

Negligence, Strict Liability, and Responsibility for Climate Change

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This Article 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 by other measures, responsibility is spread widely with poor countries responsible for a majority of emissions. The differences in the measurements are due to two factors: (1) whether the data use a comprehensive measure of emissions and (2) the extent to which the data are 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 an injurer to make a payment to victims are the theories underlying tort law. This Article 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.

Claims about responsibility for past greenhouse gas emissions are one of the central reasons for the failure of recent climate negotiations. The conventional account is that wealthy countries are responsible for climate change and developing countries are the victims. Developing nations such as China and India argue that they, therefore, should not have to reduce emissions; they are not responsible for the harms and should not have to pay for them.¹ Instead, they argue that they should be compensated for the harms imposed on them by others. While developed nations have agreed to provide some adaptation funds to developing nations, they resist claims

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. The Brazilian Proposal can be found at U.N. Framework Convention on Climate Change, Ad Hoc Group on the Berlin Mandate, Additional Proposals from Parties on the Implementation of the Berlin Mandate, 7th Sess., July 31–Aug. 7, 1997, FCCC/AGBM/1997/MISC.1/Add.3, GE.97-61399 (May 30, 1997). For a summary of the history and impact of the Brazilian Proposal, see Emilio L. La Rovere et al., *The Brazilian Proposal on Relative Responsibility for Global Warming*, in BUILDING ON THE KYOTO PROTOCOL: OPTIONS FOR PROTECTING THE CLIMATE 157 (Kevin A. Baumert et al. eds., 2002), available at http://pdf.wri.org/opc_full.pdf.

Nations make a variety of other arguments as well. For example, they argue that poor nations should have a right to develop and an emissions cap would unfairly keep them poor. I focus here only on responsibility. See ERIC A. POSNER & DAVID WEISBACH, CLIMATE CHANGE JUSTICE (2010), for a discussion of other arguments about who should have to pay for emissions reductions.

about responsibility as a general basis for allocating emissions reductions. They argue that only global action can adequately address the problem and that arguing about past actions only gets in the way of pragmatic solutions.

Because of its importance to climate negotiations, philosophers, scientists, and legal analysts have all made arguments about the extent to which past emissions should give rise to obligations of one sort or another. For example, philosopher Peter Singer argued:

[T]o put it in terms a child could understand, as far as the atmosphere is concerned, the developed nations 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.²

Others have made similar arguments. Scientists have weighed in through a United Nations body commissioned to study how to allocate responsibility for past emissions.³ They have proposed a variety of formulas based on measurements of the extent to which past emissions have led to or in the future will lead to actual temperature changes. Legal analysts have focused on the details of lawsuits against emitters and have also made more

2. PETER SINGER, ONE WORLD: THE ETHICS OF GLOBALIZATION 33–34 (2002).

3. The United Nations Framework Convention on Climate Change delegated additional research on the Brazilian Proposal, described *supra* note 1, 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. To view these reports, see *News Archive 2007*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, <http://unfccc.int/press/news.archive/items/4282.php> (last visited Oct. 26, 2011). An ad hoc group of scientists working on this research formed Modeling and Assessment of Contributions to Climate Change, or MATCH. To view their results, see *What's New?*, MATCH, <http://www.match-info.net> (last visited Oct. 3, 2011). Another group of scientists has created FAIR: Framework to Assess International Regimes for differentiation of commitments. See *Framework To Assess International Regimes for Differentiation of Commitments*, PBL NETHERLANDS ENVTL. ASSESSMENT AGENCY (Oct. 13, 2010), <http://themasites.pbl.nl/en/themasites/fair/index.html>.

For additional discussions of responsibility for past emissions, see Simone Bastianoni et al., *The Problem of Assigning Responsibility for Greenhouse Gas Emissions*, 49 *ECOLOGICAL ECON.* 253, 253–57 (2004) (comparing different methods and proposing a specific method to assign responsibility for greenhouse gas emissions); Michel den Elzen et al., *Analysing Countries' Contribution to Climate Change: Scientific and Policy-Related Choices*, 8 *ENVTL. SCI. & POL'Y* 614, 634–36 (2005) (evaluating the Brazilian Proposal and its sensitivity to parameter choice); Niklas Höhne & Kornelis Blok, *Calculating Historical Contributions to Climate Change—Discussing the 'Brazilian Proposal'*, 71 *CLIMATIC CHANGE* 141, 163–64 (2005) (discussing methodological issues with the “Brazilian Proposal”); Luiz Pinguelli Rosa et al., *Comments on the Brazilian Proposal and Contributions to Global Temperature Increase with Different Climate Responses—CO₂ Emissions Due to Fossil Fuels, CO₂ Emissions Due to Land Use Change*, 32 *ENERGY POL'Y* 1499, 1504–08 (2004) (studying the sensitivity of responsibility measures to estimates of climate response); Richard S.J. Tol & Roda Verheyen, *State Responsibility and Compensation for Climate Change Damages—A Legal and Economic Assessment*, 32 *ENERGY POL'Y* 1109, 1123–25 (2004) (estimating state responsibility for climate change using cumulative emissions after 2000).

general ethical arguments.⁴ Finally, philosophers and political scientists have argued that responsibility notions should play a central role in determining obligations to reduce emissions.⁵

This Article reexamines responsibility for climate change. Claims of responsibility are based on legal and ethical principles concerning liability for wrongdoing. They are, in essence, tort claims. Tort law principles might be used in actual legal disputes to make quasi-legal arguments in a negotiation or to simply claim moral wrongdoing by a set of actors. The goal, therefore, is to examine whether tort law or similar theories of obligation apply to past greenhouse gas emissions.⁶

Any claim of responsibility, tort-based or otherwise, must be based on causation and demonstrate that the entity facing the obligation actually did the wrongful act. Part I of this Article addresses this issue by examining the available data on past emissions.

To do this, I use data gathered by the World Resources Institute (an environmental NGO), which is publicly and freely available in their Climate Analysis Indicators Tool (CAIT).⁷ The data show that under a wide variety of

4. See, e.g., Daniel A. Farber, *Basic Compensation for Victims of Climate Change*, 155 U. PA. L. REV. 1605 (2007) (sketching the design of a compensation system for harms from changes to basic geographical characteristics); Michael G. Faure & André Nollkaemper, *International Liability as an Instrument To Prevent and Compensate for Climate Change*, 43A STAN. J. INT'L L. 123 (2007) (examining the case for liability); David Hunter & James Salzman, *Negligence in the Air: The Duty of Care in Climate Change Litigation*, 155 U. PA. L. REV. 1741 (2007) (examining whether greenhouse gas emitters have a duty of care); Eric A. Posner, *Climate Change and International Human Rights Litigation: A Critical Appraisal*, 155 U. PA. L. REV. 1925 (2007) (arguing against legal liability for climate damages). For a discussion of ethical issues by legal commentators, see POSNER & WEISBACH, *supra* note 1, at 99–118 (arguing against responsibility as a basis for emissions reductions); Matthew D. Adler, Commentary, *Corrective Justice and Liability for Global Warming*, 155 U. PA. L. REV. 1859 (2007) (arguing that corrective-justice principles are not sufficient to support legal liability for climate damages); Daniel A. Farber, *The Case for Climate Compensation: Justice for Climate Change Victims in a Complex World*, 2008 UTAH L. REV. 377 (arguing that the United States has a duty to reduce emissions because of its responsibility for past emissions).

5. See, e.g., CLIMATE ETHIC: ESSENTIAL READINGS (Stephen M. Gardiner et al. eds., 2010); JAMES GARVEY, THE ETHICS OF CLIMATE CHANGE: RIGHT AND WRONG IN A WARMING WORLD (2008); PAUL G. HARRIS, WORLD ETHICS AND CLIMATE CHANGE (2010); STEVE VANDERHEIDEN, ATMOSPHERIC JUSTICE: A POLITICAL THEORY OF CLIMATE CHANGE (2008). For collections of essays about equity in climate abatement and adaptation more generally, see FAIR WEATHER? EQUITY CONCERNS IN CLIMATE CHANGE (Ferenc L. Tóth ed., 1999); FAIRNESS IN ADAPTATION TO CLIMATE CHANGE (W. Neil Adger et al. eds., 2006).

6. 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. 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.

7. CAIT: *Climate Analysis Indicators Tool*, WORLD RESOURCES INST. (2010), <http://cait.wri.org>. The data presented here, with the exception of that contained in Figure 3, are based on CAIT as of April 22, 2011. As discussed below, Figure 3 uses CAIT data as of November 10,

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 than developed countries. Similarly, if we measure emissions on a per capita basis or an intensity basis, many poor or small countries are near the top of the list. Simple stories about climate change 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 are 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 is no justification 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.

Part II of this Article addresses whether the measures of responsibility so far proposed are consistent with tort-based theories of responsibility for past harms. 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, is 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.

Part II then examines how past emissions fit into each of these notions of tort obligations. Responsibility notions, I argue, do not work very well in the climate change context. There are four problems. First, there is no feasible way to measure responsibility. In most theories of responsibility, dating back to Aristotle, an actor is responsible only where he is at fault. Carbon emissions are part of almost everything we do, however, so determining fault requires determining which activities are culpable and which are not. For example, we have to know whether it is blameworthy to burn fossil fuels to heat your home if you live in a very cold environment or

2008 in order to include land-use-change data which were subsequently deleted from the CAIT database. Issues surrounding the use of that data are discussed *infra* Part I.A–B.

to cool your home if you live in a hot environment (and if so, what sort of insulation is required and what size home is allowed); what size car you can drive and how far; whether it is ethical to eat meat (the production of which causes high levels of emissions); and whether it is ethical to increase the population by having, say, more than one or two children. We have to know whether the use of fertilizers to feed the population is ethical because it reduces the land needed for agriculture, or is unethical because its use permits a larger population (and hence greater ultimate emissions) to be sustained. We do not have answers to these sorts of questions. We do not even have any way of answering them. Responsibility notions, which were developed with clear wrongdoing in mind, do not work well when applied to everyday living.

An alternative would be to base the claim of responsibility on strict liability theory. We would, under this approach, count all emissions, regardless of whether they are a result of culpable behavior. Strict liability 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 need to make fine distinctions between different types of behaviors, although not entirely. We would still need to determine a starting date—strict liability can be (although rarely is) imposed fully retroactively, only prospectively, 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 Similar issues arise for population and immigration issues.

Second, responsibility-based arguments 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, twenty-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, responsibility-based arguments may 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 certain poor countries. Being poor does not excuse you from tort liability; poor nations could not use the bad distributive effects of a responsibility-based theory to avoid obligations. A climate treaty may have to choose between good distributive effects and basing future abatement obligations on responsibility for past emissions.

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.

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.

The 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 than the responsibility-based approach. An 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 focuses on how structuring obligations under a treaty affects the decisions of actors today.

In particular, under an incentives-based approach, we would not want future treaties to give benefits to nations that resisted earlier treaties. The focus of an incentives-based approach, therefore, would be on recent climate-favorable or climate-unfavorable activities, rewarding nations that have reduced emissions now or in the recent past. This approach, for example, might draw a sharp distinction between the United States and Europe on this basis, while a responsibility-based approach would tend to treat them similarly because of similar past emissions.

An incentives-based approach would also be concerned with costs, attempting to find ways to minimize the costs of emissions reductions. Although further empirical study is needed, wealthy nations may have a far greater ability to act now. To minimize costs if this is the case, wealthy countries would bear much of the immediate burden in reducing emissions.

The two Parts of this Article follow the two pieces of the argument. Part I considers the data on past emissions and the problem of aggregation. Part II considers theories of responsibility. Part III concludes.

I. CAUSATION: WHO EMITTED IN THE PAST?

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, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride.⁹ The Intergovernmental Panel on Climate Change (the “IPCC”) lists around sixty gases that contribute to climate change (the six gases or categories of gases covered by Kyoto plus ozone-depleting chemicals, fluorinated ethers,

9. Kyoto Protocol to the United Nations Framework Convention on Climate Change Annex A, Dec. 11, 1997, 37 I.L.M. 22, available at <http://unfccc.int/resource/docs/convkp/kpeng.pdf>.

perfluoropolyethers, and certain hydrocarbons).¹⁰ Moreover, land-use change, such as deforestation or agricultural production, 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 a particular 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 one hundred years compared to the contribution of a unit of carbon dioxide, known as CO₂-eq.¹¹ All of the data used below (to the extent gases other than carbon dioxide are considered) are in CO₂-eq units.

A. DATA SOURCES

The data on emissions vary considerably, both by source and by time period. The World Resources Institute is an environmental think tank whose mission is to protect the Earth's environment and, in particular, to "[p]rotect the global climate system from further harm due to emissions of greenhouse gases."¹² It developed CAIT as a database of information on greenhouse gas emissions.¹³ CAIT is publicly and freely available and 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.¹⁴ All the data used here are from CAIT.¹⁵

10. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 33-34 tbl.TS.2 (Susan Solomon et. al. eds., 2007).

11. *Id.* at 31.

12. *Who We Are*, WORLD RESOURCES INST., <http://www.wri.org/about> (last visited Oct. 26, 2011).

13. *CAIT: Climate Analysis Indicators Tool*, *supra* note 7.

14. *Id.*

15. All of the data comes from CAIT accessed on April 22, 2011, except for the data used to produce Figure 3 and Table 5. Those results use data on cumulative emissions from land-use change. The cumulative emissions from land-use change were deleted from CAIT. The data for that figure are from CAIT accessed on November 10, 2008, when CAIT contained this data. *See supra* text accompanying note 7.

There are a number of other similar sources for emissions data. For instance, EDGAR provides the data used in the IPCC chart reproduced below. *EDGAR: Emission Database for Global Atmospheric Research (EDGAR)*, PBL NETHERLANDS ENVTL. ASSESSMENT AGENCY (Oct. 5, 2010), <http://www.mnp.nl/edgar/>. Additionally, the Carbon Dioxide Information Analysis Center

The sources of the data used by CAIT are discussed extensively on their website.¹⁶ I highlight here only the most central issues. 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 “Framework Convention”).¹⁷ CAIT supplements the Framework Convention data with additional sources to fill in gaps and reduce uncertainties.¹⁸

Carbon dioxide is the most important greenhouse gas and also, fortunately, is where the data are the strongest. Starting in 1990, most developed countries (so-called Annex I countries under the Framework Convention)¹⁹ were obligated to submit greenhouse gas inventories using standardized and transparent methodologies;²⁰ so the data for these countries since 1990 are generally good. Developing countries have fewer reporting obligations,²¹ and the data are correspondingly less reliable. Some developing countries have submitted inventories of emissions from which one or two years of data can be derived but others have not yet submitted any data.²²

Emissions data for years prior to 1990 (and for some developing countries for more recent years as well) have to be stitched together from a variety of less accurate sources, including the International Energy Agency and the Energy Information Administration.²³ These sources, however, only extend the coverage back until the 1960s at best.²⁴ 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

collects emissions data. CDIAC, <http://cdiac.ornl.gov/> (last visited Oct. 26, 2011). Finally, the IPCC data are publicly available on their website. I chose CAIT because of its completeness and its ease of use.

16. CAIT: *Climate Analysis Indicators Tool*, *supra* note 7; see also WORLD RES. INST., CAIT: GREENHOUSE GAS SOURCES & METHODS (2010), available at http://cait.wri.org/downloads/cait_ghgs.pdf.

17. WORLD RES. INST., *supra* note 16, at 23; see United Nations Framework Convention on Climate Change, art. 4, ¶ 4(a), May 9, 1992, 1771 U.N.T.S. 107 [hereinafter Framework Convention]; see also UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, <http://unfccc.int/2860.php> (last visited Oct. 26, 2011) (explaining the Framework Convention).

18. WORLD RESOURCES INST., *supra* note 16, at 6.

19. Framework Convention, *supra* note 17, Annex I.

20. *Id.* art. 2, ¶ 2(b).

21. *Id.* arts. 4, 12.

22. See WORLD RES. INST., *supra* note 16, at 6; CAIT: *Climate Analysis Indicators Tool*, *supra* note 7.

23. WORLD RES. INST., *supra* note 16, at 6.

24. *Id.* at tbl.1.

Information Analysis Center,²⁵ which has data back to 1751.²⁶ There are no direct data on emissions going back this far. Instead, the data are derived from historical records of coal and oil production, as well as imports and exports, on the theory that any extracted or imported fossil fuel that was not exported must have been burned locally.²⁷ As one might expect, the data get less reliable when CAIT goes back further in time.

All of the data in the CAIT database (and all other major databases on carbon dioxide emissions) allocate emissions to the physical location of the emissions.²⁸ For example, suppose that an exporting country emits carbon while producing a good that is ultimately consumed by individuals in an importing country. The emissions physically come from the exporting country, and, as a result, under the usual measure of emissions, all of the emissions are allocated there. This approach follows the IPCC convention for allocating emissions in its emissions inventories. It is not at all clear, however, that this is appropriate, and an alternative measure might use the place of consumption or some mix of production and consumption. Part I.C.4 presents a consumption-based measure of emissions based on input-output analysis.²⁹

Non-CO₂ gases make up about 40% of global emissions, but data for emissions of these gases are sparse. CAIT currently has data for five additional greenhouse gases (CH₄, N₂O, PFC's, HFC's, and PF₆) for four years: 1990, 1995, 2000, and 2005.³⁰ A problem arises because emissions of these gases are from many dispersed sources where measurement is difficult. Major sources of CH₄ and N₂O, for example, include enteric fermentation in livestock, rice farming, soil tilling, landfills, and fugitive gases from coal mining.³¹ HFC emissions arise from leakages of systems such as air conditioning. Even for developed countries following Framework Convention protocols, the data are 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

25. *Id.*

26. *Global, Regional, and National Fossil-Fuel CO₂ Emissions*, CDIAC (2010), http://cdiac.ornl.gov/trends/emis/overview_2007.html. CAIT itself includes data back to 1850. WORLD RES. INST., *supra* note 16, at 7.

27. *See* WORLD RES. INST., *supra* note 16, at 8 box 1.

28. *Id.*

29. *Infra* Part I.C.4. Those calculations are based on the GTAP7 database rather than CAIT. *Global Trade Analysis Project (GTAP)*, PURDUE UNIV. (2011), <https://www.gtap.agecon.purdue.edu/databases/v7/default.asp> (on file with author). "The GTAP Data Base is a fully documented, publicly available [(although not free)] global data base which contains complete bilateral trade information, transport and protection linkages among 113 regions for all 57 GTAP commodities for a single year (2004 in the case of the GTAP 7 Data Base)." *Id.*

30. WORLD RES. INST., *supra* note 16, at 13-14.

31. For a discussion of emissions sources, see Gilbert E. Metcalf & David Weisbach, *The Design of a Carbon Tax*, 33 HARV. ENVTL. L. REV. 499 (2009).

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

Prior versions of CAIT had estimates of emissions from land-use change dating from 1950 to 2000 (and in some cases to 2005). The estimates were based on data from researchers specializing in measuring emissions from land-use change rather than on Framework Convention data.³² In 2008, these researchers updated their work, but with the exception of a few major emitting countries, they included only regional-level and global-level estimates, not country-level estimates. CAIT correspondingly updated its data, and as a result, country-level, historical land-use emissions data are no longer available in CAIT. Because one of the goals of the data presented here is to focus on country-level estimates, I continue to use the data provided in the prior version of CAIT. Estimates of emissions from land-use change are uncertain at best. Given the revisions made to the data, the estimates should be viewed as suggestive rather than definitive.³³ The overall trend in the 2008 updates was to reduce the estimated emissions from land-use change and forestry, so the data presented may reflect an upward bias.

One of the more difficult challenges in determining past greenhouse gas emissions 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 there may not be 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 to 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 on Global Climate Change reports

32. See R.A. Houghton, *Revised Estimates of the Annual Net Flux of Carbon to the Atmosphere from Changes in Land Use and Land Management 1850–2000*, 55B TELLUS 378 (2003), for one example of the type of data used in prior versions of CAIT.

33. The estimates also go back to 1850, but these data are not included in any version of CAIT and are not used here. For the older data, see Richard A. Houghton, *Carbon Flux to the Atmosphere from Land-Use Changes 1850–2005*, CDIAC (2008), <http://cdiac.ornl.gov/trends/landuse/houghton/houghton.html>.

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 benefitted from emitting vast quantities of greenhouse gases over the last century.”³⁴ Similarly, a paper published by Resources for the Future states that “[d]eveloped countries are responsible for the largest share of cumulative past [greenhouse gas] emissions by far.”³⁵ The United Nations Environment Programme states, “Historically the developed countries of the world have emitted most of the anthropogenic greenhouse gases.”³⁶ And Peter Singer, a prominent philosopher, assumes that emissions are essentially entirely from developed countries.³⁷

The IPCC presents a chart summarizing this view, which is reproduced as Figure 1.³⁸ 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. The percentages listed are the region’s share of total emissions in 2004.

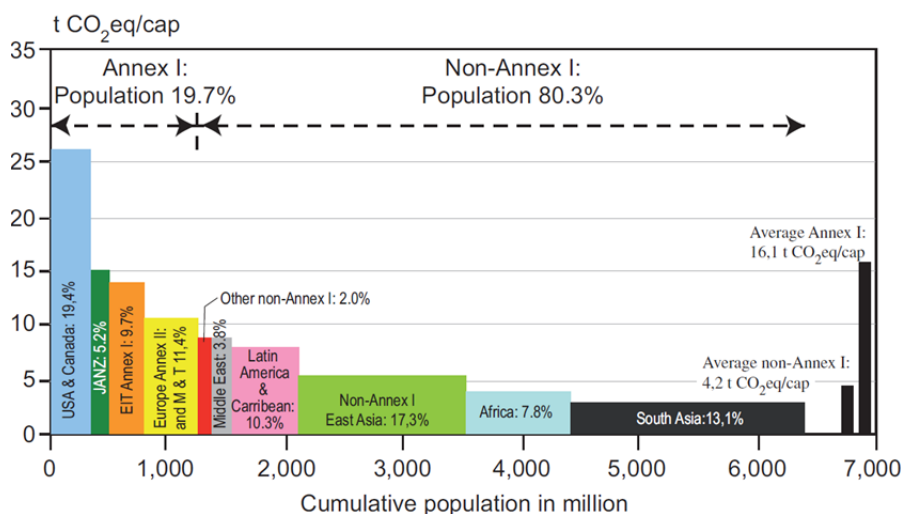


Figure 1

34. EILEEN CLAUSSEN & LISA MCNEILLY, PEW CTR. ON GLOBAL CLIMATE CHANGE, EQUITY & GLOBAL CLIMATE CHANGE 20 (1998), available at http://www.pewclimate.org/docUploads/pol_equity.pdf.

35. MARINA CAZORLA & MICHAEL TOMAN, RES. FOR THE FUTURE, INTERNATIONAL EQUITY AND CLIMATE CHANGE POLICY 3 (2000) (Res. for the Future’s Climate Econ. and Policy Program, Climate Issue Brief No. 27), available at <http://www.rff.org/rff/Documents/RFF-CCIB-27.pdf>.

36. UNITED NATIONS ENV’T PROGRAMME, VITAL CLIMATE CHANGE GRAPHICS 14 (2005), available at http://www.grida.no/files/publications/vital-climate_change_update.pdf.

37. *Supra* text accompanying note 2.

38. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: MITIGATION OF CLIMATE CHANGE 106 fig.1.4a (Bert Metz et al. eds., 2007).

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

The IPCC chart is based on data from the Emission Database for Global Atmospheric Research (EDGAR) and the International Energy Agency (IEA).³⁹ To confirm the results, I recreated the same chart using CAIT data for emissions from 2005 using the six Kyoto gases and land-use change. The result, while not precisely the same, is qualitatively similar. The results are presented graphically in Figure 2 and numerically in Table 1. The percentage listed in each column in Figure 2 (e.g., 17.6% for USA & Canada) is the percent of global emissions from each region.⁴⁰

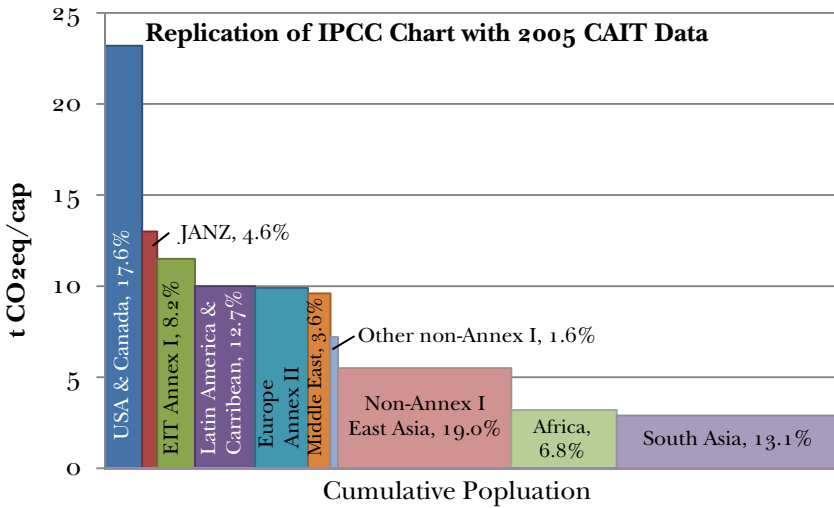


Figure 2: Replication of IPCC Presentation

39. See *supra* note 15.

40. The countries within each region are listed in the IPCC chart, *supra* note 38.

Table 1: 2005 Emissions, CAIT data, IPCC Aggregation

Six Kyoto gases + land-use change

Region	MtCO ₂ -eq	% of Total	Tons/ Person	Thousands of People (2006)	% of World
USA & Canada	7,601	17.6%	23.2	334,266	5.1%
JANZ	1,983	4.6%	13	153,072	2.3%
EIT, Annex I	3,536	8.2%	11.5	304,873	4.6%
Latin America and Caribbean	5,478	12.7%	10	561,731	8.49%
Europe Annex II & M&T	4,648	10.8%	9.9	476,884	7.20%
Middle East	1,536	3.6%	9.6	166,242	2.51%
Other Non-Annex I	681	1.6%	7.2	96,566	1.46%
Africa	2,193	6.8%	3.2	952,642	14.39%
South Asia	5,676	13.1%	2.9	1,992,357	30.10%
Non-Annex I East Asia	8,206	19.0%	5.5	1,498,139	22.63%

C. ALTERNATIVE VIEWS

In this Subpart, 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.

1. Flows

Start with the simplest measure: flows of the six most important greenhouse gases plus the effects of land-use change. The list of the top twenty emitters in 2005 for the six Kyoto gases plus land-use change is presented in Table 2.⁴¹ These countries make up 74% of worldwide emissions. The table also lists per capita emissions (in absolute terms and by rank) and per capita wealth (calculated on a purchasing-power-parity basis).

41. I look at the top twenty emitters because these are likely to be among the most important nations to include in a climate treaty. As discussed in Part I.D, any selective use of data, even if merely for convenience and to help understanding, risks missing important information.

Table 2: Total GHG Emissions in 2005CO₂, CH₄, N₂O, PFCs, HFCs, SF₆ and land-use change, in Mt of CO₂-eq.

Rank	Country	MtCO ₂ e	% of Total	Tons/Person	Rank	\$/Person
1	China	7,186	16.6%	5.5	93	5,085
2	United States	6,797	15.7%	23.0	10	43,031
3	Brazil	2,842	6.6%	15.3	19	9,146
4	Indonesia	2,042	4.7%	9.3	55	3,519
5	Russia	2,013	4.7%	14.1	23	13,911
6	India*	1,859	4.3%	1.7	153	2,600
7	Japan*	1,346	3.1%	10.5	45	31,669
8	Germany*	978	2.3%	11.9	33	33,183
9	Canada	804	1.9%	24.9	9	36,324
10	Mexico	685	1.6%	6.6	81	13,307
11	UK	644	1.5%	10.7	44	34,192
12	S. Korea*	569	1.3%	11.8	34	25,021
13	Italy*	562	1.3%	9.6	54	28,789
14	Iran*	559	1.3%	8.1	67	10,346
15	Australia*	558	1.3%	27.3	7	35,184
16	France*	550	1.3%	9.0	59	30,636
17	Ukraine*	494	1.1%	10.5	46	6,547
18	Nigeria	455	1.1%	3.2	117	1,872
19	Venezuela	447	1.0%	16.8	16	11,480
20	Spain*	437	1.0%	10.1	50	28,510

* Data from land-use change not available

Table 3 provides a number of different ways of aggregating this data. If we confine our attention to the top twenty emitters (on the theory that these countries will be most of the central countries in any emissions-reduction treaty) and use the World Bank's definition of high-income nations as those with more than \$12,276 per capita,⁴² high-income nations make up 37% of global emissions. The other nations in the top twenty also produce 37% of global emissions; emissions from the top twenty are split evenly between wealthy and non-wealthy nations. If we instead look at all nations, high-

42. *How We Classify Countries*, WORLD BANK, <http://data.worldbank.org/about/country-classifications> (last visited Oct. 26, 2011).

income nations emit about 46% of the total; other (non-wealthy) nations emit about 53%.

If we increase the standard for being high-income (\$12,276 per capita is not a lot), the proportion of emissions from wealthy nations goes down. The key issue is whether we consider Russia, with a per capita income of \$13,911 to be high-income. Russia has roughly the same per capita income as Botswana. Even though it plays an important role in international politics, it is not clear that it should be counted as high-income. If we exclude Russia by defining high-income nations as those with per capita income of \$18,000 and we consider all nations, high-income nations make up 37% of the total global emissions.

Table 3 also provides a breakdown by whether a nation is in Annex I of the Framework Convention. This does not precisely correspond to wealth. South Korea, with per capita income of more than \$25,000—wealthy under any measure—is not in Annex I, while Russia is. Mexico, with per capita income almost exactly the same as Russia's, is not.⁴³

Finally, Table 3 shows the breakdown if we look only at energy-related emissions, using the World Bank's definition of wealthy. It presents 2007 data instead of 2005 data because this information is available for energy emissions. After this aggregation, wealthy nations are the dominant source of emissions and are responsible for 65% of the total. The reason for the difference is that middle-income and poor countries have higher emissions from land-use change while rich countries have higher emissions from energy.

Table 3: Summary of aggregations

Flows, six Kyoto gases and land-use change 2005 (2007 for energy only)

Which nations?	Test	Wealthy/ Annex I	Other nations
Top 20	Wealthy, World Bank definition	37%	37%
All nations	Wealthy, World Bank definition	46%	53%
All nations	Wealthy = \$18,000 per capita	37%	62%
Top 20	Annex I	35%	40%
All nations	Annex I	41%	57%
Energy only, top 20	Wealthy, World Bank definition	65%	28%

2. Stocks

Current emissions are not a very good measure of responsibility because carbon dioxide and other greenhouse gases have long lives in the

43. Framework Convention, *supra* note 17, Annex I.

atmosphere. A ton of carbon dioxide in the atmosphere has the same effect regardless of when it was emitted. 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. As noted, CAIT currently does not have historic land-use change data by country; a prior version of CAIT had data on land-use change back to 1950 and up to 2000. CAIT also does not have data on gases other than CO₂ prior to 1990. Historical data, therefore, are subject to significant measurement error. Subject to this error, Figure 3 illustrates CAIT data on cumulative emissions from 1950 to 2000 from energy and land-use change.⁴⁴

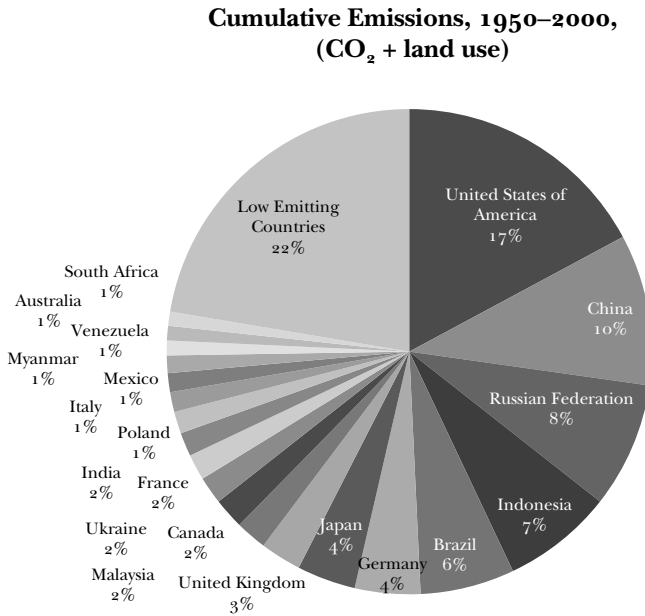


Figure 3: Cumulative Emissions, 1950–2000, CO₂ and land-use change

The numbers do not differ substantially from the flow data given above. The top twenty emitters make up 77% of the global total. Using the World Bank's definition, high-income countries in the top twenty comprise 47% of cumulative emissions. Other countries in the top twenty make up 30% of cumulative emissions. High-income, top twenty emitters in this case include Russia, Malaysia, and Mexico—all of which are essentially right at the borderline of the definition of high income (per capita income of \$12,276). If these three countries are not treated as high income, the wealthy countries in the top twenty make up 36% of cumulative emissions while the

44. These data were accessed on CAIT in November 2008. *CAIT: Climate Analysis Indicators Tool*, *supra* note 7.

other countries in the top twenty make up 42% of the total. Roughly similar results hold if we look at the entire list of Annex I countries.

If we want to go back further, the only data available are carbon-dioxide emissions from energy use. The CAIT database has emissions from energy use from 1850 to 2006. CAIT calculates the removal of carbon dioxide from the atmosphere, allowing us to calculate current carbon dioxide in the atmosphere from emissions in the past.

Out of the top twenty emitters, high-income countries are responsible for 62% of the global concentrations of carbon dioxide.⁴⁵ Annex I countries are responsible for the same amount. If we exclude Russia and Mexico from the list of wealthy countries, wealthy countries are responsible for 53% of current concentrations. 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 definition of high income. Broader measures of emissions or different aggregations produce different numbers.

3. Per Capita Measures

The IPCC chart reproduced as Figure 1 was based on per capita emissions presumably because 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 (i.e., for a given year) or a stock basis. Table 4 is a list of the top twenty countries for per capita emissions in 2005 for the six Kyoto gases plus land-use change. Notably, most of the top countries are small and wealthy. Moreover, a large number of the countries on this list have economies based on petroleum extraction, which is highly carbon intensive.

45. If we instead calculate the sum of prior emissions, not adjusting for the removal of CO₂, the result is almost identical, with wealthy top twenty countries responsible for 64% of the total, 2% more than if we allow for carbon to be reabsorbed.

Table 4: Per Capita GHG Emissions in 2005
CO₂, CH₄, N₂O, PFCs, HFCs, SF₆ and land-use change

Rank	Country	CO ₂ e/ Person	MtCO ₂ e	% of Total	\$/ Person
1	Qatar**	68.9	61	0.14%	63,151
2	United Arab Emirates*	39.0	160	0.37%	53,386
3	Kuwait*	34.8	88	0.20%	45,539
4	Brunei**	33.1	12	0.03%	47,949
5	Bahrain**	29.0	21	0.05%	30,962
6	Trinidad & Tobago**	27.4	36	0.08%	22,551
7	Australia*	27.3	558	1.29%	35,184
8	Luxembourg*	26.7	12	0.03%	74,028
9	Canada	24.9	804	1.86%	36,324
10	United States	23.0	6,797	15.74%	43,031
11	Bolivia	21.9	201	0.46%	3,788
12	New Zealand*	19.1	79	0.18%	25,532
13	Turkmenistan*	18.9	91	0.21%	5,647
14	Oman	18.9	50	0.11%	21,412
15	Equatorial Guinea**	18.0	11	0.03%	28,876
16	Venezuela	16.8	447	1.04%	11,480
17	Ireland*	16.8	70	0.16%	41,294
18	Saudi Arabia*	16.3	377	0.87%	21,643
19	Brazil	15.3	2,842	6.58%	9,146
20	Central African Republic**	14.9	61	0.14%	683

* Land-use change data not available.

** Land-use change, PFC, HFC, and SF₆ data not available.

The list changes somewhat if we include estimates of land-use change from a number of smaller countries. Table 5 presents the list, this time for cumulative emission, and using, as above, the older CAIT data that includes historical land-use change information on a per country basis.

Table 5: Cumulative Emissions, 1950–2000CO₂ (energy) + land-use change

Rank	Country	CO ₂ /Person	MtCO ₂	% of Total	Rank
1	Belize	3,390	958	0.09%	88
2	Guyana	2,146	1,610	0.15%	72
3	Luxembourg	1,310	594	0.05%	103
4	Malaysia	900	22,397	2.06%	11
5	Papua New Guinea	759	4,381	0.40%	39
6	Panama	709	2,252	0.21%	60
7	Canada	708	22,631	2.08%	10
8	Czech Republic	665	6,790	0.62%	30
9	Estonia	664	895	0.08%	92
10	United States	636	186,669	17.15%	1
11	Russia	634	91,182	8.38%	4
12	Zambia	598	6,867	0.63%	29
13	Qatar	582	452	0.04%	115
14	Germany	576	47,525	4.37%	7
15	Kazakhstan	575	8,624	0.79%	24

This list includes a number of small, relatively poor countries that do not appear in Table 4, such as Belize, Guyana, and Papua New Guinea. Although the reason for the difference is not entirely clear, it appears to be that the more recent data in CAIT do not include land-use-change data at all for these countries even though most of their emissions are from land use. The countries at the top of the list in Table 4 tend to be oil-producing countries instead of countries with deforestation. If we do not include land use (say because we want to go back to years before the very best land-use data were available), many of the poor countries that have engaged in significant deforestation fall off of the list.

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 in a climate treaty. If we were to limit the list to major emitters plus wealthy countries—the most important candidates for a climate treaty—Australia, Canada, the United States, Venezuela, and Brazil would top the list. Russia is 23rd, Indonesia is 55th, China is 93rd (at almost exactly the global average), and India is 152nd, out of 185 countries in CAIT.⁴⁶ To the extent that China and India are the central developing-country negotiating partners in a climate treaty, it

46. These numbers are based on 2005 per capita flows of emissions for the six Kyoto gases and land-use change.

is clear that they have much lower per capita emissions than wealthier nations. Brazil, on the other hand, has high per capita emissions, is likely to play an important role in negotiating a climate treaty, and is not wealthy.

4. Production vs. Consumption

The numbers in the CAIT database are based on production. If a country emits carbon dioxide during the production of a good, the emissions are attributed to that country even if the good is consumed elsewhere. Production measures are standard. They are mandated by the Framework Convention for its inventories⁴⁷ and are used by the European Union in allocating emissions reductions to countries within the European Union for complying with the Kyoto Protocol.⁴⁸

An alternative measure would attribute the emissions to the consumer. There is no clear reason why one measure is preferable to the other. Emissions could equally be assigned to the producer, the consumer, or some of each; there is a multiparty transaction in which all the parties gain and which results in emissions. The advantage of production numbers is that they are far easier to collect—but that does not make them correct.

Production data can be converted into consumption data using input-output analysis, which enables us to follow the flow of goods through the economy. The basic procedures are described in an extensive literature.⁴⁹ Table 6 is from the calculations based on GTAP 7 data, which is for 2004.⁵⁰ The production numbers are close to (but not precisely the same as) the CAIT data for emissions from energy.

The diagonal entries are the emissions from the domestic production of goods that are consumed domestically. Across a row are emissions from local production for goods consumed elsewhere. For example, the United States “exported” 280 million metric tons of carbon dioxide to the European Union in the sense that 280 million tons of emissions in the United States are for the production of goods consumed in the European Union. Total emissions from production in the United States in 2004 were 6,002 million metric tons. Reading down a column gives the imports. The United States imported 303 million tons of carbon dioxide from the European Union in

47. Framework Convention, *supra* note 17, art.12.

48. For a discussion of the burden-sharing agreement, see Per-Olov Marklund & Eva Samakovlis, *What Is Driving the EU Burden-Sharing Agreement: Efficiency or Equity?*, 85 J. ENVTL. MGMT. 317 (2007).

49. Steven J. Davis & Ken Caldeira, *Consumption-Based Accounting of CO₂ Emissions*, 107 PROC. NAT'L ACAD. SCI. 5687 (2010); Thomas Weidmann, *A Review of Recent Multi-Region Input-Output Models Used for Consumption-Based Emission and Resource Accounting*, 69 ECOLOGICAL ECON. 211 (2009).

50. The calculations are taken from Joshua Elliott et al., *CIM-EARTH: Framework and Case Study*, 10 B.E. J. ECON. ANALYSIS & POL'Y, Article 11, at 21 (2010), and Joshua Elliott et al., *Trade and Carbon Taxes*, 100 AM. ECON. REV. 465, 467 (2010).

that the emissions from production occurred in the European Union, but the consumption of the resulting good was in the United States. The row labeled “Cons” gives us the total emissions in a region measured on a consumption basis. The column labeled “Production” gives us the traditional production-based measure. The bottom row, “Net,” gives us the difference.⁵¹

Table 6: Consumption v. Production Measures of Emissions

Energy only, GTAP 7 database

2004	Annex I					Non-Annex I			Production
	US	EU	RUS	JAP	CAN	CHK	LAM	ROW	
US	5,012	280	7	95	177	109	209	113	6,002
EU	303	3,928	63	72	28	96	66	306	4,862
RUS	71	408	1,468	22	3	83	22	100	2,177
JAP	84	82	3	1,146	8	160	12	98	1,593
CAN	248	33	1	9	223	12	8	10	544
CHK	577	587	32	390	50	3,679	103	478	5,896
LAM	293	122	6	18	16	36	956	40	1,487
ROW	300	657	31	289	20	376	55	3,199	4,927
Cons.	6,888	6,097	1,611	2,041	525	4,551	1,431	4,344	27,488
Net	886	1,235	-566	448	-19	-1,345	-56	-583	

As can be seen, the United States, the European Union, and Japan are substantial importers of carbon. Of the Annex I nations, only Russia is a substantial exporter; Canada is a very modest exporter—almost entirely to the United States. This is likely because Russia exports fossil fuels, and fossil fuel extraction is highly energy intensive.⁵² All of the non-Annex I countries or regions are net exporters, with China being by far the largest exporter. In 2004, the United States and China had roughly the same emissions when measured on a production basis, but the United States had much larger emissions when measured on a consumption basis.

51. “JAP” is Japan, “CHK” is China and South Korea, “LAM” is Latin America, and “ROW” is the rest of the world.

52. Note that direct trade in fossil fuels does not affect the numbers. Under the normal production measure, emissions are counted where they occur, so if a nation purchases fossil fuels from another nation and then burns the fuel, the purchasing nation is attributed the emissions. Therefore, trade in actual carbon molecules is already taken into account under production-based measures. Russia’s exports of fossil fuels, for example, are not attributed to Russia under the production (or consumption) measure. The table adjusts the production measure for virtual trade in carbon—trade in goods whose production resulted in emissions. If fossil fuels take energy to extract and are then traded, emissions from the energy used for extraction is treated as trade carbon in the calculation.

On net, shifting to consumption-based accounting from production-based accounting reinforces the standard view that wealthy countries are largely responsible for emissions (with the exception of Russia and Canada, if we count Russia as wealthy, where it cuts the other way).

5. Intensity

Yet another 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 7 is a list of the top twenty 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 very poor countries.

Table 7: GHG Intensity of Economy in 2005

CO₂, CH₄, N₂O, PFCs, HFCs, SF₆, including land-use change

Rank	Country	tCO ₂ e Eq./Mill.\$	Index
1	Zimbabwe*	28,398.70	100.0
2	Central African Republic**	22,691.30	79.8
3	Congo, Dem. Republic	17,141.90	60.1
4	Zambia*	11,901.10	41.5
5	Bolivia	5,819.30	19.9
6	Cambodia	5,300.00	18.1
7	Papua New Guinea*	4,628.40	15.7
8	Mongolia*	4,544.50	15.4
9	Solomon Islands**	4,315.40	14.6
10	Turkmenistan***	4,043.10	13.6
11	Myanmar	3,566.70	11.9
12	Uzbekistan**	3,454.00	11.5
13	Cameroon*	3,061.80	10.1
14	Korea (North)*	2,959.30	9.8
15	Indonesia	2,896.10	9.6
16	Honduras*	2,813.80	9.3
17	Guyana**	2,813.00	9.3
18	Tanzania*	2,738.30	9.0
19	Guinea-Bissau**	2,692.70	8.8
20	Nauru***	2,432.30	7.9

*PFC, HFC and SF₆ data not available, ** PFC, HFC, SF₆ data and land-use data not available, *** Land-use data not available

The United States is 126th, with an index of 1.2, while Germany is 160th, at less than 1% of the intensity of the Central African Republic.⁵³

6. Future Emissions

A final way to think about responsibility is to imagine we are in the future looking back at who has emitted. If we believe that it is appropriate to apply responsibility-based measures to impose emissions-reductions obligations, those measures will continue to apply in the future. By estimating which nations will emit in the future, we can estimate which nations will bear the burden of emissions reductions under a responsibility-based measure.

Projections of future emissions are highly uncertain as they involve projections of economic growth over long periods of time, projections of the energy use that will come with that growth, and projections of the carbon intensity of that energy. Projections, therefore, need to be used with caution.

Given appropriate caution, Figure 4 projects a set of projections taken from the United States Energy Information Agency (the “EIA”) reference scenario for 2010 to 2035. The EIA is the U.S. government agency (part of the Department of Energy) responsible for providing information about the energy sector, both in terms of collecting data from past usage and disseminating it and making projections about future use.

53. The IPCC has an intensity chart that shows somewhat different results. *Supra* Fig.1. Using the same aggregations as the IPCC, the CAIT data produce a different ordering of emissions intensities, with the Middle East, for example, having the sixth-highest intensity while the IPCC puts it at third. *Supra* Fig.2. 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 and wealthy countries move up but are still nowhere near the top (for example, the United States moves up to fifty-six and the European Union to ninety-three).

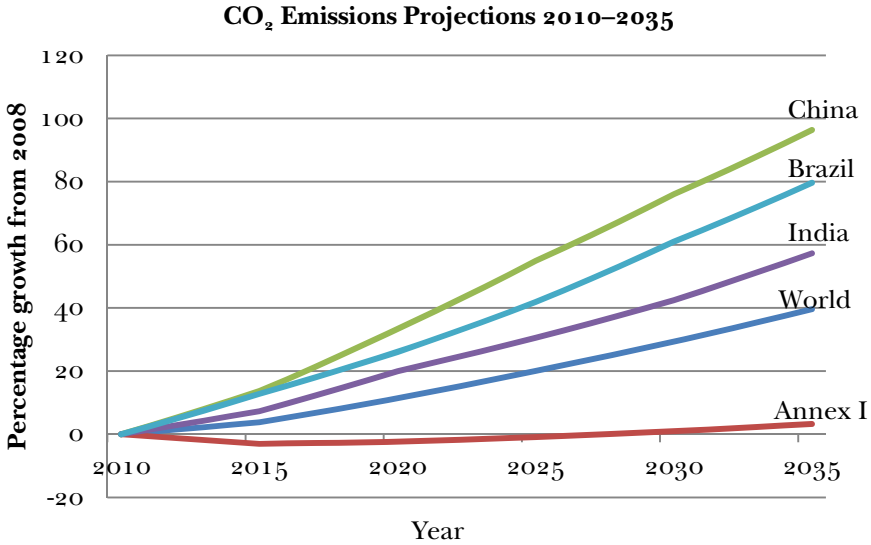


Figure 4: EIA Emissions Projections

As can be seen, essentially all of the growth in global emissions is projected to come from developing countries. Annex I emissions are projected to stay roughly level over the next twenty-five years while global emissions are projected to grow by about 40%. Chinese emissions are projected to double.

Responsibility is a backward-looking notion; we do not impose a duty to restore a harm before the harm has been done. Nevertheless, if responsibility is to be the basis for emissions-reductions obligations, we would expect developing countries to bear the burden for their future emissions.

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. Middle-income and poor countries combined currently emit more total greenhouse gases than high-income countries; per capita emissions are dominated by either poor countries or by oil-producing countries, depending on whether land-use change is included. The questions are 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 are 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 around 200 nations, we cannot easily present data for each country in an understandable format. Instead, the data are 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. Poor countries that have high emissions from land use are combined with low-emitting countries in the same region so they do not show up. The per capita numbers in Tables 4 and 5 have no aggregation—they are lists of individual countries. This means that relatively small countries—countries that are unlikely to play a significant role in climate negotiations—dominate the list. These tables emphasize variance by individual countries rather than overall trends. The conclusions I presented on total emissions by high-income and other countries also aggregated the information. The cutoff 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 countries regardless of their relative emissions, as was done in the IPCC chart? Should Brazil's high per capita emissions be offset by Chile's low per capita emissions? Is it appropriate to treat high-income nations as one group and all other nations as another group, as was done in Table 3?

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 United Arab Emirates, and Kuwait. Treating all of Latin America as a single data point hides the high per capita emissions of Bolivia, Brazil, and Venezuela. Wide variations in emissions get washed out in the averages of groups that are essentially randomly chosen because of the happenstance of geography rather than an underlying theory of responsibility. Similarly, the decision in the IPCC 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 ten-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) because its neighbor behaved well. The same problem arises with theories of distributive justice: aggregation by geographic region cannot be justified based on theories of distributive justice.

Complete disaggregation of the data would require us to look at individuals. This is impossible. Nations, however, are a good level of aggregation for examining the data. Nations are the likely actors in any climate treaty or other 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 countries 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 of responsibility that are based on per capita emissions do not distinguish between large countries and small countries, or rich countries 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. For example, look at modest, but not the very smallest, countries that 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. Norway's emissions are about 52 CO₂-eq. (There are Annex I nations with much lower emissions, such as Luxembourg and Lithuania.) If we use this as an arbitrary cutoff, the top per capita emitters in 2005 are as shown in Table 8.

Table 8: Total GHG Emissions 2005 (High-Emitting Countries Only)
CO₂, CH₄, N₂O, PFCs, HFCs, SF₆

Rank	Country	MtCO ₂ e	% of World	CO ₂ e/ Person	\$/ Person
1	Qatar**	61	0.1%	68.9	63,151
2	United Arab Emirates*	160	0.4%	39.0	53,386
3	Kuwait*	88	0.2%	34.8	45,539
4	Australia*	558	1.3%	27.3	35,184
5	Canada	804	1.9%	24.9	36,324
6	United States	6,797	15.7%	23.0	43,031
7	Bolivia	201	0.5%	21.9	3,788
8	New Zealand*	79	0.2%	19.1	25,532
9	Turkmenistan*	91	0.2%	18.9	5,647
10	Venezuela	447	1.0%	16.8	11,480
11	Ireland*	70	0.2%	16.8	41,294
12	Saudi Arabia*	377	0.9%	16.3	21,643
13	Brazil	2,842	6.6%	15.3	9,146
14	Central African Republic**	61	0.1%	14.9	683
15	Malaysia***	375	0.9%	14.6	12,763
16	Russian Federation	2,013	4.7%	14.1	13,911
17	Czech Republic*	142	0.3%	13.8	22,862
18	Netherlands*	224	0.5%	13.7	37,404
19	Kazakhstan*	203	0.5%	13.4	10,259
20	Zambia***	157	0.4%	13.4	1,212

*Land-use change data not available, **Land-use change, PFC, HFC, and SF₆ not available, ***PFC, HFC and SF₆ data not available

Some of the very small nations, like Brunei and Luxembourg, drop off of the list, and the United States moves up from tenth to sixth. The qualitative nature of the list, however, does not change; many developing countries are in the top twenty, including such countries as Brazil and Malaysia. Changing the arbitrary size cutoff used to create this table does not change the basic results unless a very high cutoff 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 the Massachusetts Institute of Technology, modeled a worldwide cap-and-trade regime designed to limit greenhouse gas concentrations to 450 ppm CO₂-eq by 2050.⁵⁴ 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. Figure 5 does this for 2000, looking at the six Kyoto gases plus land-use change. As can be seen, there is a positive relationship, but a low R² and many outliers.⁵⁵

54. HENRY D. JACOBY ET AL., JOHN F. KENNEDY SCH. OF GOV'T, HARVARD UNIV., SHARING THE BURDEN OF GHG REDUCTIONS 7–10 (2008) (The Harvard Project on International Climate Agreements, Discussion Paper 08-09), *available at* <http://belfercenter.ksg.harvard.edu/files/JacobyWeb2.pdf>.

55. 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 an artifact of the units used to measure income (dollars) and emissions (tons).

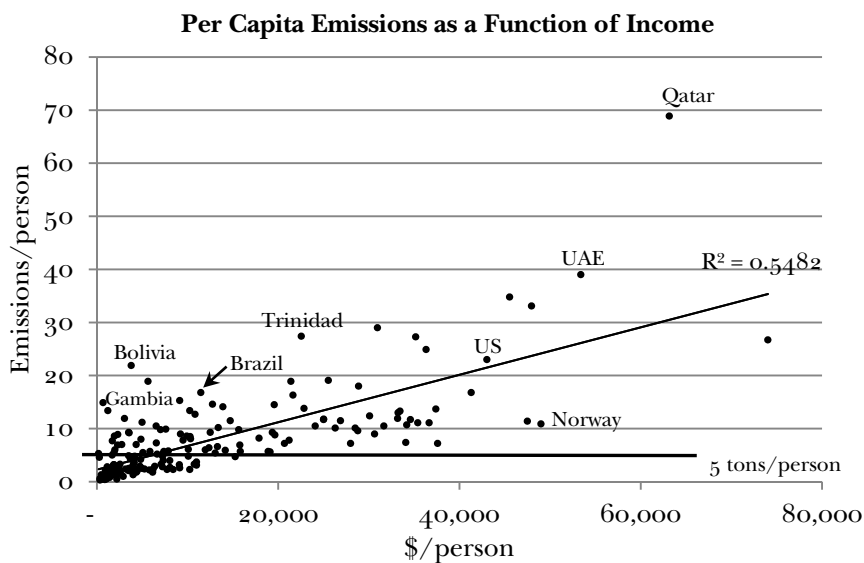


Figure 5

It seems from Figure 5 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 five tons per person per year (which is likely well above the long-term sustainable level). All countries above the horizontal line at five tons per person would have a net obligation based on how far above the line they are. 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.

II. THEORIES OF OBLIGATION

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 as a literal measure of responsibility. The approach is claimed to be scientific and, therefore, to provide an objective basis for allocating treaty obligations.⁵⁶ 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

⁵⁶ See La Rovere et al., *supra* note 1, at 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.”).

be supported by an ethical theory. This Part discusses 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 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, detailed legal requirements for tort liability have to be met, and, indeed, they most likely are not. Instead, we should be thinking in terms of a climate treaty—not a climate lawsuit. I am also not claiming that there can be no other theories of responsibility. Instead, the goal is to look at a developed body of thinking in an analogous context to see what has been required.

There are two distinct rationales for tort liability: responsibility/corrective-justice theories and incentive-based theories.⁵⁷ Responsibility theories focus on compensating victims of wrongful actions. Incentive-based theories focus on internalizing costs that dangerous acts impose on others. I examine both theories to see how each would use emissions data. The focus is on responsibility-based theories because these are the basis of most claims about the importance of past emissions. After discussing these, I turn to incentive-based theories.

A. RESPONSIBILITY-BASED THEORIES

1. Responsibility and Fault

Most notions of responsibility require an action to be culpable before the actor bears responsibility for the harm. Culpability or fault is deeply embedded in tort law. Civil law regimes have a very strong fault rule, stemming back to the Napoleonic Code.⁵⁸ Common law regimes are more mixed but are best described as imposing fault or negligence in common cases with specified exceptions where strict liability rather than fault is used.⁵⁹

57. 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 & STEVEN SHAVELL, *FAIRNESS VERSUS WELFARE* 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.

58. 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), and André Tunc, *The Twentieth Century Development and Function of the Law of Torts in France*, 14 *INT'L & COMP. L.Q.* 1089 (1965).

59. See RICHARD EPSTEIN, *CASES AND MATERIALS IN TORTS* 101–53 (9th ed. 2009) (discussing the historic and analytical foundations of strict liability and negligence).

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.⁶⁰ 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.”⁶¹

If fault is the central notion in assigning responsibility, we have to determine which emissions are culpable and which are not. The difficulty is immediately apparent: determining culpability requires detailed judgments about a vast number of decisions made every day by each individual living in different circumstances.

One approach is to argue that emissions from luxury consumption—say heated swimming pools, oversized vehicles, and McMansions—are wrongful, but emissions from necessary or survival consumption are not.⁶² We might tend to think in terms of simple examples: why should a wealthy person in a wealthy country have the right to emit greenhouse gases to drive an SUV to his summer home on the beach while a poor person cannot use fossil fuels in order to avoid starvation?

Examples such as this often implicitly appeal to distributive concerns, which are distinct from arguments based on responsibility. Poor people can act wrongfully, and most actions by rich people are not wrongful.⁶³ While

60. ARISTOTLE, NICOMACHEAN ETHICS bk. III, at 1–5 (Robert C. Bartlett & Susan D. Collins trans., Univ. of Chi. Press 2011) (c. 384 B.C.E.).

61. Stephen R. Perry, *The Mixed Conception of Corrective Justice*, 15 HARV. J.L. & PUB. POL’Y 917, 931 (1992). For additional works on corrective justice and tort law, see GUIDO CALABRESI, *THE COSTS OF ACCIDENTS* (1970); George P. Fletcher, *Fairness and Utility in Tort Theory*, 85 HARV. L. REV. 537 (1972); Stephen R. Perry, *The Moral Foundations of Tort Law*, 77 IOWA L. REV. 449 (1992); Ernest J. Weinrib, *Toward a Moral Theory of Negligence Law*, 2 L. & PHIL. 37 (1983). Richard Epstein argues that corrective justice requires strict liability. Richard A. Epstein, *A Theory of Strict Liability*, 2 J. LEGAL STUD. 151 (1973).

62. See, e.g., JAMES GARVEY, *THE ETHICS OF CLIMATE CHANGE: RIGHT AND WRONG IN A WARMING WORLD* 81 (James Garvey & Jeremy Stangroom eds., 2008) (“The emissions resulting from the efforts of a farmer in Africa as he attempts to feed his family are not on a par with the emissions resulting from the efforts of an American dermatologist as he attempts to get to Vegas for a weekend of gambling. There is a meaningful distinction between subsistence emissions and luxury emissions, even if pinning it down takes some doing. . . . Arguing the point is as good as saying that some Rwandans should die so that some Virgin Islanders can recharge their mobile phones.” (citation omitted)).

63. Distributive concerns focus on the rich versus the poor and are not based on responsibility. For example, Henry Shue wrote, “[T]hose living in desperate poverty ought not to be required to restrain their emissions, thereby remaining in poverty, in order that those living in luxury should not have to restrain their emissions.” Henry Shue, *Subsistence Emissions and Luxury Emissions*, in *CLIMATE ETHICS* 200, 202 (Stephen M. Gardiner et al. eds., 2010). Shue’s argument appears to be purely distributive rather than based on culpability for past

the facts might, by happenstance, cause the two concerns to overlap (although as discussed below they might not), we need to keep the two separate for purposes of analyzing the problem.

If we focus on culpability and not distributive concerns, the notion of luxury emissions cannot do the work required. Emissions are simply too pervasive to make this determination. We have to divide everyday activities into the bad luxurious emissions and good emissions. For example, we would have to determine how many square feet of living space is allowable for each individual in a family in various climates. How far from work or school is it permissible to live given particular commuting methods? 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 move, well, out of Canada? Do these answers change if a country has a natural reserve of some particular type of clean energy, such as hydroelectric power, or a natural carbon sink, such as a forest? Does the preservation of historical lifestyles, such as reliance on meat or types of housing or fuel, change the conclusions in any of these cases?

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.⁶⁴ We simply cannot make the necessary distinctions to determine which emissions are faulty and which ones are not.

Moreover, even if we had an agreed-upon notion of wrongful emissions, we would not have the data necessary to determine who is responsible for wrongful emissions. The data presented in Part I and the data developed by the various scientific bodies attempting to calculate responsibility do not have the necessary granularity for sorting out fault. Certainly, the sort of crude lists presented in Part I and those that provide the basis for claims like Peter Singer's cannot be used as a basis for determining the extent of wrongful emissions.

An alternative to trying to define luxury emissions at a fine level of granularity might be to use a crude cutoff—we could say that any emissions above some global per person average are culpable regardless of individual circumstances. The problem with this approach is that it is actually based on

wrongs. I do not address distributive concerns here. For a discussion of these issues, see POSNER & WEISBACH, *supra* note 1, at 73–98.

64. 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.

intuitions about equality, not responsibility. It might be appropriate to allocate the use of the environment on some sort of equal basis—say provide cap-and-trade permits on a per capita basis to all people—but this again has nothing to do with responsibility.⁶⁵ Individuals with equal emissions are not likely to be equally culpable for those emissions. It would be hard to tell someone living in Finland or Canada that they cannot heat their homes because people living in warm climates do not need to do so.

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.⁶⁶ The only way to base obligations on past emissions is to use a non-fault-based theory of obligations.⁶⁷

2. Strict Liability

As an alternative to fault, we might instead use a strict liability standard. 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, although this is very much a minority view.⁶⁸ Liability for harm from environmental damages in particular has, to some extent, moved away from fault-based regimes toward strict liability. In the European Union, this move has largely been under the rubric of the polluter pays principle.⁶⁹ The rationale is that it is too difficult to prove fault in the environmental context because of the complex process of tracing emissions to harm (and because the polluter has better information about the process). Moreover, strict liability is thought to better provide

65. It might not be appropriate to provide equal per capita permits. See POSNER & WEISBACH, *supra* note 1, at 119–43 (explaining that the per capita approach does not satisfy several important principles, such as equality and distributive justice, and suggesting that a more normative approach would be both more feasible and fair overall).

66. 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 CAIT 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.

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

68. EPSTEIN, *supra* note 59, at 143, 159–61.

69. See Consolidated Version of the Treaty Establishing the European Community, pt. 3, tit. XIX, Dec. 24, 2002, 2002 O.J. (C 325) 33, 108 (establishing an environmental policy based on the principle that the polluter should pay).

compensation to victims of pollution and to impose the risk from pollution on the party that can control it.⁷⁰

The shift to strict liability in the European Union, however, has been halting and limited. In many versions, the polluter pays principle has been implemented as a fault regime, not a strict liability regime. The most recent and comprehensive manifestation of this is the European Union's Environmental Liability Directive ("ELD") adopted in 2004.⁷¹ The ELD explicitly states that it adopts the polluter pays principle and provides a specific set of rules for its implementation.⁷² It provides strict liability for a specified class of particularly risky activities such as waste-management operations or the storage of dangerous chemicals.⁷³ However, 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).⁷⁴ For all other covered environmental harms, however, the ELD requires fault and, moreover, limits liability for harms to specified items, such as harm to protected species and natural habitats.⁷⁵ At least in this implementation, the polluter pays principle does not follow a general strict liability approach.

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 a selected list of sites.⁷⁶ The United Kingdom imposes strict liability for designated nature-protection sites.⁷⁷ Brazil imposes strict liability for environmental harms,⁷⁸ although it is not clear how strongly it is enforced. There are scatterings of strict liability, so the idea of using strict liability notions in the climate context would not be unheard of.

70. For a history of the development of the polluter pays principle, see NICOLAS DE SADELEER, ENVIRONMENTAL PRINCIPLES: FROM POLITICAL SLOGANS TO LEGAL RULES (2002).

71. Directive 2004/35/CE, of the European Parliament and of the Council of 21 April 2004 on Environmental Liability with Regard to the Prevention and Remedying of Environmental Damage, 2004 O.J. (L143) 56.

72. *Id.* at 56.

73. *Id.* art. 3, ¶ 4; *id.* Annex III.

74. *Id.* art. 8, ¶ 4(b).

75. *Id.* art. 4.

76. See Gerd Winter et al., *Weighing Up the EC Environmental Directive*, 20 J. ENVTL. L. 163, 175-77 (2008).

77. See The Environmental Damage (Prevention and Remediation) Regulations 2009, part 4, § 18 (Eng.).

78. Act No. 6.938, Aug. 31, 1981 (Braz.) (on file with author) (National Environmental Policy Act).

Common law regimes impose strict liability in circumstances that are similar to when 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, dangerous 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 that simply prohibit certain activities. The most important case of strict liability (in fact, the *only* major example) is the Comprehensive Environmental Response, Compensation, and Liability Act (“CERCLA”).⁷⁹ 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 while there is some precedent for using a strict liability standard in contexts similar to climate change, it is quite limited. Even in environmental contexts, most countries require fault most of the time. 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. For instance, we 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 have to be taken into account.

As an example, consider the Haber-Bosch process.⁸⁰ Invented in Germany just prior to World War I, this process fixes nitrogen to produce ammonia. The ammonia can be used as fertilizer or a component of fertilizer. The resulting fertilizer is responsible for 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 anything 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

79. Comprehensive Environmental Response, Compensation, and Liability (CERCLA) (Superfund) Act, 42 U.S.C. §§ 9601–9675 (2006). One could argue that the SO₂ trading regime in the 1990 Clean Air Act is a strict liability regime as it imposes caps on emissions entirely without regard to fault. *See* Clean Air Act Amendments of 1990, 42 U.S.C. §§ 7651c(a)(1), 7651d(a)(1) (2006). 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.

80. *See* VACLAV SMIL, ENRICHING THE EARTH: FRITZ HABER, CARL BOSCH, AND THE TRANSFORMATION OF WORLD FOOD PRODUCTION 109–32 (2001) (discussing the evolution of ammonia synthesis).

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 probably would not have been found but for industrialization and the resulting emissions.

A second problem is the time period over which we measure emissions. If we go back long enough, for example, the deforestation numbers change dramatically because areas that were deforested long ago would be assigned the resulting emissions. Much of Europe was deforested centuries ago, but the resulting lack of a carbon sink still creates climate change. 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 that are not your fault, at a minimum, you should be told in advance.⁸¹

A third problem is how we should treat population growth. If we use a per capita measure, countries with rapid population increases look better. It is not clear, however, why we would want to treat countries that have increased their populations rapidly as behaving better, as less responsible for climate harms. If we are not going to treat these countries as behaving better, however, we would need some theory for allowable population growth, and then we could use this number as the denominator in a per capita emissions calculation. This is infeasible.⁸²

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.

3. 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. As one prominent corrective justice scholar explained, “[I]n every account of corrective justice,

81. We could set 1990 as a starting date for a strict liability regime on the theory that the science was relatively clear and the international movement toward addressing climate change, including the Framework Convention, had begun. While this date seems plausible, the intuition behind it is based on fault: emissions after this date are more culpable than emissions before this date. If the theory for not applying strict liability retroactively is notice rather than fault, 1990 does not seem appropriate.

82. Similar arguments apply to immigration.

there is presumed to be a relationship between the parties that makes the claims of corrective justice appropriate to them—and not to others.”⁸³

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 resulted in (culpable) 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.⁸⁴ Some arguments suggest that there is little connection between past emitters, future victims, and the individuals who would have to pay under a responsibility-based measure. Others argue that the descendants of current high emitters will benefit from those emissions. The problem 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.

4. Distributive Effects

The data presented in this Article 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 the harm that they have caused might have terrible consequences.⁸⁵

I have argued elsewhere that we should separate distributive issues from obligations to reduce emissions.⁸⁶ 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

83. Jules L. Coleman, *The Practice of Corrective Justice*, 37 ARIZ. L. REV. 15, 27 (1995); see KAPLOW & SHAVELL, *supra* note 57, at 89 n.9 (summarizing the literature taking this view).

84. See, e.g., POSNER & WEISBACH, *supra* note 1; Eric A. Posner & Cass R. Sunstein, *Climate Change Justice*, 96 GEO. L.J. 1565 (2008); sources cited *supra* notes 3–4.

85. 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.

86. See generally POSNER & WEISBACH, *supra* note 1.

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 that people believe this argument, the bad distributive effects of using responsibility as the basis for a treaty will not matter. Many people, however, will be very troubled by such distributive effects. It is not clear whether notions of responsibility 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 of income: if you negligently run over me with your car, you are liable even if you are poor. Tort damages are based on harm to the victim, not on the wealth of the injurer.

Moreover, notions of fault are unlikely to exempt poor countries. Emissions from poor countries are often the result of highly wasteful deforestation, activities that result not only in climate change but also in a host of other environmental ills without producing 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.⁸⁷

5. Measuring Harm for Ongoing Acts

The final problem with applying notions of responsibility within the 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—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 result in emissions, and we are not likely to find methods of agricultural production that do not. Merely tilling the soil can release carbon. Emissions are not just a past wrong; they are and will be ongoing.

Continuing emissions might not be a problem if emissions in the past predicted emissions 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 (to the extent we have such a notion), however, will change over time, with developing countries

87. As noted *supra* note 1, Brazil proposed a strict liability regime for emissions reductions based on past emissions. The Brazilian proposal, in its initial form, would not have applied to developing countries. Brazil proposed 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.

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 2011. Figure 3 illustrates the issue: we expect emissions from fast-growing developing nations to become the dominant source of emissions in the near future.

Proposals for a responsibility-based emissions-reduction obligation seem 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 one and *Y* emits 100 in period two, we should not assign responsibility forevermore at the end of period one and ignore *Y*'s actions in period two.

It is not clear, however, how to fix this within a responsibility-based approach. 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 be hard to argue that those nations would be at fault in such a case. But given the global harm from future emissions, we need to reduce those emissions, not protect them because of notions of culpability.

Moreover, if we treat future emissions allowed under a treaty as culpable, we get a paradox. Suppose that we have a treaty that is adjusted every period—say every five years—to impose emissions-reductions obligations based on a look backward from that period. Consider a nation that emitted very little in the past, so it is not responsible for past emissions. Suppose that its economy grows and during the next five years it increases its emissions. When we revise the formula, it is now held responsible for those emissions. The result is a forward-looking measure rather than a backward-looking measure. The whole idea of using a snapshot at the time of a treaty to determine emissions reductions would fail.

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.

6. Summary

Is it possible to develop a workable notion of responsibility for climate change based on notions of corrective justice? Fault-based notions are unlikely to be workable. Instead, the method would have to use a strict liability measure, counting all emissions after some cutoff date, such as the date of the signing of the Framework Convention. The measure of emissions

would have to be as comprehensive as possible, including emissions from land-use change and agriculture as well as energy use. Some account might need to be made for population growth as nations with fast population growth impose a greater overall burden on the world. Corrective-justice notions cannot easily account for distributive effects, so these would be whatever they turn out to be. Finally, it would have to account for future emissions, perhaps by regularly updating the formula based on emissions in future periods.

Even a simplified and crude measure such as this would be subject to a number of criticisms. It would not be based on fault. Instead, it would be a strict liability notion, an idea which has not gained acceptance except in limited circumstances. The distributive effects would likely be bad. Finally, it is difficult to see how the updating process would work. A nation that emits today would be immediately responsible for reducing emissions, which effectively means that the nation is not allowed to emit today.

Given these caveats, Table 9 presents one version of such a list that leaves aside the updating problem. It presents emissions from the six Kyoto gases and land-use change for the years since 1990 where that data are available on CAIT (1990, 1995, 2000, and 2005). It sums these emissions. It then ranks nations by emissions per person based on 2007 populations.⁸⁸

88. The number in the emissions per person total is the total emission multiplied by five, divided by the 2007 population. A factor of five is used because data are available only for one of every five years. An alternative would have been to interpolate across the missing years, which would have weighted nations with fast growing emissions more heavily.

**Table 9: Cumulative Emissions Since 1990,
CO₂, CH₄, N₂O, PFCs, HFCs, SF₆ and Land-Use Change**

Country	MtCO ₂ e 1990	MtCO ₂ e 1995	MtCO ₂ e 2000	MtCO ₂ e 2005	Total	2007 Pop (thousands)	Emissions/ person
1 Qatar*	18	23	35	61	137	1,138	603.3
2 Brunei*	9	12	11	12	44	385	568.8
3 UAE*	77	103	128	160	467	4,364	534.7
4 Trinidad & Tobago*	25	24	37	36	123	1,328	461.2
5 Canada	666	737	768	804	2,974	32,976	451.0
6 Australia*	403	428	503	558	1,892	21,073	449.0
7 Luxembourg*	12	9	9	12	42	480	440.6
8 Kuwait*	32	49	62	88	232	2,663	435.2
9 Bahrain*	14	14	17	21	66	760	432.2
10 United States	5,857	6,145	6,703	6,797	25,502	301,290	423.2
11 Bolivia	170	174	196	201	741	9,524	389.0
12 Estonia*	42	19	18	20	98	1,342	366.6
13 Central African Republic*	95	86	63	61	306	4,257	358.8
14 New Zealand*	59	62	72	79	272	4,228	321.9
15 Russian Federation	2,990	2,144	1,964	2,013	9,111	142,100	320.6
16 Venezuela	390	407	425	447	1,669	27,483	303.6
17 Czech Republic*	187	148	144	142	621	10,334	300.3
18 Kazakhstan*	312	226	160	203	901	15,484	290.9
19 Ireland*	54	58	67	70	249	4,357	285.3
20 Turkmenistan*	71	55	64	91	282	4,977	282.8

*No data on land-use change

Table 9 only lists the top twenty. Nations left off of this list include Brazil, ranked 21; the UK, ranked 32; China, ranked 107; and India, ranked 154.

B. INCENTIVES-BASED APPROACHES

An alternative basis for tort obligations is to focus on incentives and 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 marginal 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.⁸⁹

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 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 precede 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 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—in 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). For example, imagine an actor engaging in an action now that we are not sure is harmful, but might be. In the event that we later learn that the action is harmful, the actor will be subject to liability. The actor has an incentive in the present to internalize the possible harms.⁹⁰ A climate treaty that looks to past emissions might increase the expectation that other treaties would reach back and, therefore, create better incentives to remedy the situation in the present.

89. See Steven Shavell, *Liability for Accidents*, in 1 HANDBOOK OF LAW AND ECONOMICS 139, 143–47 (A. Mitchell Polinsky & Steven Shavell eds., 2007) (Handbooks in Econ., Handbook No. 27 (Kenneth J. Arrow & Michael D. Intriligator eds., 2007)).

90. See generally Louis Kaplow, *An Economic Analysis of Legal Transitions*, 99 HARV. L. REV. 509 (1986).

The problem with applying this logic to long-past emissions is that it is doubtful that doing so would create very much of 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 is different than that living in 1975, 1950, or 1850. That is, the incentive effects of a backwards-looking climate regime may not be large.

An incentives-based approach, one that focuses on getting a treaty signed and creating the incentives actors need to reduce emissions, would emphasize recent behavior rather than 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 in the present, not bad behavior in the distant past.

III. TAKING STOCK

There are two key lessons. The first is that the data on past emissions present a mixed picture and do not support the claim that wealthy countries are primarily responsible for past emissions. Under almost any measure, responsibility is spread widely but 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 capita emitters.

The second lesson is that theories of traditional responsibility, those that require fault, require far more complex considerations than our moral intuitions and the data are ever likely to support. Activities that result in emissions are pervasive, and we cannot decide which activities are culpable 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 some 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 some other specified date in the past) 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 only 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 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. Responsibility cannot play the hoped-for role of an objective scientific method of determining treaty obligations.