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Emerging markets and climate change: Mexican standoff or low-carbon race?

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Abstract

Schelling (1995) stressed the importance of correctly disaggregating the impacts of climate change to understand how individual interests differ across space and time. This paper considers equity implications at a level of disaggregation which we consider insightful, but which is non-standard in the literature. We consider a "three-agent" model, comprising the G20 North, the G20 emerging markets (the GEMs), and the rest of the world (ROW), and consider their impact on emissions and temperature increases to 2100. Using the MAGICC and RICE models, we calculate that simply stabilising emissions in GEMs would avoid about twice as much warming as an 80% emissions reduction in the North. We further show that decisions regarding the carbon intensity of economic development in the developing world are first order determinants of the likelihood of dangerous climate change in the coming century, and that early GEM participation in mitigation initiatives is essential if we are to safeguard the interests of the world's most vulnerable. Finally we argue that though this three-handed strategic structure may lead to impasse, it may also stimulate a low-carbon race between nations.

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1. Introduction

Climate change is complex. Simplification can provide insight. But inappropriate simplification can be more misleading than insightful. In the economic analysis of climate change, perhaps the most severe simplification is to employ a single infinitely-lived representative agent model. This brings out the intertemporal elements of the analysis, but completely obscures the international elements and the conflicting interests between different people at the same point in time.

Schelling (1995) cautioned against the risk of a "fallacy of composition" in the use of such optimisation models, stressing that mitigation now is for the benefit of different people living in the future. Specifically, mitigation conducted by rich countries today benefits the future poor, who are poorer than the current rich but richer than the current poor. Single-agent optimisation models can mislead the user into assuming that mitigation now is for the benefit of the same (rich) world later, with results that may be "either dubious or wrong" (Schelling, 1995). They do not provide an adequate number of degrees of freedom, and often compress a range of ideas (e.g. aversion to risk, inequality and interemporal fluctuations) into a single parameter (Atkinson et al, 2009).

Another extreme simplification, which has also both provided insight and which has misled, is the "two-agent" model of climate policy, frequently employed in both the academic literature[1] and international negotiations, where the distinction between Annex 1 and non-Annex 1 countries has become the default structure for managing the complex and multi-faceted idea of "common but differentiated responsibility".

Like the representative agent model, this two-part classification has had its uses. But it fails to capture one of the most striking patterns of economic development over the last twenty years: the emergence of a group of rapidly growing, rapidly industrialising markets based in the "global south". This growth has raised the living standards and life prospects of vast numbers of people. But, as with previous patterns of economic development in the global north, growth in so-called emerging markets is being accompanied by the familiar by-product: emissions of greenhouse gases (GHG), most significantly carbon dioxide (CO_2) which alters Earth's energy balance and changes Earth's climate.[2]

[1] See for instance, Shue (1992) and Agarwal and Narain (1991).

[2] See for instance Andrews (2000) or any other elementary atmospheric physics text.

These rapidly growing economies collectively are expected to make an extremely significant contribution to 21st century climate change, and this is easily neglected in a two-agent model. Yet it turns out that growth pathways in emerging markets are crucial to our ability to avoid dangerous anthropogenic climate change, and this has implications for the normative dimensions of climate policy.

In this chapter, we divide countries into three categories: the G20 North, the G20 emerging markets (or the "GEMs"), and the rest of the world (the "ROW"), as shown in Table 1. In section 2, we employ the MAGICC and RICE models to consider their respective contributions to climate change to 2100, estimate the associated economic impacts, and tease out the strategic and ethical implications.

[Insert Table 1 about here]

In considering the ethical implications, we focus on our discussion on "the poor". We do not focus on poor countries. Rather, we accept the reality that there are some extremely rich individuals in poor countries, and some very poor individuals in rich countries.[3] As such, we adopt a highly stylised division of the poor into three categories (see section 4): the industrialised-world poor (IWP); the aspirational and urbanising poor (AUP) often in emerging markets or the developing world; and the traditional and rural poor (TRP) often in the least developed countries, but also within emerging market economies.[4] While this categorisation is coarse and caricatured, we find it provides more insight than simply dividing impacts into binary categories based on national per capita income.

We employ the division into the North, the GEMs and the ROW to compare the relative impacts of three plausible emission trajectories: a "no deal" scenario, a "North leads" scenario and a "North and GEM action" scenario. We find that it is impossible to protect the world's very poorest without the early action in emerging market countries.

This has interesting implications for international climate policy, and in this respect we keep in mind two perfectly reasonable yet completely contradictory questions. First, "why has so little been achieved on climate change?" (Helm, 2010) Second, "why has so much been achieved?" (e.g.

[3] This is the motivation behind suggestions that levies on international air travel, for instance should be imposed (Hepburn and Mueller, 2010).
[4] See section 3 below for details.

Barrett, 2003)[5] These questions start from opposing assumptions. The first question implicitly starts from cost-benefit analysis which suggests low-carbon growth is economically rational, and asks why we have to date failed to achieve anything like rational climate policy. The second question views the problem as a global public goods problem in which any degree of cooperation might come as a surprise. These two questions motivate the idea that the system of interaction between the relevant agents potentially involves elements of both conflict and cooperation. We investigate the notion that the conflict of interests between countries does not necessarily lead to delay and free-riding, but might instead create a race to capture new low-carbon markets.

The chapter is organised as follows. Section 2 shows the centrality of emerging market countries to the climate change problem. Section 3 briefly considers notions of equity and fairness before examining the differential impacts of climate change on the three different categories of "the poor". Section 4 examines two potential outcomes: one in which policy and incentives result in a strategic impasse or "Mexican standoff"; the other in which incentives and policy harmonise to create the oft-invoked but as yet inchoate "low-carbon race". Section 5 concludes.

2. Emerging markets and their inconvenient truth[6]

As noted above, arguments concerning mitigation responsibilities have usually concentrated on two-agent models: Annex 1 and non-Annex countries, or the "rich" and "poor" as defined by per capita income. However, a two-agent model fails to account for the rapid economic development and emissions growth in advanced developing countries, which are now critically important players in climate negotiations.

Our three agent model[7] includes the G20 North, the G20 emerging market countries ("GEMs"), and the rest of the world (ROW) on temperature increases over the coming century. We define the GEMs as the G20 countries

[5] The question as to whether or not climate policy has been a striking success or dismal failure depends on the areas to which it might be compared. If one compares it to management of stratospheric ozone destruction or the release of sulphurous aerosols, then climate policy has been very unsuccessful. If, however, compared to the UN biodiversity convention signed at the same time as the UNFCCC, then climate policy appears a lively, innovative and successful endeavour.

[6] The section builds on similar (but slightly different) modelling work to that presented by Hepburn and Ward (2011).

[7] The authors are aware that in terms of resolving the issue this is, in many ways, an incremental improvement. The three categories include countries that may share some features to do with recent economic performance, but which are otherwise diverse. Aggregation on this scale masks important differences regarding climate change, demographics, economic development and performance and geography (to name a few). This can lead to absurdities, as the authors are personally aware: both authors are from the "North", as usually defined, in spite of being from the south coast of Australia in one case, and the south coast of the South Island of the New Zealand in the other. Nevertheless, we think that the use of a three agent model provides important strategic insights that are masked in the more standard two agent description, and which are also obscured in models based on nation states (or even blocs of nation states).

that do not have legally binding commitments to reduce emissions under Annex B of the Kyoto Protocol[8] and that had a Gross National Income (on an international dollar Purchasing Power Parity basis) of less than USD 9,000 per capita in 1990. This definition leads them to comprise Argentina, Brazil, China, India, Indonesia, Korea, Mexico, South Africa and Turkey (see Table 1 above).

GEM countries already account for a larger proportion of global emissions (43%) than the G20 Annex 1 countries, as shown in Figure 1. The largest member of the GEMs, China, has also surpassed the largest G20 Annex 1 country, the USA, as the world's largest emitter of CO_2 and is also the largest energy consumer (IEA, 2010). GEM countries also accounted for the bulk of global growth in combustion CO_2 emissions in recent years, and are projected to increase their share of emissions in the coming decades (IEA, 2010).

[Insert Figure 1 about here]

We consider three emissions scenarios, described below, and apply the MAGICC climate model (discussed in Appendix 2) to determine the impact of emissions on Earth's levels of atmospheric CO_2, global mean temperature, and sea-levels. The RICE 2010 model[9] is used to evaluate mean economic impacts. As is well-understood, these models are simplifications of a complex and vast problem, and involve a high degree of uncertainty. The analysis that follows is strongly limited in that we do not provide ranges of outcomes, but instead merely describe central estimates. We acknowledge that this is an egregious simplification for a challenge such as climate change, where risk and ambiguity are critical features of the analysis. We note that the physical impacts and resulting socio-economic consequences may be much more benign, or considerably worse, than suggested by the modelling here.[10] However, as damages are a function of cumulative emissions, the relative contribution of a country or region to climate-change damages depends only on their relative contribution to cumulative emissions, irrespective of uncertainty or other distributional considerations. For instance, if the GEMs are responsible for x% of cumulative emissions then they are responsible for x% of climate change damages, regardless of the magnitude and

[8] Despite the common reference to Annex 1 and non-Annex 1 countries in discussing the Kyoto Protocol, it is countries listed in Annex B that have emission reduction obligations under the treaty. However, for the remainder of this report, given the much more familiar language, we contrast the GEMs, as defined above, with G20 Annex 1 countries.

[9] See Nordhaus and Boyer, 2000; Nordhaus, 2010 and the associated supplementary material.

[10] This is compounded by current levels of uncertainty: opinions differ as to whether we can yet reasonably assign zero probability to the possibility that some impacts of climate change may prove catastrophic, perhaps even at large scales. See Weitzman (2009). At the time of writing, one of the authors (Hepburn) is involved in developing a stochastic analysis for a different research project, undertaken by Vivid Economics Ltd.

distributional details of those damages.[11] Only if patterns of economic development are very different from those seen in the last twenty years, and assumed under standard business-as-usual assumptions, would the strategic picture presented here be radically changed.

Our three scenarios are as follows:

1. A "No deal" scenario, where the recent trends in emissions are projected forward on the basis of GDP forecasts broadly consistent with the IPCC SRES A1FI scenario, which at present fits the evidence better than the other SRES scenarios;

2. A "North leads" scenario in which developed countries commit to reduce emissions by 80% on 1990 levels by 2050 (consistent with the target advanced by the EU and Japan, and similar to the target under consideration in the US);

3. A "North and GEM action" scenario where, in addition to action by the North as per scenario 2, GEMs also commit to stabilisation emissions (except from land use change) at 2005 levels by 2050. This is consistent with a proposal from China (Sustainability Institute, 2010). Further we assume that GEMs reduce emissions from deforestation and land use change by 50% on 2005 levels.

These are of course sketches, drawn selectively from the range of possible climate mitigation futures. One could argue with the choice of the three scenarios but these seem basically to describe the positions that are on the table: no one advocates scenario (1), but it is a highly likely possibility if we cannot agree on any alternative; (2) is in broad outline what emerges from many of the developing world proposals (such as the Brazilian proposal, for instance); (3) is in essence the position advocated by the USA. The following sections provide some more detail on the three scenarios.

2.1 The "No deal" scenario

[11] It follows that as contributions to cumulative emissions change over time, so too will the fractional contributions of nations and regions. Specifically, while the North's (cumulative) contributions to climate change damage is currently around 45%, under many plausible scenarios this fraction is expected to decline to around 25% by the end of the century; the GEM share is expected to grow considerably to potentially around twice that of the North. This change across time has implications for the institutional management of the problem, since the future of "historical responsibility" is very different from its past. Institutions structured to deal with the portfolio of cumulative emissions we see today may find themselves ineffective to deal with the portfolio of emissions our children have to deal with tomorrow. Sound institutional design would anticipate significant political and economic changes, as well as changes in responsibility for the climate change problem.

The "No deal" scenario is based on the recent historic relationship between GDP and emissions for each GEM/G20 Annex 1 country between 1990 and 2005 taking into account improvements in this relationship over this period. This generates an emissions profile reasonably similar to the SRES A1FI scenario. Using this scenario, results from MAGICC show that the world in 2100 will have dramatically higher atmospheric concentrations of greenhouse gases, and be substantially hotter than in 1990, as reported in Table 2.

[Insert Table 2 about here]

Global mean temperature increases of 4-5°C are expected to involve changes to the climate which would be highly unfavourable for most human societies. Although the physical and social impacts in this world are highly uncertain, there is some evidence that this level of climate change would present existential threats to many unique ecosystems, such as coral reefs and some biodiversity hotspots, risks of extreme hydro-meteorological events to which societies are maladapted, and potentially risks of discontinuities in large-scale climate regimes (Smith, 2009). For instance, it is likely that the global water cycle would be significantly altered, potentially affecting vast numbers of people, particularly those who live in delicately balanced climate regimes. The flow of rivers from glaciers, which serve countries accounting for around half the world's current population, may well be disrupted (Stern, 2008). In a 900ppmv CO_2 world, it is expected that ocean acidity could present potentially severe, but not yet fully understood, risks for the natural regulation of ocean biochemistry, marine ecosystems and commercial fisheries worldwide (Royal Society, 2005).

This level of mean temperature increase may lead to sea-level rises of around half a metre by 2100, bringing storm surge risks to a large number of GEM cities. For instance Nicholls et al (2007) list the cities most exposed to a 1 in 100 year surge-induced flood event following a 0.5m increase in sea levels and with no further defence measures implemented. Impacts are measured in terms of future population exposure and future economic exposure. Seven of the twenty most exposed cities are in the GEMs, with an expected exposed population of almost 50 million people in 2070. In terms of asset exposure, eight of the twenty (and six out of the top ten) most exposed cities are in the GEMs, with a combined expected asset exposure of USD 12.7 trillion.

Clearly, under central estimates of the scientific parameters, a "No deal" scenario is not in the interests of the North, the GEMs or the ROW.

2.2 The "North leads" scenario

In the second scenario, in which the only the North takes action, warming is still expected to be substantial. Even if the North reduces emissions by 80% of 1990 levels by 2050,[12] we expect (using the same parameter values employed above) the mean global temperature to increase to around 4°C above 1990 levels by 2100. This would be associated with CO_2 atmospheric concentrations of over 700ppm.

Unsurprisingly, therefore, this scenario still involves major economic losses. Most of the risks (threats to ecosystems, sea level rise, etc.) described in the previous section still apply here. Some risks might be less severe; others might be marginally less likely; but most of the "reasons for concern" noted above still apply. For instance, using the RICE model suggests that aggregate losses for all of the GEMs would be 5.1% of GDP in 2100. For China, losses might be 3.2% of GDP and for India they could reach 5.9% of GDP.

2.3 The "North and GEM action" scenario

Consistent with their high and growing emissions, the potential for GEMs to make a difference to global temperature increases is materially greater than for the North. In this scenario, in addition to the North reducing emissions by 80 per cent on 1990 levels, the GEMs ensure that: (i) emissions in 2050 are no higher than they were in 2005;[13] and (ii) emissions from land use change are 50 per cent lower, then temperature increases are much reduced.

In this scenario, global temperature increases are limited to 2.7°C (on 1990 levels). Atmospheric concentrations of CO_2 in 2100 are 550ppm. The economic damage suffered by GEMs with these temperature increases is significantly smaller, although still far from negligible.

2.4 Summary

The key results from the scenario modelling are reported in Table 2. A very clear, and inconvenient, truth emerges: action by the North does comparatively little to contain climate change, and the choices of the GEM countries largely drive global mean temperatures in 2100.[14] The demographic and economic growth of the GEMs implies a very high business-as-usual

[12] This, for instance, is the target that the EU has adopted.

[13] According to Sustainability Institute (2010), as of April 2010, this is a 'potential' proposal of the Chinese government where potential proposals are defined to include conditional proposals, legislation under consideration, and unofficial government statements.

[14] This is not simply a function of the fact that GEM reductions are added to Northern efforts — if GEM reductions are examined first, they still generate comparatively larger impacts because, consistent with most GCM predictions of 21st century climate change [eg. Meehl et al., 2007], the underlying scientific model is rather linear in its response function over the time period and level of forcing considered here.

emissions trajectory, so only the GEMs have the scale to make a substantial material impact on climate outcomes. Furthermore, the GEMs also have a greater incentive to act, as the damages they suffer under business-as-usual emissions are larger than in the North.

This combination of scale and incentive is illustrated in Figure 2, which shows current emissions and expected damages as a proportion of GDP in 2100, with the bubble size proportional to current population. The figure shows that even today GEMs are higher and further to the right than either of the other two regions; the picture only becomes more striking if say 2050 data are examined.

[Insert Figure 2 about here]

3. Equity and "the poor"

The United Nations Framework Convention on Climate Change (UNFCCC) identifies "equity" as an important governing principle: "Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities." Of course, "equity" means very different things to different people. Lines of fracture include, but are not limited to, deciding whether or not equity refers to processes or outcomes, within a consequentialist framework or not[15], and whether or not one's position, be it relative or absolute, matters for equity.

We focus our analysis here by adopting a consequentialist view, and consider distributional justice. This is not to suggest that this is a uniquely important measure of "equity", but a consequentialist perspective is adopted in much of the recent literature, both academic[16] and popular[17], that does provide a tractable attempt to address the ethical dimensions of climate change. We adopt such a viewpoint here to show how the familiar moral terrain associated with "climate change and equity" alters when one considers a three-agent game, even when one remains within perhaps the most commonplace ethical framing.

We further simplify by focussing exclusively on the impacts of climate change on the "poor". Within countries and internationally, public policy initiatives including those related to climate change are often justified in terms of the outcomes they imply for the poor. Activists, academics and policy makers

[15] See, for instance, Scheffler (1988).
[16] See for instance Roberts and Parks (2007).
[17] See http://www.climate-debt.org or http://www.climatenetwork.org/ and links therein.

routinely seek "poor-friendly" climate solutions, though exactly who they have in mind varies from case to case. This is not to say that policies are actually enacted in the interests of the poor. But the ethical evaluation of policies often takes particular note of the interests of the poor, either explicitly by placing greater weight on their interests[18], or implicitly in traditional utilitarian approaches incorporating diminishing marginal utility of consumption[19]. Climate outcomes for "the poor" thus play an important role in the overt *justification* of climate policies, even if the real drivers are often to be found elsewhere.

However, a generic label such as "the poor" is often unhelpful, since it obscures crucial tensions for governments around the world. In this case, it hides the conflict between at least three sorts of people who might reasonably claim that considerations regarding "the poor" ought to include them because, prima facie, they can reasonably claim to be disadvantaged relative to many other people with whom they interact. The three groups[20] are:

– the industrialised world poor (IWP);
– the aspirational/urbanising poor (AUP); and
– the traditional and rural poor (TRP).

The first of these is clearly a part of the "rich" world, though at least for some their incomes and patterns of consumption may more closely resemble members of the developing world. Membership of the IWP is reasonably straightforward; it is just those citizens of the industrialised world who are poor relative to the bulk of their fellow citizens. They may work in a car factory in Oxford or in a call centre in Dublin, be unemployed in Chicago or occasionally wash dishes in a restaurant in Sydney. They are citizens in the industrialised world, and their patterns of carbon consumption largely co-vary with those of their wealthier neighbours, but at considerably lower levels.

The aspirational and urbanising poor are to be found both in emerging market economies such as China, India, Brazil, Mexico and the other GEMs, but are also the "middle class" in less developed countries. The AUP comprise those citizens of advanced developing countries who are enjoying enhanced material life prospects as a result of the rapid growth in emerging

[18] As is the case with prioritarianism: see Parfit (1997) or Broome (2004); or with sufficientarianism: see Caney (2005)
[19] See for instance, Dasgupta, this volume, or Hepburn and Beckerman(2007)
[20] We recognise that welfare ultimately adheres to individuals, not groups (Bourguignon and Coyle, 2001) and also that we should be conscious of the identities of the individuals within these three groups, particular given that the composition of our three groups will be changing over time, as discussed below.

economies; they may be a factory foreman in Shanghai, work in a call centre in Mumbai, be a chef in a restaurant in Sao Paolo or be tasked with organising shipping contracts in Kuala Lumpur. Their incomes would, in purchasing power terms, put them squarely in the lowest socioeconomic quintile in developed countries. They are poor relative both to the middle classes in their own countries, and to citizens of the developed world. Yet they are doing well, compared to their parents and some of their fellow citizens, from globalisation, and the wealth creation story they are part of is powering high rates of municipal or nation economic growth.

The traditional and rural poor are also found in both emerging markets and the least developed countries, although as time passes a greater proportion are expected to reside in the latter. The TRP are those who are not part of the recent success stories in emerging markets. They are goatherds in the remote Gansu province in China, rice planters in rural India or Vietnam, cotton workers in Kazakhstan, fish filleters in Southern Argentina or subsistence farmers in Ghana. Globalisation, at least thus far, has been of little or no material benefit to them. They are the poorest of the three groups, are the least responsible for climate change and the most vulnerable to its impacts.

Changes in numbers and composition of each of these groups will play an important role in the strategic dimensions of climate policy. These changes are hard to predict. For now, note that the analysis presented here is not very sensitive to the numbers in each group – the qualitative strategic analysis would hold regardless of whether the fraction of the world's population in each group remained the same, or even if the fractions were halved or doubled i.e. the basic tensions outlined here would remain unless the number of people in one of the groups essentially disappeared. This would be the case if any of the following happened: (1) the industrialised world finally did manage to solve its long-standing and surprisingly persistent issues with relative poverty (while maintaining high growth and average standards of living); (2) AUP incomes and quality of life managed to approach those of either the rich in poor countries or the rich in rich countries, and hence the people who currently make up the AUP managed to escape both absolute and relative poverty; or (3) improvements in standards of living among the world's very poorest were so successful that absolute poverty was essentially eliminated. This is of course the ultimate aim of much of development policy, and while it is a very laudable aim, it remains a long way from being achieved.

Nevertheless, changes to current ratios and numbers in each of these groups are strategically relevant since they bear on the relative bargaining power of the three groups. Since the most likely outcome of patterns of economic

development in the next fifty years is probably a shift of demographic mass from the TRP into the AUP, the central thesis of the paper – that the cumulative emissions of the GEMs matter more than those of any other single group and that the central trade off in climate change is between different members of the developing world – is, if anything, likely to become even more starkly evident.

We justify the separation between AUP and TRP in this case because, in the realm of energy consumption and climate change, the interests of the AUP – those doing well out of recent patterns of economic growth – are fundamentally different from those in the TRP, even though large numbers of members of both communities may live within the same nation state, and membership of the communities is in flux as intrastate migration moves specific individuals between groups (Du et. al., 2005).

The demarcation between the AUP and TRP groups is rough, even blurred; what they have in common is that their income is low compared with middle class developed world standards, but they are diverse in many ways – age, nationality, literacy and educational attainment, sector of employment, cultural practices and so forth. The three groups differ in terms of how they are benefitting from recent currents in global economic development, their patterns of carbon dioxide emissions, and by the impacts of climate change they and their communities might expect to bear.

[Insert Table 3 about here]

Table 3 provides a qualitative and impressionistic reading of how each of the groups fare, intertemporally, under each of the three scenarios described in section 2 above: + indicates that they benefit, ~ that the policy has little effect on them, and – indicates that they suffer a welfare loss. Doubled symbols indicate that the benefit or loss might be expected to be particularly large. One could of course argue about the details of the assignation of the symbols within the boxes: one might for instance agree with the technological optimists who believe that "North leads" will lead to a green boom in developed countries, and that mitigation, far from representing a cost, is actually going to be a benefit. One could also argue that the damages under "No deal" may warrant even more minus signs than are currently assigned. These are points over which reasonable minds may disagree.[21] But it would be hard to argue that the basic structure is obviously wrong, and, especially in view of the analysis emerging from the preceding section, that there is no

[21] A defence of the assignations of +, –, ~ is presented in Appendix 1.

tension between the AUP's interests now and TRP's interest later (the blue boxes).

The basic point in table 3 is simple. Regardless of the scenario, the interests of AUP now are in conflict with those of TRP later[22]. This is relevant for climate damages and historical responsibility since the climate response broadly scales with cumulative emissions (Allen et al., 2009, Matthews et al., 2009). This scenario – and related A1-family scenarios – is often taken as being broadly representative of "business as usual" without emissions reductions, corresponding to the "No Deal" case here.

Reasonable minds may again disagree over some of the details regarding the structure of emissions under business as usual, but the basic story is not contentious: as emerging markets grow and embed the sorts of energy infrastructure currently seen in the North, their emissions will more accurately reflect global demography (though not entirely). As section 2 has demonstrated, the bulk of unabated climate change – and the resulting damages – this century will be driven by emerging market economy emissions, and even if the North undertakes a radical decarbonisation programme to mitigate climate change, this is extremely unlikely to be sufficient to avoid a warming of 2°C without accompanying emissions reduction from the developing world.[23]

This demonstrates that decisions regarding the carbon intensity of economic development in the developing world are first order determinants of the likelihood of dangerous climate change in the coming century. Therefore we have an extremely serious climate change problem – much like a slightly scaled version of the one we fear today – regardless of the behaviour of the developed world.

4. Discussion

4.1 A Mexican stand-off?[24]

How the tension between the near-term interests of the AUP and the longer-term interests of the TRP ought to be addressed is an issue that receives only a small fraction of the attention lavished on climate change. Yet it raises substantive issues, particularly regarding the relative weights of the interests of each group.

[22] Following Schelling (1995) we may choose to consider 50 years' time as our future reference period, but the argument might be expected to hold for any period in the second half of the 21st century.
[23] See Appendix 2.
[24] A Mexican stand-off is described by the Oxford English Dictionary as "a deadlock, stalemate, impasse; a roughly equal (and freq. unsatisfactory) outcome to a conflict in which there is no clear winner or loser". We use it in this broad sense, rather than in the narrow sense of the classic game-theoretic structure.

There are policies and scenarios each group might fear: the IWP's worst near-term (and arguably long-term) scenario is "North leads", while this is the best near-term policy for AUP. AUP might fear "North and GEM action" because this would reduce near-term economic growth, while this scenario secures the best long-run outcome for TRP. Other concerns at the interface between trade policy, climate and development run together to give grounds for worry: the AUP fear protectionist action from the North (spurred by complaints of the IWP such as the recent claim over green jobs in the United States), the TRP fear the AUP pressing ahead with fossil-fuel driven growth and expand their emissions, while the IWP fear the TRP launching an effective moral campaign employing arguments of historical responsibility and colonial guilt that encourages Northern elites into deep unilateral emission reductions without participation from the emerging markets. And so on. There is a metaphorical sense in which this is a little like the closing scenes in the classic Sergio Leone film *The Good, The Bad And The Ugly*: three mutually suspicious protagonists trapped in a strategic deadlock.

The likelihood of the world drifting into a stalemate on climate change is not diminished when one includes other politically contentious factors related to but not identical with climate change, such as "unfair" competition in trade, protectionism, political instability, lack of trust in other countries' institutions, population concerns and so forth.

There are a couple of possible objections to this line of argument. One would be to place great faith in the second fundamental theorem of welfare economics: given that, in many instances, many members of AUP and TRP live in the same nation states, there is in principle no reason that the asymmetries in welfare that arise as a result of emissions-related policy cannot be mitigated by lump-sum transfers. Alternatively, one could argue – following [Schelling, 1983] – that returns on investments made in boom times could be stored for later such that the currently developing world would be better able to adapt to climate change as it happens.

Yet these sorts of arguments are undermined by most of the currently available evidence: rapidly industrialising societies are unusually bad at sharing gains within society (Kuznets, 1955); furthermore, arguments that we can save up and adapt to climate change as it emerges run counter to almost all recent studies of the expected impacts of climate change (Stern, 2007; Arrow 2007; Tol, 2008), which indicate that adaptation possibilities are limited once temperatures (and other variables) exceed key thresholds. Finally, while for many countries there are significant communities of both AUP and TRP within national borders, the world's poorest states are currently populated

almost entirely of TRP, rendering moot arguments about lump-sum or inter-temporal redistribution.

The strategic deadlock model answers the question: "why has so little been achieved on climate change?" We argue that this model provides some additional insight to the traditional and much simpler explanation that we simply face a global public goods problem where all nations have an incentive to free ride on emission reduction efforts by others, since it picks out incentives, strategic position and justifying arguments common across broad groups of countries.

Of course, the realpolitik turns on other factors. One of these is power; and here the three sets of countries (North, GEMs, ROW) find themselves in very different situations. Notwithstanding the impressive economic development in the GEMs over the last couple of decades, the North, taken as a whole, still represents by far the dominant power bloc. The GEMs have narrowed the gap faster than was anticipated in the late 1980s, but remain concerned by Northern hegemony. The ROW has limited leverage compared to the other two groups.

The question of exactly whose interests are represented by climate change negotiators is another important caveat on the strategic issues set out in this paper. It would be naïve and simplistic to believe that negotiators' behaviour is perfectly aligned with, perfectly opposed to, or perfectly orthogonal to the interests either of "the poor" or "the powerful", or of sectoral interests such as NGOs or the fossil fuel lobby. Negotiators face numerous pressures: economic, popular, moral, strategic and political, to name a few. There has been considerable speculation regarding which of these pressures come to dominate proceedings, and it is hard to see at all clearly through the haze of claims and counter-claims in attempts to piece together negotiators' "real" motives. We claim no special skill at reading negotiators' minds. We simply note that: (1) in public, countries justify their positions on climate change mitigation issues by reference to notions of fairness, and that these notions often turn on the interests of vulnerable people; (2) unless these public declarations are completely irrelevant, or cruelly ironic, then the interests of vulnerable groups are playing some strategic role in negotiations, even if this is largely decorative. If these propositions are both reasonable, then the details of negotiators' "real" interests do not derail the analysis presented here.

4.2 A low-carbon race?

But this pessimistic lens is not the only way to view the strategic dimensions of this problem. The groups also want things from each other, too. They want access to new markets, investment opportunities, political stability, reliability in international relations, good global citizenship. The major industrial transition to a low-carbon economy offers many of these desirable objectives, and what looks like a potentially vicious circle from some angles can appear to promise a potentially virtuous circle from another.

Interestingly, rather than a discussion about a "stand-off", an increasing proportion of the rhetoric in domestic narratives within the EU and the US refers to a "race to compete" in the low-carbon world. In July 2010, a coalition of CEOs of large European companies wrote to support the ministers of the United Kingdom, Germany and France who are pushing for a 30% reduction in emissions by 2020. The CEOs argued that without such a target, "Europe might lose the race to compete in the low-carbon world to countries such as China, Japan and the US".

The US President and some Democrat and Republican politicians have engaged in similar discourses. For instance, President Obama has stated that "the nation that leads the clean energy economy will be the nation that leads the global economy. And America must be that nation." (State of the Union, 2010).

Senior Chinese officials are also beginning to make similar claims. For instance, the Senior Economist at the Chinese Ministry for Environmental Protection, Dr Hu Tao, has been reported as saying that the reason for China's success in clean energy is that "the leadership has a clear concept – to lead the next industrial revolution." (ABC Carbon, 2010). China's twelfth "Five Year Plan", covering 2011-2015, identifies seven "strategic emerging industries", of which five are relevant to growth in low-carbon markets – electric vehicles, energy saving and environmental protection, low-energy lighting, smart grids and ICT, and investment in new energy (wind, hydro, solar etc.) over the period may total US $1.5 trillion (Hannon et. al., 2011),.

Many reasons are given to justify jostling for position in a low-carbon economy, including claimed benefits from technological leadership, to beneficial shifts in geopolitical and economic power,[25] to improvements in the balance of payments. Furthermore, it is politically relevant that renewable energy appears to have a higher proportion of labour costs than fossil energy,

[25] Eras of rapid technological progress in industries such as energy generation have sometimes driven changes in the relative economic strength of countries. For example, Great Britain leapfrogged The Netherlands in the eighteenth century due to being the first movers in the Industrial Revolution and the US overtook Great Britain in the late nineteenth century through the adoption of mass market production technologies.

implying that there may be a substantial number of "green-collar" jobs to emerge. For instance, it is claimed that investment of US $80 billion under the Recovery Act in the USA may generate 800,000 jobs in clean energy.[26]

Given the results from our three scenarios above, GEMs may have a self-interest in triggering and accelerating a race to a low-carbon global economy; their TRP appear to have the most to lose from a slow transition, and the most to gain from a fast transition. If shifts in competitive advantage imply that the AUP may also benefit from the transition, through the creation of new clean energy markets and "green industrial" activity, then the Mexican standoff is avoided and mitigation action might result. This is not to deny the incentive to free ride, but it is also worth noting that this incentive is weaker in larger countries, and the GEMs collectively comprise a substantial proportion of the global population. If coordinated GEM action triggered the North to implement their suggested commitment of reducing emissions by 80% by 2050, this would provide larger markets for GEM low-carbon products.[27]

In the short term, both dynamics may play out in different domains. The Mexican standoff could prevail in international climate negotiations for another 5-10 years, while a low-carbon race simultaneously develops between firms and countries holding the view that as the transition to a low-carbon economy is highly likely to happen at some point, in some fashion, they prefer to shape the strategic landscape rather than react to it.

5. Conclusion

Moving from a two-agent model to a three-agent model of climate change yields interesting results for at least two reasons. The first reason is that the tension between the interests of the AUP and those of the TRP emerges naturally from the fact – obvious but seldom discussed – that climate change damages in the latter half of the 21st century are largely a function of emerging market country emissions. The second reason is that this tension fits with the disquiet some national leaders from predominantly TRP countries are beginning to express with the AUP-focussed positions expressed by countries like Brazil and others within the G77. More positively, it also fits with recent rhetoric about a technological race towards low carbon technology.

[26] These comprise 722,000 jobs in renewable energy and advanced energy manufacturing (253,000 from direct government spending, and 469,000 from leveraged private investment), and 104,000 in smart grid investment. This does not include jobs from investments in advanced vehicles and batteries or energy efficiency. See White House (2009). However, all such claims should be viewed with some scepticism, particularly analyses that fail to clearly distinguish between gross and net job creation (by ignoring job destruction in the former case).

[27] HSBC (2010) claim that by 2020, the low-carbon market could be worth 2.7 trillion dollars if governments go a reasonable way beyond their COP 15 commitments, and still around 2 trillion dollars if governments keep their COP 15.

Exactly how these tensions will be resolved presumably depends on a fairly delicate balance of forces. The best way to secure the virtuous circle is likely to be to create flexibility in bi-lateral and multi-lateral negotiations so that more things of strategic value (market access, investment funds, development assistance) are in play. Kyoto's narrow framing the problem purely in terms of greenhouse gas emissions reductions this decade or at a couple of anchor points in the future probably has restricted this, since it discourages agents from doing mitigation-for-trade deals. Yet these sorts of additional components might well be an effective way of greasing the wheels of climate negotiation, and inevitably side deals have already long been a feature of the informal negotiations.

The issue of how national policymakers should weigh the competing interests of each of these groups of poor is difficult. How should an OECD national government weigh the interests of its IWP vs. those of the AUP and TRP? The familiar tension between realism and competing schools of thought presumably comes to the fore. In the case of developing countries, there are the additional complications of the tension between the interests of today's AUP, whose voices are presumably becoming amplified by their recent economic empowerment, and those of tomorrow's TRP (who have a weaker voice).

Though there are of course a very wide range of views on how to balance these interests, many argue that we ought to give special considerations to the interests of the very poorest. In this case, this would suggest that we pay special attention to the interests of TRP. Across time, the interests of the TRP are best protected by "North and GEM action": this is the only of the three scenarios that secures welfare enhancements in the "later" period, even though a global mitigation effort would damage TRP's interests now, through increased transport costs and reduction in demand for their goods and services as an effective price on carbon starts to bite.

The analysis presented here is of course impressionistic, and it suffers from considerable limitations. In particular, the scenarios sketched out above, while broadly illustrative of suggestions under consideration, lack subtlety. The two-period description, while simple and intuitive, obscures important inter-temporal compromises. Since compromise regarding the timing and scale of developing country participation is likely to be the key to finding a workable solution to the problem, these are not minor omissions. In spite of these limitations, we think this argument makes three points that ought to remain of interest: (1) that there seems to be an unavoidable tension between the interests of the AUP now and the TRP later, and; (2) that the only way to protect the interests of the very poorest people in the world, their

communities and their descendants, is through early, if not perhaps immediate, action by developing countries; (3) that given historical experiences of technological leapfrogging and high-level rhetoric surrounding a low-carbon race, such action might be more likely to occur than many people think.

Appendix 1: Justification of values in Table 3

The baseline against which the values are assigned is something like an SRES A1FI scenario, treated here as a BAU reference scenario making best-guess assumptions regarding climate sensitivity, ocean heat uptake and assuming something like the sorts of damages functions considered by the Stern Report. This choice is made to bring out the upfront costs of mitigation policy in the "now" period, to bring out the damages we might expect under a BAU scenario, and to show that the TRP stand to gain most (in the later period) from strong early mitigation.

No deal

Under this scenario, all three groups continue much as they are, namely with IWP and TRP enjoying the sorts of economic growth broadly consistent with SRES A1FI scenario, while AUP are enjoying economic boom times, though this is accompanied by higher than expected emissions of GHG. In the later period, following the arguments that underpin the Stern Report (2007), we assume that virtually all countries face net costs from climate change in the late years of this century. These impacts are, of course, expected to be felt most severely among the world's poorest, namely among the TRP.

North leads

In this scenario, the North undertakes strong early action, with business-as-usual from GEMs and ROW. In the near term, the IWP are adversely affected as industry decamps from Northern regimes, where there is a high effective price on carbon, to Southern regimes, where there is not. This assumes, perhaps unrealistically, that there are no border tariffs to reduce this incentive. Under the scenario envisaged, this amplifies the already impressive economic growth with which AUP are associated; TRP continues much as they have been, though one could argue that some of the benefits that accrue to AUP also trickle down to TRP through enhanced demand for goods and services, and through the development of infrastructure that is beneficial to both groups in those societies which possess significant communities of both AUP and TRP. For present purposes this is taken as a second order effect; it may not be, of course, but it nevertheless fails to remove the principle line of tension which is between AUP now and TRP later. In the later period, the picture is very like that under no deal, since cumulative emissions in 2100 due to emissions from the industrialising world amount to around 70% of all cumulative emissions; assuming the industrialised world has some inertia in its response, this would imply climate damages >80% of those expected under BAU, which lead to a similar level of damage to global societies by the late years of this century; and if not by then, then perhaps by the early 2100s, since

extended BAU in the global South would really just delay the sorts of impacts considered by Stern (2007).

North and GEM Action

It is assumed that this imposes costs directly on IWP and AUP since they face a carbon price that bites if not equally, at least significantly on both communities. But in this instance, because the mitigation burden is shared, there is no incentive for firms that employ IWP to emigrate to regimes with a softer mitigation policy. TRP feel this through reduced demand for their goods and services and through an effective carbon price in the North and the GEMs which raises transport costs. In the later period it is assumed that the avoided climate damages that accrue through the mitigation policy roughly offset the costs of early mitigation; AUP and IWP have basically followed an "optimal path" in the sense that they have paid an integrated price on carbon that roughly offsets the damages from climate change by the last decades of this century. TRP are better off than they would have been, since they face weaker climate-related damages than they would under the baseline scenario. This is the only scenario under which they are ahead in comparison to the baseline.

Appendix 2: The MAGICC model

The MAGICC model is a simple climate model, described as an "upwelling diffusion energy-balance model" which also incorporates a carbon cycle allowing for system feedbacks (Wigley and Raper, 2001).

As a central estimate, we employ a climate sensitivity parameter (which measures the change in temperature for a doubling of CO_2) of 3ºC, based on the most recent IPCC report (Meehl et al., 2007) which concluded that "equilibrium climate sensitivity is likely to lie in the range 2–4.5°C, with a most likely value of about 3°C." For the ocean diffusivity parameter, a parameter of 2.3cm^2/s was used, broadly following Wigley (2005). For the carbon cycle component incorporating positive feedbacks in the carbon cycle, we used the medium option provided by MAGICC.

MAGICC reports expected temperature increases relative to a 1990 baseline. Implicitly, there has been a 0.4°C increase in global average temperatures between pre-industrial times and 1990. This is consistent with the IPCC 4th assessment report which provides a central case increase in global average temperature from pre-industrial times to 2000-2005 of 0.8°C (within a range of 0.6 - 1ºC) and the results from Brohan et al (2006) – the most recent relevant study reported in the IPCC report – which estimates that the global average temperature increase per decade from 1979 to 2005 has been 0.268°C. The Brohan et al (2006) results suggest that there was a 0.4°C between 1990 and 2005, implying a further 0.4°C between pre-industrial and 1990.

Tables and Figures

Table 1 North, GEMs and ROW classification

Grouping	*North*	*GEMs*	*ROW*
Countries included	Australia, Canada, France, Germany, Italy, Japan, Russia, United Kingdom, USA	Argentina, Brazil, China, India, Indonesia, South Africa, Korea, Mexico, Turkey	All other countries

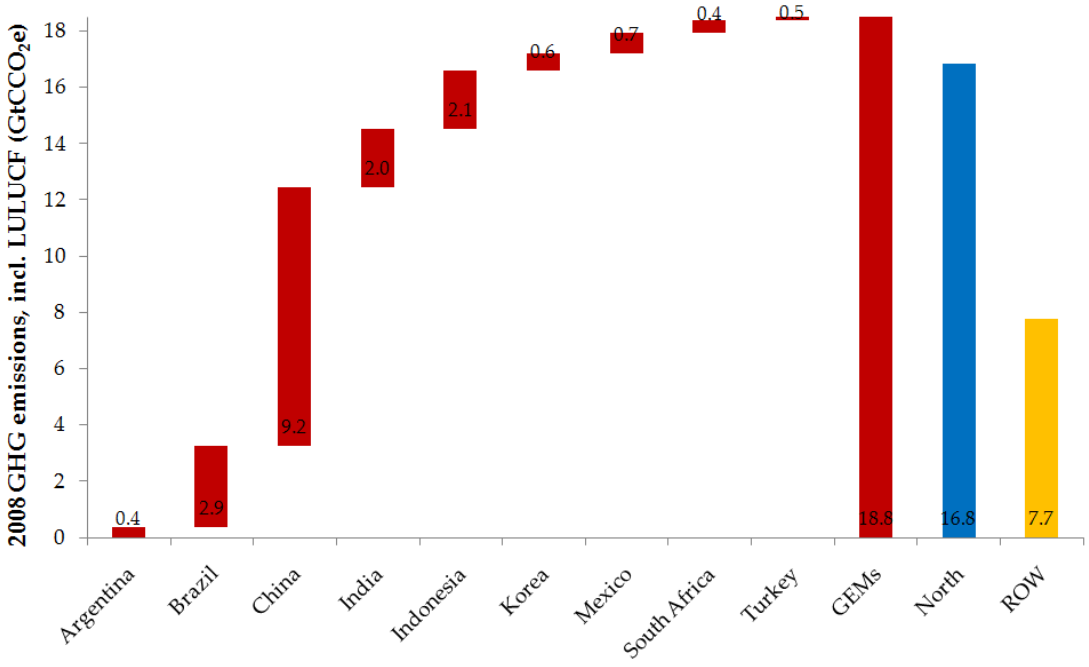
Table 2 Scenario results

Variable	*No deal*	*North leads*	*North and GEMs joint action*
Average global temperature increase in 2100 (on 1990 levels), °C	4.6	3.9	2.7
Atmospheric concentrations of CO_2, parts per million	905	730	550
Sea level rise in 2100, cm above 1990 levels	48	41	32
Economic damages in 2100, % of GDP in GEMs:	3.0	2.3	1.5

Table 3 Stylised impacts of the three scenarios on the poor

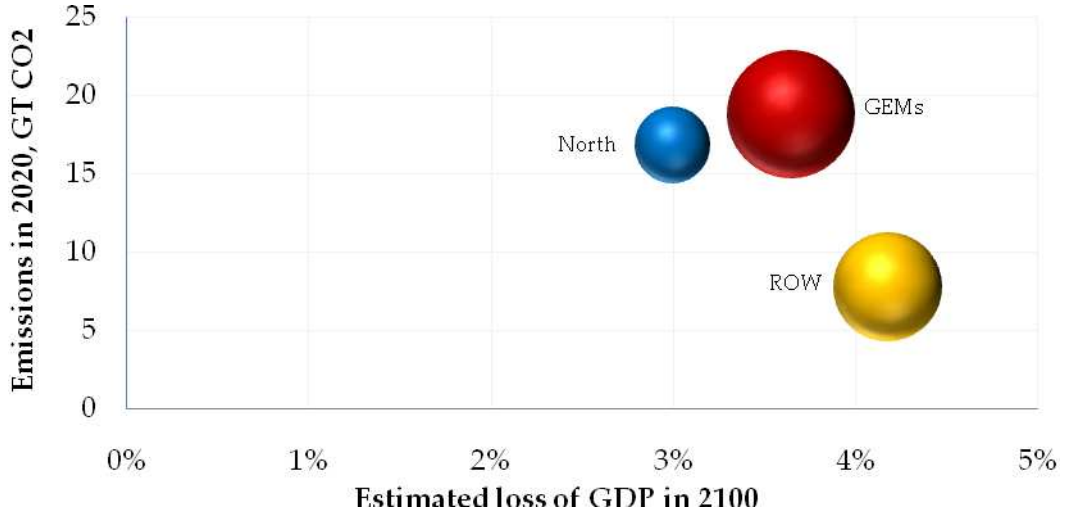
		Now	**Later**
No Deal	IWP	~	-
	AUP	+	-
	TRP	~	--
North Leads	IWP	--	-
	AUP	++	-
	TRP	~	--
North and GEM action	IWP	-	~
	AUP	-	~
	TRP	-	+

Figure 1. GEMs accounted for more emissions than G20 Annex 1 countries in 2008



Source: (G20 Annex 1) UNFCCC; (GEMs and Rest of World) World Resources Institute, projections from 2005 data

Figure 2. GEMs have an incentive to address climate change, and the scale to make a difference



Note: Bubble size proportional to 2008 population

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