The only real question appears to be whether or not there will be international disciplines on such trade penalties.

3. Conclusion: Changing Directions

While this assessment clearly suggests the need for a fundamental change in direction with respect to global coordination on climate change policy, there is a concomitant need to re-evaluate policy within many Developed Countries as well as Developing Countries.

3.1 Rethinking National Action

In public discourse on responses to the challenge of climate change, particularly in North America, the development of new technologies has become a key mantra. While the role of technological change is undoubtedly important, this does not mean that governments should be promoting this or that specific new technology. For example it is generally a dubious proposition to subsidize hybrid vehicles, wind power, carbon capture and storage, etc. Governments have been notoriously bad at picking winners to promote via subsidies or other means. Rather, the primary job of government is to set policy such that the price that users of fossil fuel face reflects the full social cost and to provide general incentives for research and development by protecting intellectual property. Getting the price signals right is particularly important over the long-term to provide the incentive for the development of new technologies that will result in fuel saving and abatement.

While policy to reduce GHG emissions must be multifaceted and include initiatives related to land use, particularly in forestry and agriculture, it is most important to implement measures aimed at reducing emissions from fossil fuel use. Either GHG emissions *per se* or the underlying fossil fuel consumption could be reduced by means of direct controls or indirectly through taxes. If direct controls are used, in the interest of economic efficiency it is crucial that permits for GHG emissions or fossil fuel use are tradable so that any aggregate reduction in emissions is achieved at minimum cost. Countries must deliberately implement either environmental taxation or cap-and-trade policies if they are to move beyond gesturing toward action on climate change.

Regions that are net fossil-fuel consumers — whether they are individual countries, groups of countries or sub-national jurisdictions such as Canadian provinces — often tend to see fossil-fuel producing areas as the primary problem. Nevertheless, reductions in the use or consumption of fossil fuel are actually central to reducing GHG emissions. Since consumption is the culprit, it is consumption that should be the focus of policy so that the price rises and users pay the full social cost. In a closed competitive economy, basic economics does indicate that taxing the production of fossil fuel would be equivalent to taxing consumption. For a competitive trading economy, however, imports as well as production would have to be taxed and exports would have to be subsidized, all to the same extent, so as to boost the domestic price to reflect the marginal social cost in the same way as a consumption tax. Given the difficulties associated with trade commitments, it appears clear that the policy focus should remain on fossil fuel consumption.

3.2 Rethinking Global Coordination

While economic growth and international trade undermined the Kyoto Protocol, growth and trade are certainly not the issues. Rather, the key problems in addressing GHG emissions under the Kyoto Protocol have been the incomplete coverage across countries and lack of credibility. Real progress on mitigating the impact of climate change in the post-Copenhagen world is not possible without a fundamental change of direction in these areas. While significantly more onerous reduction commitments should be expected and required of Developed Countries in the name of economic fairness, GHG emissions must also be capped effectively in Developing Countries.

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World Bank, World Development Indicators (WDI) Database. Website: http://devdata.worldbank.org.ezproxy.lib.ucalgary.ca/dataonline/.

Endnotes

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1. The 25 Developed Countries in Annex B of the Kyoto Protocol (United Nations, 1998) include: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxemburg, Liechtenstein, Monaco, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The 13 Transition Countries are: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Russian Federation, Slovakia, Slovenia, and Ukraine. Except for the exclusion of Turkey and Belarus, Annex B of the Kyoto Protocol contains the same countries as Annex I of the UNFCCC (United Nations, 1992).
2. The data source for calculations the overall reduction commitment and overall emissions is the UNFCCC (United Nations Framework Convention on Climate Change) "GHG data from UNFCCC."
3. See Figures 1 and 2 in the Technical Annex to this paper for further data on Kyoto commitments and emissions results for Annex-B Countries.
4. The data source for calculations of increased fossil fuel use is the United States, Energy Information Administration (EIA) Database. See Figures 3 and 4 in the Technical Annex for further data on trends in fossil fuel use across a variety of important countries.
5. The data source for calculations of shares of world CO_2 emissions is the United States, Energy Information Administration (EIA) Database. See Figure 5 in the Technical Annex for additional information.
6. Calculations are based on CO_2 emissions data from the United States, Energy Information Administration (EIA) Database and population data from the World Bank, World Development Indicators (WDI) database. See Figures 6 and 7 in the Technical Annex for further data on trends in CO_2 emissions per capita across a variety of important countries.
7. The data source for calculations of per-capita GDP is the World Bank, World Development Indicators (WDI) database. See Figures 8 and 9 in the Technical Annex for further data on trends in per capita GDP across a variety of important countries.
8. The data source for GHG emissions is the UNFCCC (United Nations Framework Convention on Climate Change) "GHG data from UNFCCC."
9. The data source for the calculations of CO_2 emissions is the United States, Energy Information Administration (EIA) Database. See Figure 10 in the Technical Annex

for further data on Kyoto commitments and emissions results for Annex-B Countries.

10. The data source for the calculations of CO_2 emissions is the United States, Energy Information Administration (EIA) Database. See Figure 11 in the Technical Annex for further data on Kyoto commitments and emissions results for Developing Countries.
11. These calculations are based on CO_2 emissions data from the United States, Energy Information Administration (EIA) Database and real GDP data from the World Bank, World Development Indicators (WDI) database. See Figures 12 and 13 in the Technical Annex for further data on trends in CO_2 emissions intensities across a variety of important countries.
12. See Gaisford and Pancoast, 2005; Pancoast, 2003; and Sagidova, 2007. Copeland and Taylor (2005) show that "crowding in" could also occur in the context of a theoretical model where all countries use broadly similar production techniques and a group of countries that are net importers of emission-intensive goods agree to tighten their emissions caps. Starting from an initial policy equilibrium where all countries have emission caps, emission reductions by the net importing group causes increases in the prices of emission-intensive goods that makes the net-exporting group of countries richer and induces them to reduce their emissions. Unfortunately, this model appears to be of limited relevance. The empirical evidence in the Technical Annex suggests that Developing Countries use production techniques that are systematically more emission-intensive than Developed Countries and that Developing Countries have no effective caps on their overall emissions.
13. The data source is the UNFCCC (United Nations Framework Convention on Climate Change) "GHG data from UNFCCC." See Figure 1 as well as Figure 2 in the Technical Annex for further data on Kyoto commitments and emissions results for Annex-B Countries. See also Figure 12 for data on CO_2 emissions intensities in Annex-B Countries.