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Responsibility for Climate Change, By the Numbers

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Executive Summary

This paper examines the data on responsibility for climate change due to past emissions. It addresses two aspects of responsibility. First it shows that the data present a mixed picture. By some measures, developed or wealthy countries are responsible for most past emissions while on other means, responsibility is spread widely with poor countries responsible for a majority of emissions. The differences in the measurements are due two factors: whether the data uses a comprehensive measure of emissions and the extent to which the data is aggregated into regions. The more comprehensive the measure and the less aggregation, the more that poor countries are responsible for past emissions. Second, it examines how theories of responsibility apply to the data. The most well developed theories of responsibility that impose an obligation on injurer to make a payment to victims are the theories underlying tort law. The paper shows that standard fault-based tort theories cannot be used to support climate change obligations. Instead, the theory would have to rely on strict liability, give up on the normally required connection between injurer and victim, and accept undesirable distributive consequences. Moreover, it would not be a basis for ongoing obligations to reduce emissions because relative emissions of nations will change over time. Instead, were such a theory of obligation to be sustainable, it could only be used to support a one-time payment for harm.

Responsibility for Climate Change, By the Numbers

David Weisbach

The conventional account of greenhouse gas emissions is that wealthy countries are responsible for climate change and developing countries are the victims. As a result, developing nations such as China and India argue that they should not have to reduce emissions; they are not responsible for the harms and should not have to pay for them.[1] Brazil has gone so far as to propose a mathematical formula for calculating responsibility and proposed that obligations under the Kyoto Protocol be allocated based on the resulting calculations.[2] Although this formula was ultimately withdrawn, the United Nations has commissioned scientists to study and refine the formula for use in future negotiations.[3] Commmentators and analysts agree.[4] Peter Singer, for example, put it this way:

> To put it in terms a child could understand, as far as the atmosphere is concerned, the developed countries broke it. If we believe that people should contribute to fixing something in proportion to their responsibility for breaking it, then the developed nations owe it to the rest of the world to fix the problem with the atmosphere.[5]

The notion of responsibility resonates deeply; it makes sense that developed nations are responsible for past emissions because they are the major users of fossil fuel energy; the conclusion inevitably follows.

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[1] They make a variety of other arguments as well. For example, they argue that poor nations should have a right to develop and emissions cap would unfairly keep them poor. I focus here only on responsibility. See Eric Posner, Cass Sunstein, and David Weisbach, Climate Change Justice (forthcoming) for a discussion of other arguments about who should have to pay for emissions reductions.

[2] The Brazilian Proposal can be found at unfccc.int/resource/docs/1997/agbm/misc01a03.pdf. For a summary of the history and impact of the Brazilian Proposal, see Emilio La Rovere, Laura de Macedo, and Kevin Baumert, *The Brazilian Proposal on Relative Responsibility for Global Warming*, in Building on the Kyoto Protocol: Options for Protecting the Climate (Kevin Baumert, ed. 2002).

[3] The United Nations Framework Convention on Climate Change delegated additional research on the Brazilian Proposal to its Subsidiary Body for Scientific and Technological Advice, which in turn convened a scientific panel to evaluate the proposal. In 2007, this panel completed a series of reports on the proposal, which can be found at unfccc.int/methods_and_science/other_methodological_issues. An ad hoc group of scientists working on this research formed MATCH (Modeling and Assessment of Contributions to Climate Change). Their results can be found at match-info.net. Another group of scientists have created FAIR: Framework to Assess International Regimes for differentiation of commitments, found at www.mnp.nl/en/themasites/fair.

[4] See, for example, Steve Vanderheiden, Atmospheric Justice, A Political Theory of Climate Change (2008); James Garvey, The Ethics of Climate Change, Right and Wrong in a Warming World (2008); Peter Singer, One World (2004).

[5] Peter Singer, One World (2004).

This paper examines responsibility for climate change. The paper is divided into two somewhat distinct halves. The first half examines the data on responsibility for climate change. To do this I use data gathered by the World Resources Institute (an environmental NGO), publicly and freely available in their Climate Analysis Indicators Tool (CAIT).[6] The data show that under a wide variety of measures, responsibility for greenhouse gas emissions is spread widely, with developing countries contributing as much as developed countries and with some poor countries at or near the top of all measures. For example, comprehensive measures of contributions to the stock of greenhouse gases in the atmosphere show that both developed and developing nations top the list. Of the countries at or near the top of the list, developing countries emit as much or more as developed countries. Similarly, if we measure emissions on a per capita basis or an intensity basis, many poor countries are near the top of the list. The Brazilian formula and more complex variants produce the same result. Simple stories about responsibility are simply not true.

These results immediately raise the question of why the measures presented here differ from the standard account that developed countries are responsible. The standard account is an artifact of the way that the emissions data is aggregated into regions. Poor countries with high emissions are averaged with poor countries with low emissions so that they do not show up in the data. Moreover, narrow measures of emissions, such as emissions from energy use only, are often used, and poor countries often do better on these narrow measures. There are no justifications for aggregating countries by region. The justifications for using narrow measures of emissions relate to availability of data and cannot be used to support claims about actual responsibility.

The second half of the paper addresses whether the measures of responsibility so far proposed are consistent with ethical theories of responsibility. The claim made by Brazil and others is that one party has harmed another and, therefore, has an obligation to make restitution. This is an ethical claim, not a scientific claim. The data that is gathered and used must be supported by an ethical theory of responsibility and of obligations to make payments.

There are many theories of responsibility and I cannot canvas them all. To keep the project manageable, I will focus on theories that have been invoked to impose an obligation to make a payment because of a past action; these are theories of tort law. The question is whether the theories of responsibility underlying tort law support the types of calculations that have been

[6] Found at cait.wri.org. The data presented here is consistent with the data in CAIT as of November 10, 2008.

done and the types of claims that been made in the climate context. To be clear, I am not claiming that there need be an actual tort claim against emitting nations. Such claims are subject to numerous problems, many of which have been discussed elsewhere.[7] Instead, I look to tort theories as the best theories for supporting the types of obligations that are claimed in the climate change treaty context.

There are two broad approaches to tort obligations. The first is grounded in notions of responsibility or corrective justice. It focuses on both assigning responsibility for blameworthy acts and compensating victims of those acts. The second focuses on the incentives created by the tort system, viewing the tort system as a sort of Pigouvian tax on harm-causing activities. Under the latter approach, fault, and whether fault is even required, are determined instrumentally, and victim compensation, as we will see, may be positively harmful. The two approaches overlap in many cases, but also can produce distinct results in other cases.

I will examine how past emissions fit into each of these notions of tort obligations. Responsibility notions, I will argue, do not work very well in the climate change context. There are four problems. First, there is no feasible way to measure responsibility. The measurement of responsibility depends on the underlying theory of responsibility. In most theories of responsibility, dating back to Aristotle, an actor is responsible only where he is at fault, where he is culpable. Basing emissions calculations on fault, however, is a morass. The data cannot be used to determine which emissions are culpable and which ones are not, and they are unlikely to ever be able to do so. They do not, for example, help us determine when or whether it is a problem to burn fossil fuels to heat your home if you live in a very cold environment, what size car you can drive, whether it is ethical to eat meat, and whether it is ethical to increase the population by having, say more than two children. Carbon emissions are part of almost everything we do, and any attempt to determine fault would be perilous.

An alternative would be to base the claim of responsibility on a strict liability notion. We would, under this approach, count all emissions, regardless of whether they are harmful. These theories have limited acceptance even in the environmental context where they are most prevalent. Because we would not have to determine fault, using a strict liability approach would reduce the data requirements, although not entirely. We would still need to determine a starting date – strict liability can be (although rarely is) imposed fully retroactively, only prospectively,

[7] Eric Posner, Climate Change and International Human Rights Litigation: A Critical Appraisal, 155 U. Pa. L. Rev. 1925 (2007).

or somewhere in between. We would also have to be able to determine the size of any offsetting benefits created by emissions. That is, if an action imposes both harms and benefits on third parties, we care about the net effect.[8] Synthetic fertilizers, for example, were invented in Germany and allow many countries to feed vastly greater numbers of individuals and also reduce deforestation by increasing the productivity of land. To determine Germany's responsibility, we would have to determine the size of the resulting offset and make similar calculations for other sorts of offsets. Similar issues arise for population and immigration issues.

Second, responsibility-based notions also normally require a close connection between victims and injurers. Most of the victims of climate change, however, are not yet born and many of the injurers are already dead. Imposing an obligation on, say, 20-year olds today risks imposing obligations on people who are not primarily responsible for the injury and helping (by not imposing obligations) those who are not injured.

Third, given the data on emissions, responsibility-based arguments would also have bad distributive consequences because many poor nations are high emitters. In many cases, a strict application of these notions would impose crushing obligations on many poor countries. Distributive concerns such as these can be separated from claims of responsibility; being poor does not excuse you from tort liability so someone who believed strongly in responsibility would not care about the potentially crushing burdens. Nevertheless, many people believe that using a responsibility measure would also have good distributive effects. This may not be true; a treaty that seeks to have good distributive effects would in many cases work directly contrary to a treaty that is based on responsibility.

Finally, a claim of responsibility has to somehow incorporate ongoing emissions and, in particular, changes in emissions patterns that are likely to take place in the future. So far, responsibility-based claims take a snapshot of the past and use this to make claims about ongoing future actions. Unless the obligations are adjusted over time to account for new patterns of emissions, however, this approach will not accurately measure responsibility.

An alternative approach to tort obligations is to focus on incentives. The idea is that imposing an obligation to pay for harm forces actors to internalize the costs of their actions. This approach leads to somewhat different conclusions from the responsibility-based approach. An

[8] If the harms and benefits occur in different spheres, many people would not net them. For example, if I engage in a horrible crime but am otherwise a good person, I would still be fully responsible for the horrible crime. Where both harms and benefits are a result of a single action, netting makes sense and these are the cases referred to in the text.

incentives-based approach is pragmatic and forward looking in addressing climate change, attempting to reduce emissions at the lowest possible cost. Rather than focusing on emissions from 50 or 100 years ago, or more, an incentives-based approach would focus on how structuring obligations under a treaty affects the decisions of actors today. In particular, future treaties musts not give benefits to nations that resisted earlier treaties. The focus of an incentive-based approach, therefore, would be on recent climate-favorable or climate-unfavorable activities, rewarding nations that have reduced emissions in the now or perhaps recent past. Moreover, wealthy nations have a far greater ability to act now and for many reasons, likely put a higher value reducing climate change than do poor nations, which means that they should bear much of the burden in reducing emissions. But these considerations are entirely separate from considerations of responsibility, which, I will argue, are simply too ambiguous given the mixed data, for resolving a problem of this importance.

The two sections of the paper follow the two pieces of the argument. Section I considers the data on past emissions and the problem of aggregation. Section II considers theories of responsibility. Section III concludes.

I. The Numbers

Climate change is caused by a number of different greenhouse gases. Carbon dioxide is the most important greenhouse gas, but the Kyoto Protocol governs five additional gases (methane, nitrous oxide, PFC's, HFC's, and sulfur hexafluoride). The Intergovernmental Panel on Climate Change (the IPCC) lists around 60 gases that contribute to climate change (the six gases or categories of gases covered by Kyoto plus ozone depleting chemicals, fluorinated ethers, perfluoropolyethers and certain hydrocarbons). Moreover, land use change, such as deforestation or engaging in agriculture, changes the climate, for example, by changing the ability of the earth to absorb carbon dioxide, by changing the reflexivity or albedo of the Earth's surface, by the release of gases from fertilizer, and by release of gases from tilling the soil. Aerosols have complex effects because they change the albedo and because they are greenhouse gases. Any good measure of responsibility should consider all sources of climate change, to the extent possible.

A unit of one greenhouse gas will typically have a different effect on the climate than a unit of another greenhouse gas; different gases have different abilities to absorb various

wavelengths of light and different levels of stability in the atmosphere. The IPCC has developed a method of comparing all of the various gases on a common metric, known as the Global Warming Potential. It is a measure of the contribution to climate change over 100 years compared to the contribution of a unit of carbon dioxide, known as CO_2-eq. All of the data used below (to the extent gases other than carbon dioxide are considered) uses CO_2-eq as the measure of emissions.

A. Data sources

The data on emissions varies considerably, both by source and by the time period. The World Resources Institute is an environmental think tank whose mission is to protect the Earth's environment and, in particular, "protect the global climate system from further harm due to emissions of greenhouse gases."[9] It developed the Climate Analysis Indicator Tool (CAIT) as a database of information on greenhouse gas emissions. CAIT is publicly and freely available. CAIT includes information on socioeconomic factors such as health, income, and education, as well as natural factors such as land size, population, and relative heating and cooling needs in addition to data on emissions. All the data used here is from CAIT.[10]

The sources of the data used by CAIT are discussed extensively on their website, and I highlight here only the most central issues.[11] In general, CAIT draws data from a number of different sources, most notably the carbon inventories required for developed countries under the United Nations Framework Convention on Climate Change (the UNFCCC). CAIT supplements the UNFCCC data with additional sources to fill in gaps and reduce uncertainties.

Carbon dioxide is the most important greenhouse gas and also, fortunately, is where the data is the strongest. Starting in 1990, developed countries (so-called Annex I countries under the UNFCCC) were obligated to submit greenhouse gas inventories using standardized and transparent methodologies, so the data for these countries since 1990 is generally good. Developing countries have fewer reporting obligations and the data is correspondingly less

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[9] See wri.org/about

[10] There are a number of other similar sources for emissions data. EDGAR (Emissions Data for Global Atmospheric Research) provides the data used in the IPCC chart reproduced below. See http://www.mnp.nl/edgar/ . The Carbon Dioxide Information Analysis Center collects emissions data. See http://cdiac.ornl.gov/. The IPCC data is publicly available on their website. I chose CAIT because of its completeness and its ease of use.

[11] See http://cait.wri.org/downloads/cait_ghgs.pdf

reliable. Some have submitted inventories of emissions from which one or two years of data can be derived but others have not yet submitted any data.

Emissions data for years prior to 1990 have to be stitched together from a variety of less accurate sources including the International Energy Agency and the Energy Information Administration. These sources, however, only extend the coverage back until the 1960's at best. To go back to the beginning of the industrial revolution, as will be necessary under many measures of responsibility, CAIT relies on data from the Carbon Dioxide Information Analysis Center, which has data back to 1751.[12] There is no direct data on emissions going back this far. Instead, the data is derived from historical records of coal and oil production as well as imports and exports, on the theory that any extracted fossil fuel that was not exported must have been burned locally. As one might expect, the data gets less reliable when it goes back further in time.

All of the data on CAIT (and all other major databases on carbon dioxide emissions) allocate emissions to the physical location of the emissions. For example, suppose that exporting country emits carbon while producing a product which is ultimately consumed by individuals in an importing country. The emissions physically come from the exporting country and, as a result, all of the emissions are allocated there. It is not at all clear that this is appropriate and an alternative measure might use the place of consumption or possibly some mix of production and consumption. There, are however, no comprehensive consumption-based measures available, to my knowledge.

Non-CO_2 gases make up about 40% of global emissions but data for emissions of these gases is sparse. CAIT currently has data for five additional greenhouse gases (CH_4, N_2O, PFC's, HFC's, and PF_6) for three years, 1990, 1995, and 2000. The problem arises because emissions of these gases are from many dispersed sources where measurement is difficult. Major sources of CH_4 and N_2O for example, include enteric fermentation in livestock, rice farming, soil tilling, landfills, and fugitive gases from coal mining. HFC emissions arise from leakages of systems such as air conditioning. Even for developed countries following UNFCCC protocols, the data is uncertain. For example, fugitive emissions of methane are, by their nature, hard to measure. For developing countries, the uncertainties are far worse. Where possible, the tables below use

[12] CAIT itself only includes data back to 1850.

emissions from all six Kyoto gases, but in many cases, the data is unavailable and the tables list only emissions from carbon dioxide from the combustion of fossil fuels.

CAIT has data for emissions from land use change dating back to 1950 and up to 2000. They are based on estimates from independent researchers specializing in measuring emissions from land use change rather than on UNFCCC data. As CAIT notes, the errors associated with these estimates are substantial.[13]

One of the more difficult questions in determining greenhouse gas emissions in the past is allocating emissions when countries change their borders. Because many measures of responsibility go back for more than a century, the problem can be significant. CAIT allocates emissions to newly formed countries essentially pro rata. Suppose that a country splits into two new countries. CAIT looks at the relative emissions of the two new countries over the five year period following the split, and allocates emissions prior to the split based on that ratio. Although it is not clear that there is a better method, there are obvious problems with this approach when used to allocate moral responsibility for emissions. For example, suppose that a country ruled by a dominant region forcibly locates highly polluting activities in a subservient region. It is not clear that the subservient region should be held responsible for these emissions. In addition, to the extent physical location is a good measure, the five year post-independence ratios of emissions may be a very poor proxy for the location of emissions in the distant past.

B. *The Standard Numbers*

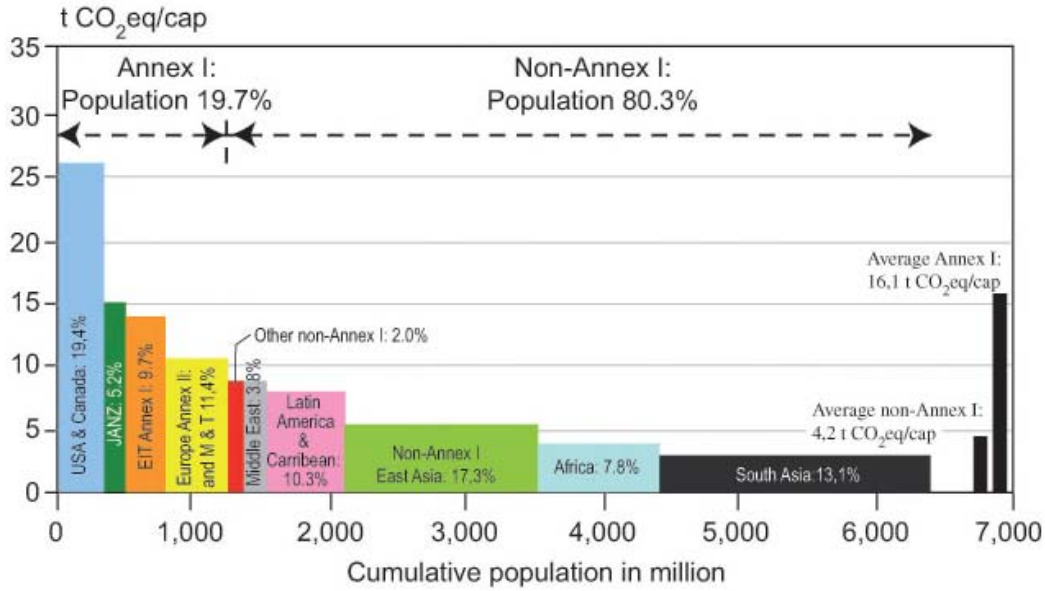
The usual view is that the developing world is responsible for most past emissions. For example, the Pew Center Global Climate Change reports that "[i]ndustrialized countries have been historically responsible [for climate change] since they as a group have some of the highest per capita energy use and also have benefited from emitting vast quantities of greenhouse gases over the last century."[14] Similarly, a paper published by Resources for the Future states that "[d]eveloped countries are responsible for the largest share of cumulative past GHG emissions

[13] These researchers have recently published land use change data going back to 1850, but this data is not included in CAIT and is not used here. These data only provide broad aggregates rather than country-by-country numbers. The data can be found at cdiac.ornl.gov/trends/landuse/houghton/houghton.html

[14] Eileen Claussen and Lisa McNeilly, Equity & Global climate change, The Complex Elements of Global Fairness, Pew Center on Global Climate Change, October 29, 1998.

by far."[15] The United Nations Environment Programme states, "Historically the developed countries of the world have emitted most of the anthropogenic greenhouse gases."[16]

The IPCC present a chart summarizing this view.[17] The chart presents data on per capita emissions of all six greenhouse gases and from land use change in 2004 aggregated into ten different regions. The width of the bars is based on the population in each region.[18] The percentages listed are the region's share of total emissions in 2004.



As can be seen, the developed countries, represented by the UNFCCC Annex I nations, have vastly higher per capita emissions than poor nations, and poor nations in African and South Asia have low emissions but large populations.

The IPCC chart is based on data from the EDGAR database and the International Energy Agency.[19] To confirm the results, I recreated the same chart using the CAIT data for emissions from 2000 using the six Kyoto gases and land use change. The result, while not precisely the same, is qualitatively similar. Below is the CAIT data aggregated into the same regions, although for the year 2000 (which is the most recent year CAIT has data on all six Kyoto gases).

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[15] Marina Cazorla and Michael Toman, International Equity and Climate Change Policy, Resources for the Future, Climate Issue Brief No. 27 (December 2000).
[16] United Nations Environment Program, Vital Climate change Graphics, February 2005, p. 14., found at grida.no/publications/vg/climate2
[17] IPCC, AR4, Working Group III, p. 106, Figure 1.4a.
[18] This chart appears to be original to the IPCC. It is based on data from the EDGAR database.
[19] Available at http://www.mnp.nl/edgar/

Table 1: Emissions Per Capita, IPCC Aggregation

Country	$MtCO_2$-eq	% World Total	Tons Per Person	Thousands of People	% World Total
USA & Canada	7,210	16.58%	23	325,644	5.12%
JANZ	1,943	4.47%	13	151,916	2.39%
EIT, Annex I	3,464	7.97%	11	307,997	4.84%
Latin American and Caribbean	5,124	11.78%	9.9	544,012	8.55%
Europe Annex II and M&T	4,471	10.28%	9.8	467,746	7.35%
Middle East	1,223	2.81%	8.6	155,256	2.44%
Other Non-Annex I	617	1.42%	6.6	95,512	1.50%
Africa	3,515	8.08%	4.4	869,221	13.66%
South Asia	7,380	16.97%	4.1	1,897,053	29.82%
Non-Annex I East Asia	5,692	13.09%	4.0	1,470,890	23.12%

Much of the data above represents the flow of emissions in a single year. The Brazilian formula goes two steps beyond this. The goal of the Brazilian proposal is to determine each nation's responsibility for climate change, not responsibility for emissions; we care about climate change, not emissions by themselves. Although emissions are closely related to climate change, the relationship is not one-to-one. Emissions in any single year do not reflect emissions over time and, because carbon dioxide has a long life in the atmosphere, we have to look at contributions to the stocks not a single year's flows. Then we need to translate stocks into temperature increases, which is not a simple process. Emissions in the far distant past may no longer be in the atmosphere because greenhouse gases have long but finite lives. Emissions in the recent past may not yet have had an effect on temperatures because the climate takes time to react to changes in greenhouse gases. We need a model of the carbon cycle and the climate to do the translation. In effect, the Brazilian approach is to layer a climate model on top of the emissions data to determine how carbon cycles through the atmosphere and the oceans, and how carbon in the atmosphere affects the climate. It proposes to use the resulting climate data as the measure of responsibility.

The Brazilian approach uses a very simple model of the climate. Since then, scientists have used more complex models to calculate the relationship between past emissions and temperature more accurately. Most importantly, the UNFCCC engaged a group of scientists to

study how the calculations could be improved, and this group produced a number of reports and published papers on refinements in the formulas.[20] There is also a body of independent work published in environmental journals that tries to further refine the data by using more complex climate models. [21] CAIT incorporates some of these formulas in its data, including a measurement of contributions to carbon dioxide concentrations and a measure of contributions to temperature increases. It would be fair to say that these refinements produce somewhat different details but that the results are qualitatively the same – they do not change the big picture. The work refining the Brazilian proposal only makes sense if we are to take this approach literally.

C. Alternative views

In this section, I present a number of alternative views of the same data. I start with the simplest data – gross annual flows – and work up to more sophisticated approaches, such as per capita contributions to temperature changes.

Flows

Start with simplest measure: flows of the six most important greenhouse gases plus the effects of land use change. The list of the top 20 emitters in 2000 for the six Kyoto gases plus land use change is presented in Table 2.[22]

[20] See note __.

[21] Niklas Hohne and Kornelis Blok, *Calculating Historical Contributions to Climate Change – Discussing the 'Brazilian Proposal,'* 71 Climatic Change 141-173 (2005); Luiz Rosa, Suzana Ribeiro, Maria Muylaert, and Christiano de Campos, *Comments on the Brazilian Proposal and contributions to global temperature increase with different climate responses – CO_2 emissions due to fossil fuels, CO_2 emissions due to land use change*, 32 Energy Policy 1499-1510 (2004); Michel den Elzen, Jan Fuglestvedt et al, *Analysing countries' contribution to climate change: scientific and policy-related choices*, 8 Environmental Science & Policy 614-636 (2005); Richard Tol and Roba Verheyen, *State responsibility and compensation for climate change damages -- a legal and economic assessment*, 32 Energy Policy 1109-1130 (2004); Simone Bastianoni, Federico Pulselli and Enzo Tiezzi, *The problem of assigning responsibility for greenhouse gas emissions*, 49 Ecological Economics 253-257 (2004).

[22] I look at the top 20 emitters because these are likely to be among the most important nations to include in a climate treaty. As discussed in section __ below, any selective use of data, even if merely for convenience and to help understanding, risks missing important information.

Table 2: Total GHG Emissions in 2000

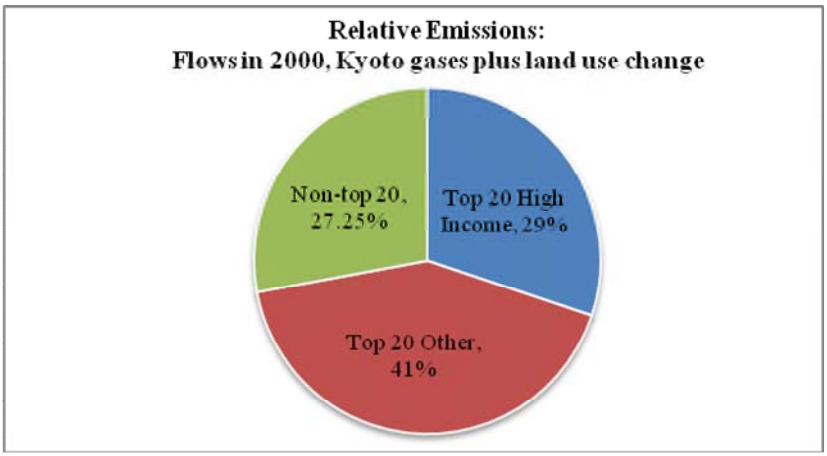
CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 and land use change, in Mt of CO_2-eq.

Rank	Country	MtCO2	% of Total	Tons Per Person	Rank	$ Per Person
1	United States of America	6,443	15.47%	22.8	13	36,451
2	China[23]	4,771	11.46%	3.8	120	5,490
3	Indonesia	3,066	7.36%	14.9	24	3,282
4	Brazil	2,314	5.56%	13.3	33	7,406
5	Russian Federation	1,960	4.71%	13.4	32	9,021
6	India	1,553	3.73%	1.5	168	2,851
7	Japan	1,317	3.16%	10.4	51	27,114
8	Germany	1,006	2.42%	12.2	37	25,945
9	Malaysia	852	2.05%	36.6	5	9,374
10	Canada	766	1.84%	24.9	12	29,136
11	Mexico	671	1.61%	6.8	83	9,385
12	United Kingdom	632	1.52%	10.7	47	29,231
13	France	535	1.29%	9.1	64	26,872
14	Italy	531	1.28%	9.3	62	25,579
15	Myanmar	520	1.25%	11.3	44	1,800
16	Korea (South)	511	1.23%	10.9	45	18,934
17	Australia	508	1.22%	26.5	8	27,840
18	Ukraine	460	1.10%	9.3	61	5,893
19	Nigeria	440	1.06%	3.5	123	959
20	Iran	431	1.04%	6.7	84	6,887

To see the relative contributions of the rich and the poor, divide the list into rich and poor. If we use the World Bank definition of high income (more than $11,456),[24] top 20 emitting high income countries emitted about 29 percent of the total in 2000, while the other top 20 emitting countries make up 41 percent of the worldwide total. Chart 2 illustrates:

[23] Chinese data for 2000 is likely significantly out of date. The International Energy Agency puts Chinese emissions in 2005 of CO_2-eq at 7,527 megatons, exceeding the U.S. 2005 emissions of 7,282 Mt of CO_2-eq. See International Energy Agency. 2007 CO_2 Emissions from Fuel Combustion 1971-2005

[24] As of November 24, 2008, the World Bank classified all countries with per capita income of $11,456 or more as high income. See World Bank Country Classification, accessed November 24, 2008.



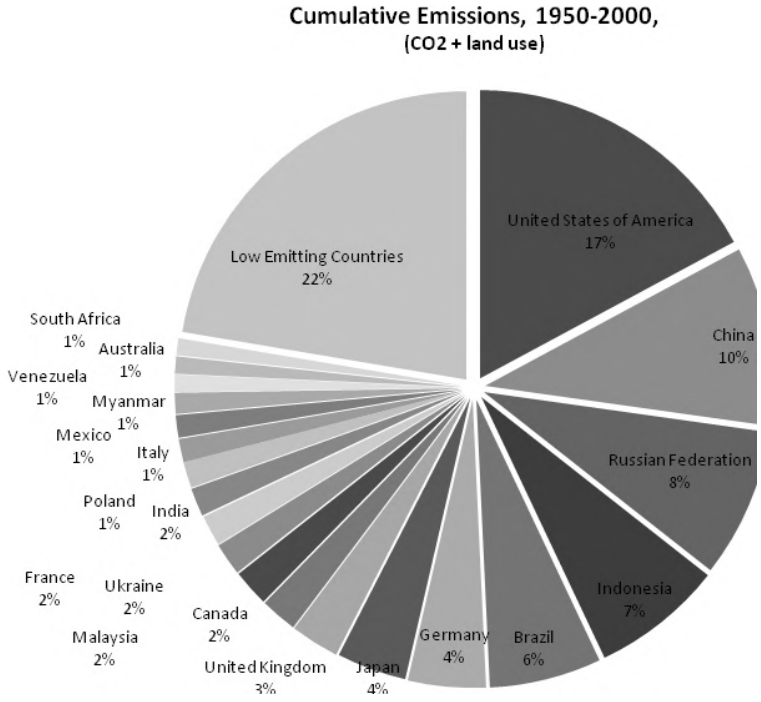
Very similar results hold if we look at all nations, not just the top 20 emitters – high income countries emit 38 percent while other countries emit 62 percent. If instead we separate countries into UNFCCC Annex I and all other countries we get similar although slightly different results because many Annex I countries are not wealthy. Annex I countries in the top 20 emitted 33 percent of the worldwide total in 2000. Non-Annex I in the top 20 emitted 36 percent of the total. Roughly similar numbers result when we look at the whole list: Annex I and non-Annex I are about equal, with both at almost exactly 50%, although, of course, there are more non-Annex I nations than Annex I nations and more people living in non-Annex I nations than in Annex I nations (scaled emissions are considered below). If we use a narrower measure of emissions, just carbon dioxide, the total emissions from rich countries (more than $20,000 in per capita GDP) in the top 20 goes up to around 36% and poor countries go down to around 37% in 2004. The reason for the difference is that poor countries have higher emissions from land use change while rich countries have higher emissions from energy.

Stocks

Current emissions are not a very good measure of responsibility because carbon dioxide and other greenhouse gases have long lives in the atmosphere. Emissions in the past (and in the future) can contribute to climate change as much as emissions today. Therefore, most measures of responsibility for emissions look at past emissions. Unfortunately, the data for past emissions are far less available than for current emissions. CAIT only has data on land use change back to 1950 and up to 2000, and it does not have data on gases other than CO_2 prior to 1990. Chart __

illustrates CAIT data on cumulative emissions from 1950 to 2000 from energy and land use change.

The numbers do not differ substantially from the flow data give above. Using the same definition, high income countries in the top 20 emitters comprise 36% of cumulative emissions. Other countries make up 41% of cumulative emissions. Similar results hold if we look at the entire list. On the other hand, if we aggregate all Annex I countries (some of which are poor), they make up about 53% of cumulative emissions.



If we want to go back further, we can only look at carbon dioxide emissions from energy use. In the CAIT database, this allows us to go back to 1850 and forward to 2004. To allow for some decay of carbon dioxide over this 154 year period, I looked at the CAIT concentration data rather than cumulative emissions data. (The difference is that concentration data estimates the removal of carbon dioxide from the atmosphere.) Depending on how the data is presented, it can seem to support either the conventional view or the view illustrated by the tables above. For example, if we divide the world into rich and poor countries, poor countries are responsible for more emissions than rich countries. Out of the top 20 emitters, poor countries account for about 43% of total concentrations while rich countries account for around 33%. If, alternatively, we aggregate countries into UNFCCC Annex I countries (some of whom are relatively poor) and all others, the Annex I countries account for more than 70% of current concentrations. That is, the

numbers show overwhelming responsibility for climate change by one group of nations if we use a narrow measure (carbon dioxide from energy use), go back a very long period in time (over 150 years) and use a particular aggregation (all Annex I countries).

Per capita measures

The IPCC chart given above was based on per capita emissions. The reason, presumably, is that notions of responsibility depend on the number of people in the nation. It would not make sense, for example, to say that China, with a population of 1.3 billion people, is responsible for emitting no more than Iceland, with a population of around 300,000 people.

We can measure per capita emissions on either a flow basis or a stock basis. Table 3 is a list of the top 25 countries for per capita emissions in 2000 for the six Kyoto gases plus land use change. The notable aspect of this list is that most of the top countries are small and poor. The reason I listed the top 25 countries instead of the top 20 countries as in the other tables is so that I could include more large emitters. Even so, the list is by far dominated by small and often poor countries.

Table 3: Per Capita GHG Emissions in 2000

CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 (includes land use change)

Rank	Country	Emissions per person	Total emissions	% of World
1	Belize	93.9	23	0.05%
2	Qatar	54.7	33	0.08%
3	Guyana	52.5	39	0.09%
4	Malaysia	37.2	856	1.97%
5	United Arab Emirates	37.2	121	0.28%
6	Brunei	33.2	11	0.03%
7	Kuwait	30.4	67	0.15%
8	Papua New Guinea	29.3	155	0.36%
9	Australia	26.1	500	1.15%
10	Antigua & Barbuda	25.4	2	0.00%
11	Zambia	24.6	263	0.60%
12	Canada	24.2	745	1.71%

13	Bahrain	23.9	16	0.04%
14	United States of America	22.9	6,465	14.87%
15	Trinidad & Tobago	22.1	28	0.07%
16	Luxembourg	21.3	9	0.02%
17	Panama	19.7	58	0.13%
18	New Zealand	19.1	74	0.17%
19	Botswana	17.8	31	0.07%
20	Bolivia	17.4	144	0.33%
21	Ireland	17	65	0.15%
22	Venezuela	15.7	381	0.88%
23	Saudi Arabia	15.5	320	0.73%
24	Estonia	15	21	0.05%
25	Indonesia	14.9	3,066	7.05%

The qualitative nature of the list does not change if we measure cumulative emissions on a per capita basis, as long as land use is included.[25] If we do not include land use (say because we want to go back to years before land use data was available), many of the poor countries that have engaged in significant deforestation fall off of the list.[26]

A central question behind this data is what to make of the dominance of small countries that are not likely to be an important part (if any) in a new climate treaty. If we were to limit the list to major emitters and wealthy countries – the most important candidates for a climate treaty – Australia, Canada, and the United States would top the list (for 2004 per capita flow of emissions), followed by Luxembourg, New Zealand, Ireland and Indonesia. Russia is 35th, China is 120th, and India is 170th out of 185 countries in CAIT. To the extent that China and India are the central developing country negotiating partners in a climate treaty, it is clear that they have very low per capita emissions.

[25] The list becomes somewhat more concentrated with wealthy nations, but the top five countries on a per capita basis using cumulative emissions of CO_2 plus land use from 1950 to 2000 are Belize, Guyana, Luxembourg, Malaysia, and Papua New Guinea, only one of which is wealthy. The United States moves up from 14th to 10th.

[26] Using the EDGAR database, the results look qualitatively similar – many poor countries are at the top of the list – but the particular countries vary significantly. The top 20 countries using the same basic calculation are Gibraltar, American Samoa, Qatar, Netherlands Antilles, Brunei, the United Arab Emirates, the US Virgin Islands, Bahrain, Bolivia, Australia, Belize, Angola, Kuwait, the US, Turk and Caicos, Norway, and New Zealand. Belize drops to 10th. The US remains at 14th.

Intensity

A final possible measure of responsibility for emissions is intensity, which is the emissions necessary to produce a dollar of GDP. The notion might be that more responsible nations produce wealth with fewer externalities. Table 4 is a list of the top 20 countries by intensity of their emissions. There are no rich countries or Annex I countries on this list. In fact, the list is dominated by African countries and by very poor countries.

Table 4: GHG Intensity of Economy in 2000

CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, including land use change

	Country	**tCO_2-eq/Mill. $**	**Index**
1	Zambia	31,292	100
2	Belize	16,524	53
3	Liberia	14,932	48
4	Congo, Dem. Republic	13,560	43
5	Guyana	13,390	43
6	Papua New Guinea	12,491	40
7	Sierra Leone	8,998	29
8	Myanmar	8,764	28
9	Central African Republic	7,487	24
10	Mongolia	7,420	23
11	Bolivia	7,278	23
12	Madagascar	7,117	22
13	Benin	6,640	21
14	Congo	5,725	18
15	Indonesia	5,118	16
16	Malawi	5,102	16
17	North Korea	5,023	16
18	Laos	5,006	16
19	Uzbekistan	4,992	16
20	Nepal	4,972	16

The United States is 126th, with an index of 1.7, while the EU 25 is 158th, at 1/100 of the Zambian intensity.[27]

D. Reconciling the numbers: the ethics of aggregation

The central observation from the above data is that the same information can produce startlingly different impressions depending on the presentation. Many studies claim to show that wealthy countries, particularly the United States, are responsible for the overwhelming majority of emissions to date. To some extent, this is true: wealthy countries have been large emitters by almost any measure (other than intensity). On the other hand, developing nations are equal contributors on many other measures. Poor countries combined have emitted more total greenhouse gases than wealthy countries; per capita emissions are dominated by small poor countries and by Arab countries. The question is what accounts for these differences and which method of looking at the data is correct?

There are two main reasons for the differences in the data. The first is breadth of the measures used. Developed nations have higher emissions from energy use and lower emissions from land use change, so measures that exclude land use change will tend to show higher relative emissions from developed nations. There is, however, no reason why a measure of responsibility for climate change should be limited to only some types of emissions. The only basis for using narrow measures is the lack of available or reliable data for broad measures. Where data is lacking, however, the correct conclusion is that we cannot calculate responsibility, not that we can pinpoint responsibility based on incomplete data.

The second reason is that the different measures use different aggregations. With almost 200 nations, we cannot easy present data for each country in an understandable format. Instead, the data is usually aggregated so that it can be understood. The IPCC chart reproduced above aggregates all of the countries in the world into ten regions. The result is that small, high per capita emitting countries get lost in the data because they are aggregated with many other low emitting countries. Belize and Guyana are combined with low emitting Central and South

[27]The IPCC has an intensity chart which shows somewhat different results (Figure 1.4b). Using the same aggregations as the IPCC, the CAIT data produces a different ordering of emissions intensities with the Middle East, for example, having the sixth highest intensity while the IPCC puts it at third. The particular countries at the top of the list change if we focus only on energy intensity as opposed to greenhouse gas intensity, but the basic nature of the conclusions does not change: the energy intensity list is dominated by (different) poor countries; wealthy countries move up but are still nowhere near the top: The US moves up to 56 and EU to 93.

American countries, so they do not show up. Malaysia is combined with low emitting South Asian countries. The per capita numbers in Table 4 above had no aggregation – it is a list of individual countries. This means that relatively small countries, countries that are unlikely to play a significant role in climate negotiations, dominate the list. The table emphasizes variance by individual countries rather than overall trends. The conclusions I presented on total emissions by rich and poor countries also aggregated the information. The cut off between rich and poor was arbitrary. The IPCC aggregated by geographic regions. Rich countries, however, are concentrated in just a few regions while poor countries are spread out, so this aggregation also potentially skews the results. Any method of presenting the data must be defended.

The question is whether there is any ethical theory for aggregation. Is it appropriate to combine Belize and Guyana with low-emitting Latin American countries as was done in the IPCC chart? Is it appropriate to treat wealthy nations as one group and all other nations as another group as I did in summarizing the data from Table x?

Some aggregation will be necessary in presenting and understanding the data. The goal of a good presentation of data is to enable the reader to understand key facts or trends in the data while ignoring noise. Aggregation of many data points into more easily understood forms can be helpful. There is, however, no justification for aggregation that hides key facts or that presents data in a way that fails to illustrate the underlying information. That is, beyond its role in helping the reader understand the data, there is no ethical theory for aggregation.

The aggregation in the IPCC report cannot be supported based on theories of good presentation of information. Treating all of the Middle East as a single data point hides the very high per capita emissions of Qatar, the UAE, and Kuwait. Treating all of Latin America as a single data point hides the high per capita emissions of Belize and Guyana. The wide variations in emissions get washed out in the averages of groups that are essentially randomly chosen because the happenstance of geography rather than an underlying theory of responsibility. Similarly, the decision in the IPCC chart to separate poor countries into many regions while aggregating wealthy countries into fewer regions means that the reader does not get a sense of the underlying data. If instead, we aggregate all poor countries into one group and all rich countries into another, we get a very different picture of the data than if we use the 10-region aggregation used by the IPCC.

Data on past emissions are used to support claims about obligations; these claims are based on ethical theories. Even a cursory examination of such ethical theories shows that aggregation is inappropriate. For example, we might look at past emissions data to establish a claim about culpability for bad actions. A nation is not less culpable (to the extent nations can be culpable at all, an issue put aside here) because its neighbor behaved well. Belize is not less culpable because Guatemala, Honduras, and El Salvador have low per capita emissions. (Guatemala was ranked 77, Honduras 110, and El Salvador 146 out of 185 CAIT nations in 2000 in per capita emissions.) The same problem arises with theories of distributive justice: aggregation by geographic region cannot be justified based on distributive theories.

Compete disaggregation of the data would require us to look at individuals. This is impossible. Nations, however, are good level of aggregation for examining the data. Nations are the likely actors in any climate arrangement. Moreover, nations can control the distribution of costs and benefits to their own citizens. For example, if a nation has a high emitting region and a low emitting region and must incur significant costs to reduce emissions, it can internally allocate those costs as it sees fit. Therefore, nations seem like a convenient level of aggregation. It is, however, hard to see any reason for aggregation beyond the national level unless we do not lose any significant information by doing so. The tables above show that we do lose important information.

One argument for aggregation by region is that what shows up in the disaggregated data given above is that some relatively small and poor countries like Belize, Guyana, and Papua New Guinea, have high per capita emissions. This, it might be argued, is irrelevant; these countries are unlikely to have any role in a climate treaty. Aggregation, therefore, is not hiding important information.

This conclusion, however, would not be correct. Theories are responsibility that are based on per capita do not distinguish between large countries and small countries or rich and poor countries. The fact that a country happens to have a small number of individuals or is poor says nothing about its culpability for its actions.

We can also redo the list to cover only large emitters to see how much such an approach would change the conclusions. To get a sense of this, take modest, but not the very smallest, countries which are obligated to reduce emissions under the Kyoto Protocol. Presumably it is worth including countries of this size and larger in a new climate change agreement. New Zealand, Finland, Denmark, and Ireland are good examples of these nations. Any country with

annual total emissions as large as these (about 60 Mt CO_2-eq) should be on the list of countries of a sufficiently large size. (There are Annex I nations with much lower emissions, such as Luxembourg and Lithuania.) Under this standard, the top per capita emitters in 2000 are as follows:

Table 5: Total GHG Emissions in 2000

CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, (includes land use change)

Rank	Country	Tons CO_2 Per Person	$MtCO_2$	% of World Total
1	Malaysia	37.2	856	1.97%
2	United Arab Emirates	37.2	121	0.28%
3	Kuwait	30.4	67	0.15%
4	Papua New Guinea	29.3	155	0.36%
5	Australia	26.1	499	1.15%
6	Zambia	24.6	263	0.60%
7	Canada	24.2	745	1.71%
8	United States of America	22.9	6,465	14.87%
9	New Zealand	19.1	74	0.17%
10	Ireland	17	65	0.15%
11	Indonesia	14.9	3,066	7.05%
12	Belgium	14.3	147	0.34%
13	Turkmenistan	14.2	64	0.15%
14	Singapore	14.1	57	0.13%
15	Czech Republic	14	143	0.33%
16	Netherlands	13.7	218	0.50%
17	Nicaragua	13.5	66	0.15%
18	Russian Federation	13.4	1,963	4.51%
19	Brazil	13.4	2,322	5.34%
20	Finland	13.1	68	0.16%

Some of the very small nations, like Belize, drop off of the list and the United States moves up from 14^{th} to 8^{th}. But the qualitative nature of the list does not change: many poor countries are in the top 20 including such countries as Malaysia, Indonesia, Brazil, and Papua New Guinea.

Changing the arbitrary size cut off used to create this table does not change the basic results unless a very high cut off is used.

A final reason to include many relatively poor or small countries is that a workable climate treaty cannot afford to leave many nations out. The reason is that low cost abatement opportunities are spread throughout the world. If we leave out smaller nations, we lose the benefit of whatever low cost reductions are within their borders. Moreover, heavy emitting industries would have an incentive to shift to these nations, creating so-called carbon leakage. In a recent study, researchers using a large scale model of the climate and the economy developed at MIT modeled a worldwide cap and trade regime designed to reach a reasonably ambitious carbon concentration goal by 2050 (450 ppm of CO_2eq).[28] Leaving out even a small number of regions with comparatively low emissions made it not only difficult but impossible to reach this goal. In one case, leaving out the Middle East and Africa from the cap and trade regime made it impossible to limit concentrations to the desired goal even if all other nations reduced emissions to the maximum extent possible within the model. The small nations that show up on these lists most likely have to be included in a carbon reduction regime.

One way to get a handle on the relationship between wealth and per capita emissions is to compute the correlation. The chart below does this for 2000, looking at the six Kyoto gases plus land use change. As be seen, there is a positive relationship, but a low R^2 and many outliers.[29]

It seems from this chart that the picture is mixed, and the implications for a climate treaty would be similarly mixed. Emissions correlate with wealth. Nevertheless, consistent application of this theory of responsibility would mean that many relatively poor countries would be faced with very large climate obligations. For example, suppose that the sustainable level of emissions for the short-term is 5 tons per person per year (which is likely below the long-term sustainable level). All countries above the horizontal line at 5 (bolded in the chart) would have a net obligation based on how far above the line they are, and many of these countries are small or poor. On the other hand, there is a clear upward slope to the chart, indicating that wealth correlates with emissions.

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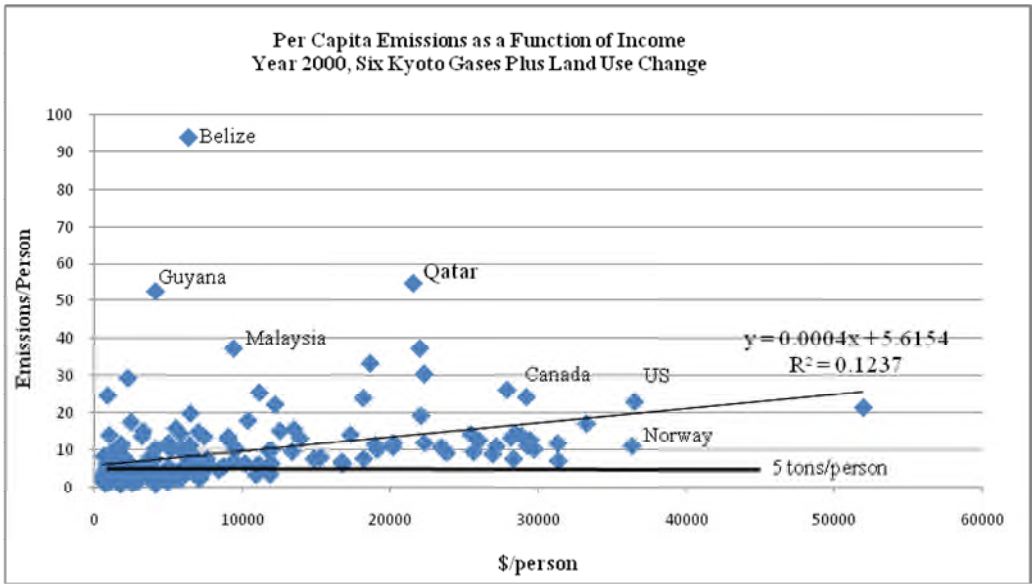
[28] Henry D. Jacoby, Mustafa H. Babiker, Sergey Paltsev, and John M. Reilly, Sharing the Burden of GHG Reductions, The Harvard Project on International Climate Agreements, Discussion paper 08-09 (October 2008), available at www.belfercenter.org/climate

[29] If we look at a broader measure of emissions, the slope of the line of best fit goes down and its y intercept goes up, reducing the effect. We should not take the zeros in front of the slope (the 0.0004) as meaningful because they are a artifact of the units used to measure income (dollars) and emissions (tons).



II. Assigning responsibility

Most of the literature on past emissions seems to view the relevance of emissions data as obvious. Scientists and economists have been refining the data as if we were to take the resulting numbers literally as a measure of responsibility. One of the claimed virtues of the Brazilian approach is that it is science-driven and, therefore, provides an objective basis for allocating treaty obligations.[30]

A claim that one party has an obligation to make a payment to another because of some past action, however, is not a scientific claim. It is an ethical claim and needs to be supported by an ethical theory. In this section I will discuss how theories of responsibility might inform the data.

There are any number of possible ethical theories that might be used. I will focus here on the theories that underlie tort law or analogous damage regimes. Tort law provides the clearest example of where we have been willing to impose an obligation to make a payment based on a harmful action. I am not claiming in any sense that the particular requirements for tort liability have to be met, and, indeed, they most likely are not – we should be thinking in terms of a climate treaty not a climate lawsuit. Instead, the goal is to look at a developed body of thinking in an analogous context to see what has been required.

[30] See La Rovere, de Macedo, and Baumert, note __ at p. 167 ("The proposed approach is science-driven. This is good news as it avoids a burden-sharing scheme based solely on the bargaining power of Parties sitting at the negotiations table.")

As noted in the introduction, there are two distinct rationales for tort liability: responsibility or corrective justice theories and incentive-based theories.[31] Responsibility theories focus on compensating victims of wrongful actions. Incentive-based theories focus on internalizing costs that dangerous acts impose on others. I will examine both theories to see how each would use emissions data. I will start with responsibility-based theories as these seem to be the focus of most of the claims. After discussing these, I turn to incentive-based theories.

A. The Theory of Responsibility: Fault and Strict Liability

Responsibility and Fault. Most notions of responsibility require fault. This is deeply embedded in tort law. Civil law regimes have a very strong fault rule, stemming back to the Napoleonic Code.[32] Common law regimes are more mixed, but are best described as imposing fault or negligence in standard cases with specified exceptions where fault is not required.[33]

The connection of responsibility and fault can be traced back to Aristotle, who argued that we can assign responsibility only for voluntary actions where the actor is aware of the harm he is bringing about. More modern approaches go beyond awareness to negligence. Regardless, fault is said to be required because only fault distinguishes pure acts of nature from moral, human conduct. As summarized by one prominent corrective justice scholar, "A right to repair in corrective justice, [therefore] only arises if the conduct that led to the harm in question was either faulty, or in some appropriate sense fault-like."[34]

If fault is the central notion in assigning responsibility, the emissions data we have to date provides nothing like the sort of information we would need. Moreover, no data would likely be

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[31] There are long and heated debates about whether theories of responsibility or more generally corrective justice theories are viable or whether tort-like obligations should instead be based entirely on consequentialist, incentive-focused theories. For an extensive criticism of the use of corrective justice and similar notions in tort law, see Louis Kaplow and Steven Shavell, *Fairness versus Welfare* p. 85-154 (2002). Corrective justice intuitions seem to be behind many of the claims about responsibility for climate change and the use of past emissions data. Therefore, I examine these theories without endorsing them here.

[32] For a summary of civil law tort regimes in the environmental context, see, Mark Wilde, *Civil Liability for Environmental Damage, A Comparative Analysis of Law and Policy in Europe and the United States* (2002). See also see Andre Tunc, *The Twentieth Century Development and Function of the Law of Torts in Franc*, 14 International and Comparative Law Quarterly 1089 (1965).

[33] See, Richard Epstein, Cases and Materials in Torts, Eight Edition (2004).

[34] Stephen Perry, *The Mixed Conception of Corrective Justice*, 15 Harvard Journal of Law & Public Policy, 917, 931 (1992). For additional work on corrective justice and tort law, see Stephen Perry, The Moral Foundations of Tort Law, 77 Iowa L. Rev. 449 (1992); George Fletcher, Fairness and Utility in Tort Theory, 85 Harvard L. Rev. 537 (1072); and Ernest Weinrib, Toward a Moral Theory of Negligence Law, 2 Law and Philosophy 37 (1983); Guido Calabresi The Cost of Accidents (1970). Richard Epstein argues that corrective justice requires strict liability. See Richard Epstein, A Theory of Strict Liability, 2 Journal of Legal Studies 151 (1973).

sufficient to perform this sort of calculation. To measure faulty emissions, we have to determine, whether each unit of emissions at each point in time was wrongful. For example, we might think that luxury consumption – say heated swimming pools, oversized vehicles, and McMansions – is wrongful but necessary consumption such as heating homes in frigid climates is not. We might think that in a large nation, some minimum emissions from transportation are not wrongful but excessive emissions are wrongful. Modest meat consumption might be okay but excessive meat consumption not.

The difficulties are immediately apparent: determining fault requires detailed judgments about a vast number of decisions made every day by each individual. Even if we had the capacity and the information necessary to make these judgments, we would likely disagree about what particular conduct is wrongful. How many square feet of living space is allowable for each individual in a family? How far from work or school is it permissible to live? What type of car can you drive? Is eating meat unethical (because of the greenhouse gas emissions from livestock, not animal welfare)? Is it ethical to live in an unduly cold or hot climate or must all Americans move to San Diego and Canadians to, well, out of Canada? Do these answers change if a country has a natural reserve of some particular type of energy or a natural carbon sink such as a forest? Because almost all activity in a modern economy results in emissions, determining wrongfulness involves judging almost every aspect of everyone's life. Fault in the climate context is not like a simple case of kicking someone in the shin or driving excessively fast, where we are likely to have shared intuitions about the wrongfulness of the conduct or methods of measuring the costs and benefits.[35] To determine fault on a global scale for pervasive activities that span more than a century is simply impossible. Not only are there overwhelming problems of data, but we simply have no underlying view on most of the conduct we would have to judge.[36] The only way to base obligations on past emissions is to use a non-fault-based theory of obligations.[37]

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[35] There is the entirely separate problem of when we should start counting because of when it was reasonable for individuals to know that carbon-emitting activities harmed the world. Unlike some of the activities listed in the text, it seems likely that we might agree on an appropriate date and once a date is set, adjusting the calculation to start at that date is not particularly hard.

[36] CAIT attempts to provide some of the relevant data. For example, CAIT allows us to rank countries by heating and cooling degree days, by the size of their populated regions, by their income, and by their access to various sources of fuel. The authors want to allow users to make the necessary sorts of adjustments to the data to reflect fault. But the game is hopeless. We cannot make judgments of the sort needed.

[37] Perhaps the best that we could do might be as follows. Define fault as all emissions in excess of those under an optimal carbon tax. We would then have to calculate the optimal carbon tax at each point in time and the elasticities of major emitting activities. Given this price change (from the tax) and the elasticities, we could estimate emissions

Strict Liability. Under strict liability, an actor is liable for any harm he causes, even if he is not at fault. Some have argued strict liability is consistent with the principles of responsibility and corrective justice.[38] Liability for harm from environmental damages has to some extent moved away from fault-based regimes, toward strict liability. In the EU, this move has largely been under the rubric of the Polluter Pays Principle. The rationale was that it was too difficult to prove fault in the environmental context because of the complex processes that are involved (and the polluter has the information about these processes). Moreover, strict liability was thought to better provide compensation to victims of pollution and to impose the risk from pollution on the party that can control it.[39]

The shift to strict liability in the EU, however, has been halting and limited, and in many versions, the Polluters Pay Principle has been implemented as a fault regime, not a strict liability regime. This can be seen in its most recent and comprehensive manifestation, the EU Environmental Liability Directive (the ELD), adopted in 2004. It explicitly states that it adopts the Polluters Pay Principle and provides a specific set of rules for its implementation. It provides for strict liability for a specified class of particularly risky activities such as waste management operations or the storage of dangerous chemicals. Even for this class of activities, individual member states can provide exemptions, such as if the polluter can demonstrate that the activities were not considered likely to cause damage based on knowledge at the time of the activity (i.e., a fault-like theory). For all other covered environmental harms,[40] however, the ELD requires fault and, moreover, limits liability to harms to specified items, such as harm to protected species and natural habitats. At least in this implementation, the Polluters Pay Principle is not a general strict liability principle.

The ELD has not yet been adopted by many member states, each of which has its own environmental and tort laws. Many of these states retain the core of fault-based civil liability regimes, although some have enacted strict liability regimes for specified environmental harms. For example, Germany has a strict liability regime for damage caused to water and soil as well as

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under the tax and then compare these estimates to actual emissions. The difficulties of such a calculation are apparent.

[38] Richard Epstein, A Theory of Strict Liability, 2 Journal of Legal Studies 151 (1973).

[39] For a history of the development of the Polluters Pay Principle, see Nicolas de Sadeler, *Environmental Principles, From Political Slogans to Legal Rules* (2002).

[40] The ELD does not cover environmental harms that result in diffuse harms, such as those from many types of air pollution.

a selected list of sites.[41] The UK imposes strict liability for designated nature protection sites. Brazil imposes strict liability for environmental harms, although it is not clear how strongly it is enforced.[42] There are scatterings of strict liability, so the idea of using strict liability notions in the climate context would not be unheard of.

Common law regimes impose strict liability in circumstances that are similar to where the ELD would impose strict liability. For example, common law regimes may impose strict liability for activities that are very likely to impose harm, such as conversion, animals, abnormally dangerous activities, and nuisances. These are not exactly the same as the strict liability categories in the ELD but the underlying intuition is similar: we impose strict liability where, if there is harm, it is very likely there is also fault.

The United States has a separate environmental law layered on top of the common law. As a general matter, American environmental law has not imposed strict liability. Most of the time, it uses command and control regulations which simply prohibit certain activities. The most important case of strict liability (in fact, the *only* major example) is CERCLA (i.e., Superfund).[43] For a variety of reasons, however, CERCLA has not been successful, at least by many measures. It is a doubtful precedent on which to base a climate change treaty.

From this brief survey, we can see that there is some precedent for using a strict liability standard in contexts similar to climate change, it is also quite limited. Even in environmental contexts, most countries most of the time require fault.

Suppose that we get over the hurdles for using a strict liability approach for measuring responsibility. The issue is then substantially simpler because we no longer have to determine fault. Nevertheless, there are still a number of problems. One problem is that we would have to calculate the net harm from emissions – the harm from temperature increases less any benefits from the emitting activity realized by the rest of the world. There are many external benefits that would have to be taken into account.

As an example, consider the Haber-Bosch process. This is a process, invented in Germany just prior to World War I that fixes nitrogen to produce ammonia. The ammonia can be used as fertilizer or a component of fertilizer. The resulting fertilizer is responsible for

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[41] See Gerd Winter, Jan Jans, Richard Macrory, and Ludwig Kramer, *Weighing up the EC Environmental Directive*, Journal of Environmental Law 20:163-191 (2008).

[42] Section 14.1 of the National Environmental Policy Act, Law 6938/81.

[43] One could argue that the SOx trading regime is a strict liability regime as it imposes caps on emissions entirely without regard to fault. The permits, however, were handed out based on historical emissions, so the regime did not impose liability for past actions as is suggested in the climate context.

sustaining a substantial portion of the world's population. Although the invention was patented and the inventors paid, there is no way that they could have captured all but a tiny fraction of the resulting benefits. The same process, however, was also used by Germany to generate munitions, and Germany may not have entered into World War I without this source of supply (or might have ended the war years earlier). There is no realistic way to measure the net benefits and costs of inventions of this sort, inventions that would be unlikely to have been found but for industrialization and the resulting emissions.

A second problem is the time period over which we measure emissions. The time period will be critical. If we go back long enough, for example, the deforestation numbers change dramatically because areas that deforested long ago would be assigned the resulting emissions. Similarly, counting industrial activity that occurred long ago produces different results than using a shorter time period. The precedent for such an approach – fully retroactive strict liability – is very limited; strict liability regimes are not generally retroactive. For example, the strict liability portions of the ELD are prospective only. The intuition is that if you are going to be held liable for harms which are not your fault, at a minimum, you should be told in advance.

A third problem is how we should treat population growth. If we use a per capita measure, countries with rapid population increases look better (unless emissions increase just as rapidly). It is not clear, however, why we would want to treat countries which have increased their populations rapidly as behaving better, as less responsible for climate harms. If we are not going to do so, however, we would need some theory for allowable population growth, and then use this number as the denominator in a per capita emissions calculation. This is infeasible. Similar arguments apply to immigration.

There are many other problems with applying a strict liability approach. The analysis above, however, should be sufficient to demonstrate that even if we eliminate considerations of fault, the problem of determining responsibility remains formidable.

The connection between injurer and victim. Regardless of whether we apply strict liability or a fault-based rule, responsibility-based arguments for tort liability almost inevitably require a close connection between the injurer and the victim. "In every account of corrective justice, there is presumed to be a relationship between the parties that makes the claims of corrective justice appropriate to them – and not to others."[44]

[44] Jules Coleman, The Practice of Corrective Justice, 37 Arizona L. Rev. 15 (1995). See Kaplow and Shavell, p. 89-90, for a summary of the literature taking this view.

In the climate change context, there is only a very loose connection between the injurers and the victims. The injurers are the set of people who have engaged in activities that result in carbon emissions in the past. This is a large and diverse group: some are rich, some are poor; some can easily avoid emitting greenhouse gases, some cannot; some are alive, some are dead. Standard notions of responsibility for bad acts usually reject collective responsibility; we have to assign responsibility to particular individuals. Similarly, the victims are dispersed and most are not yet alive (because most of the harm will be in the future).

This problem has already been noticed and written about. It is closely related to the problem of reparations, where claims of collective responsibility are also apparent. The conversation so far captures the issues well, so I will not add anything here.[45]

Distributive Effects. The data above show that many poor countries have contributed significantly to climate change. If these poor countries are to be held responsible on the same basis as rich countries, the resulting obligations would likely cause significant hardship. Many of the high emitting poor countries simply do not have the resources needed to pay for their share of harm. Asking them to pay for even a modest share of the harm that they have caused might have terrible consequences.[46]

I have argued elsewhere that we should separate distributive issues from a climate change.[47] The basic reason is that redistribution of wealth is best done through mechanisms carefully designed to be most effective. Although we remain uncertain what the most effective mechanisms are for helping developing countries, an instinctive tying of a climate change treaty to redistribution is unlikely to be one of those mechanisms. Moreover, it is difficult to get wealthy nations to agree to substantial redistribution – we give a miniscule fraction of our GDP in foreign aid. Tying a climate treaty to an order of magnitude or more increase in foreign aid is not a good method of achieving a treaty. Climate change is serious enough that we should not attempt to cure North-South problems at the same time.

To the extent people believe this argument, the bad distributive effects of using responsibility as the basis for a treaty will not matter. Many people, however, would be very troubled by such distributive effects. It is not clear, however, whether notions of responsibility

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[45] See Eric Posner and Cass Sunstein, Climate Change Justice, forthcoming ___. Posner, Sunstein and Weisbach, [title].

[46] Overall, imposing liability based on past emissions would be progressive because there is a positive correlation between emissions and income. The problem arises because of the high variance in emissions within poor countries.

[47] See Eric Posner, Cass Sunstein, and David Weisbach, Climate Change Justice (forthcoming 2009).

can be adjusted to take the distributive effects into account. Notions of corrective justice typically make no exception for income levels or poverty. Tort law imposes liability on negligent injurers regardless income: if you negligently hit me with your car, you are liable even if you are poor. Notions of fault are unlikely to exempt poor countries; emissions from poor countries are often the result of highly wasteful deforestation, activities that not only result in climate change but also result in a host of other environmental ills and yet fail to produce significant benefits. If anything, high-emitting poor countries are more at fault than rich countries because their actions cause harm while producing almost no benefit.

The Brazilian proposal, in its initial form, would not have applied to developing countries; Brazil was proposing its allocation method only for countries obligated to reduce emissions under the Kyoto Protocol, which by and large are richer than other countries. Brazil, therefore, implicitly included a distributive component. The logic, however, is unclear. If we are to use responsibility as a measure, there is no reason to exclude any responsible party. If the arguments are based on distributive concerns, it is not clear how responsibility fits.

Measuring harm for ongoing acts. The final problem with applying notions of responsibility within a climate context is that it is not clear what role it should play when the harm is ongoing. In the usual case, X kicks Y in the shin, X is responsible and pays Y damages. Or in the environmental context, X emits a pollutant which causes some sort of harm; X must pay for the harm and stop emitting the pollutant. In the climate context, however, we – almost all individuals and all nations around the globe – will continue emitting the pollutant for the time being and it is not clear that we will ever be able to completely stop emitting; even if we had an abundant carbon-free source of energy, agricultural activities such as livestock farming results in emissions, and we are not likely to find methods that do not.

Continuing emissions might not be a problem if emissions in the past predicted emission in the future because future actions would not change the relative levels of responsibility and we could use past data as a going forward measure. Those responsible for emissions, however, will change over time with developing countries likely becoming large emitters in the future. If we were in 2050 looking back, we would very likely have a different picture of responsibility than we do in 2008.

The Brazilian proposal, as well as most other less formal discussions, seems to want to take a snapshot at a fixed point in time – when the treaty is negotiated or signed – and assign responsibility on that basis. Obligations to pay for emissions reductions would be

correspondingly assigned. The obvious problem with this regime is that it ignores responsibility for future emissions. If X emits 100 units in period 1 and Y emits 100 in period 2, we should not assign responsibility forever more at the end of period 1.

It is not clear, however, how to fix this. We would have to adjust the assignment of responsibility for emissions at regular periods, so that if a nation emits a lot in, say, the next five years, it gets a higher obligation to abate than otherwise. Once a treaty is signed, however, if nations comply with the treaty they would be emitting only as much as they are allowed to under an international agreement. To the extent that responsibility includes any notion of fault, it would hard to argue that they would be at fault in such a case.

Even if we use strict liability notions, the adjustments would be difficult. A nation that is allowed high emissions in one period would then be responsible for a greater share of subsequent emissions and get a lower share in the next period. The optimization problem – what is the right amount in any given period for a nation – would be highly complex.

Notions of responsibility work best for past acts. We can imagine applying these notions to require past emitters to pay a fixed, lump sum amount, say as transfers of technology to lower-emitting countries. As an ongoing matter, however, it does not seem workable.

B. Incentive-based approaches

An alternative basis for tort obligations is to force actors to internalize harms from risky behavior. Tort liability, under this view, substitutes for a Pigouvian tax. For example, suppose an actor engages in risky conduct which exposes third parties to harm. A Pigouvian tax on the conduct would equal the expected harm from the conduct, forcing the actor to take all costs into account. If we cannot observe the riskiness of an activity in advance, we cannot impose such a tax. For example, we could not easily impose a tax on risky driving. If we instead impose an obligation to pay for any harm caused, we achieve the equivalent result. A large body of theory examines and develops tort law from this perspective.[48]

If we take this incentives-based approach, we get very different answers than if we take a corrective justice, responsibility-based approach. As a general matter, an incentives-based approach cares only about future behavior – incentives cannot affect the past. On a going forward basis, this involves some sort of price on carbon, whether from a tax or a cap and trade

[48] See Steven Shavell, Liability for Accidents, in Handbook of Law and Economics (A. Mitchell Polinsky and Steven Shavell, eds. 2007).

regime. Nevertheless, there is some role for a backward looking treaty under an incentives-based approach. In particular, the expected outcome of a treaty negotiation can affect behavior between now and when a treaty is signed. For example, if a treaty assigns emissions rights based on emissions as of the time of the treaty, it creates an incentive to increase emissions between now and when the treaty is signed (so as to increase your country's allocation). This is why most negotiations, including those behind the Kyoto Protocol, look to a base year for determining emissions reductions that precedes the negotiations. The same idea holds more broadly, for example for investments in low carbon technology (these need to be rewarded) and for imposing unreasonable delays in the negotiating process (these need to be punished). Under an incentives-based approach, a treaty should be look to behavior between now and when the treaty is signed, rewarding good behavior and punishing bad behavior. Although nominally backward looking, doing so has good going forward incentive effects.

We might be able to push this logic further and look at past behavior. The idea would be that although we cannot affect past behavior, situations similar to climate change might arise – other international negotiations – where a climate change treaty might serve as precedent. If a climate change treaty punishes bad behaviors in the past, actors anticipating a future, analogous negotiation in a different context might anticipate a similar approach and, therefore, not engage in the bad behavior (or engage in less bad behavior). That is, imagine an actor engaging in an action now that we are not sure is harmful, but might be. Even if there is no liability attached to the conduct now, if we later learn that it is harmful and impose liability retroactively, and the actor expects this, the actor has an incentive now to internalize the possible harms.[49] A climate treaty that looked to past emissions might possibly increase the expectation that other treaties would reach back and, therefore, create good incentives now.

The problem with applying this logic to long-past emissions is that it is doubtful that doing so would create very much an incentive for other, unrelated conduct. There are not, we hope, many problems like climate change where the climate change precedent would change expectations. This is particularly true because liability would not fall directly on those who emitted – the set of people living in, say, the United States now are different than those living in 1950 or 1850. That is, the incentive effects of a backwards looking climate regime seem minimal.

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[49] See Louis Kaplow, Retroactivity, __ Harvard L. Rev. __ (1986).

An incentives-based approach, one that focuses on getting a treaty signed and creating the incentives on actors needed to reduce emissions, would focus on recent behavior rather than on long-past emissions. There would still be a role in a treaty for imposing responsibility for reductions based on bad behavior, but it would involve bad behavior now, not bad behavior in 1950.

III. Taking stock

There are two key lessons. The first is that the data on past emissions presents a mixed picture, and it does not support the claim that the wealthy countries are primarily responsible for past emissions. Under almost any measure, responsibility is spread widely with a positive correlation between emissions and income. That is, wealthy countries tend to emit more but there is wide variance and many poor countries are high per emitters.

The second is that theories of traditional responsibility, those that require fault, require far more complex considerations than the data support or are ever likely to support. Activities that result in emissions are pervasive, and we cannot decide which activities are faulty and which are not. It is possible that we could base responsibility on strict liability, but even then there are problems: we would still not have a close connection between those responsible for emitting and those who end up paying for emissions reductions or those who are relieved of paying for emissions reductions and those who benefit. Moreover, strict liability would likely result in poor countries having large obligations and additional theories would need to be tacked on to prevent the resulting hardship. Finally, even if this could all be worked out, it is not clear how the notion would be applied as part of an ongoing treaty as opposed to a one-time claim for past wrongs.

Incentive-based approaches fare better – they imply that we should mostly care about preventing delay, or taking advantage of natural delays by increasing emissions in the meantime. Essentially, in allocating emissions reductions obligations, we should not give benefits to those who increase emissions between now (or possibly back for some fixed time period) and an eventual treaty. Similarly, we might want to reward those who have reduced emissions in the interim, invested in low carbon technology or engaged in similar good behaviors.

Ultimately, if we can achieve a climate agreement, obligations to reduce emissions will be a result of hard negotiations. There is no larger power that can impose obligations based on notions of responsibility so arguments about responsibility at best help with moral suasion.

Notwithstanding problems with these notions in the climate context, it is extremely likely that they will continue to be part of a negotiation. There is nothing wrong with this – negotiators will use whatever tools they have. But if we try to take them seriously rather than as mere negotiation points, their application presents many problems. The Brazilian proposal or similar arguments about responsibility cannot play the hoped-for role of an objective scientific method of determining treaty obligations.