Apportioning Climate Change Costs

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I.
INTRODUCTION

As most people now realize, our society can no longer postpone serious consideration of how to respond to climate change. Most public attention has been focused on the issue of mitigation – that is, how to reduce greenhouse gas levels and by how much. However, society also needs to consider methods of adapting to climate change. Adaptation will not be cheap. While it is too early to make confident cost estimates, it is clear that the expense for the U.S. will reach the billions of dollars threshold annually

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over the next few decades.[1] In addition, some of the harms of climate change cannot be avoided by adaptation, and these too may be expensive.

The most immediate question is *what* to do about climate change, but a very closely related question is *who* should pay. This article is the third in a trilogy addressing the question of how climate change costs should be allocated.

The previous articles in the trilogy addressed related aspects of this problem. The first article considered how we might design a scheme where emitters would compensate victims of climate change. Compensation for adaptation costs was a key part of the solution, because of the relative administrative manageability of using this measure of damage. The second article considered the question of how to allocate climate adaptation costs, and concluded that at least some of these costs should be allocated to emitters. Thus, via different paths of reasoning, the two articles converged on the same destination – that emitters should bear at least part of the burden of adaptation costs.

A related issue is how mitigation costs should be allocated. Dealing with climate change requires that we reduce total greenhouse emissions to much lower levels. In effect, this goal dictates a cap on emissions. Within that cap, it might be appropriate to allocate emission rights solely on the basis of economic efficiency, or to consider taking other factors into account. Even if emission rights are allocated on the basis of efficiency, side payments could be arranged based on equity or other considerations. Thus, allocation of emission costs could be an issue.

The cost allocation issue could arise under any mitigation scheme. For example, if a carbon tax is used to limit emissions, there could well be claims that current emitters deserve to have some compensation from past emitters, on the theory that mitigation is only required because of the cumulative effects of past and present emissions. Similarly, if a cap-and-trade scheme is used to limit emissions, permits might be allocated so as to require emitters with large amounts of past emissions to purchase more permits on the open market. Thus, there could potentially be efforts to shift adaptation costs, mitigation costs, and costs that cannot be avoided through either mitigation or adaptation. In each case, the claim would be that the costs in question should

1. *See infra* text accompanying note 28-29, for some cost estimates.

be allocated on the basis of responsibility for climate change rather than falling where they may.

Assuming that we did decide that some costs should be shifted to emitters, there are some difficult problems about how to allocate responsibility among the emitting parties. Those problems are the focal point of this paper. Emissions differ greatly between sources. For example, the U.S. was responsible for twenty percent of the world's emissions in 2000, which was about equal to its share of Gross Domestic Product (GDP). The European Union (EU) was responsible for only fourteen percent of the emissions (but received about as much of the world's GDP as the U.S.).[2] Emissions are not equally attributable to all economic sectors: over sixty percent come from energy consumption.[3] Globally, motor vehicles (and hence petroleum derivatives) account for about ten percent of total emissions, while power generation accounts for twenty five percent.[4] To complicate matters, past emissions that remain in the atmosphere were emitted from different sources or in different proportions between sources. Thus, the cost apportionment question presents difficulties.

After Part I of this article presents background information about climate change, Part II summarizes the arguments of the previous articles for requiring emitters to bear some of the costs of climate change. Part III then goes a step further by asking how the costs should be allocated among various emitters. Part III considers four questions: (1) Should emitters be responsible for the impact of all of their emissions, or only those that fall above some optimal control strategy? (2) Should liability be based on the marginal effect of adding an extra ton of greenhouse gas, or on the average impact per ton of climate change at a given time? (3) Should liability be apportioned on the basis of current or cumulative emissions? (4) How should we account for the future impacts of current emissions?

These are not simple questions, but we do not need perfect answers in order to formulate a cost apportionment scheme. Given the variety of legitimate goals that a cost apportionment system may serve and the cross-cutting arguments that favor different solutions, we can only expect to do rough justice among emitters. An imperfect solution to the problem is better than no

2. *See* Kevin A. Baumert et al., *Navigating the Numbers: Greenhouse Gas Data and International Climate Policy* 12, fig. 2.1 (World Resources Institute 2005).

3. *Id.* at 41.

4. *Id.* at 57.

solution, because the alternative is to allow impunity for emitters, whereby they will not be held accountable for the problems that their past and present acts have inflicted and will continue to inflict on the rest of society.

II.
BACKGROUND ON CLIMATE CHANGE

In a few years, it will probably no longer be necessary to preface an article like this with a general discussion of climate change and its impacts. Hopefully, individuals will be exposed to this information at increasing levels of sophistication from the time they are children. But, climate change is still a new issue for many people, and some background is still in order before discussing more technical issues.

Skepticism about climate change seems to be fading out rapidly, but some readers may still be unsure about the solidity of the evidence. Thus, it behooves us to start by asking how sure we can be that climate change is a genuine threat.

The most reliable source is the Intergovernmental Panel on Climate Change's (IPCC) 2007 Report, which explains the scientific consensus that:

> Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.[5]

The IPCC report is the result of an exhaustive review process.[6] Notably, because of improvements in modeling and data, the 2007 Report was able to eliminate some concerns that had previously been raised about the evidence on climate change. The IPCC's conclusions represent the best "sound science," and to

5. The IPCC explains that "the understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to *very high confidence* that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m^2." Intergovernmental Panel on Climate Change [hereinafter IPCC], *Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment on Intergovernmental Panel on Climate Change* 3 (Feb. 2007).

6. Richard A. Kerr, *Scientists Tell Policymakers We're All Warming the World*, 315 SCI. 754 (2007).

demand further research is to give up on the idea of reality-based social policy entirely. Governments, firms, and individuals have to make the best decisions they can today on the basis of available information.

Even those who are aware of the strength of the evidence supporting the reality of climate change may not realize that it has already begun, nor may they be aware of the inevitability of further change in the coming decades. Mitigation may affect the degree of adaptation that is ultimately required, but it will have little short-term effect. The reality is that, regardless of whatever mitigation measures are adopted, a significant degree of climate change seems unavoidable.[7] As the IPCC explains, "[a]nthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized."[8]

The evidence indicates that a doubling of carbon dioxide from pre-industrial levels would result in a temperature increase between 1.5 °C and 4.5 °C (1.8 °F - 5.4 °F) by the end of this century.[9] For this reason, even in the best-case scenario, we will be faced with a number of adverse impacts from climate change. Indeed, those impacts may already be occurring. "Examples of observed changes caused by human releases of greenhouse gases (GHG) include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid to high latitude growing seasons, poleward and altitudinal shifts of plants and animal ranges, declines of

7. As described in Donald A. Brown, *The U.S. Performance in Achieving Its 1992 Earth Summit Global Warming Commitments*, 32 ENVTL. L. REP. 10741, 10756 (2002):

> Many scientists and policy makers believe that a doubling of CO2 from pre-industrial levels to 560 ppm may be unavoidable in the 21st century. This is so because the world's political and economic system cannot respond rapidly enough to make faster changes in some major polluting sources such as gasoline-powered automobiles or coal-fired power plants. . . . Even if all nations could have stabilized emissions in the year 2002, the concentrations of GHGs would continue to rise and would approach 500 ppm by the year 2100. After that, GHG concentrations in the atmosphere would continue to rise for several hundred years before stabilization would be achieved. Even to stabilize CO2 at 1,000 ppm will require reductions of emissions below current levels.

8. IPCC, *supra* note 6, at 12.

9. *See* Richard A. Kerr, *Latest Forecast: Stand By for a Warmer, But Not Scorching, World*, 312 SCI. 351 (2006). For an up-to-date source of information on climate science, see http://www.realclimate.org/.

some plant and animal populations, and earlier flowering of trees, emerging of insects, and egg-laying in birds."[10]

Sea level rise is one of the most predictable (and to some extent least avoidable) consequences of climate change.[11] As the IPCC explains, "[o]bservations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80% of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise."[12] Moreover, the IPCC reports that "[m]ountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise (ice caps do not include contributions from the Greenland and Antarctic ice sheets)."[13] Thus, sea level rise can no longer be deemed speculative.

This rise in sea level will result in loss of coastal lands,[14] inundation of some estuary systems with salt water, salt water intrusions into some sources of drinking water, and increased exposure to flood damage.[15] Sea level change may have drastic effects on island populations.[16] For example, the small island state of Tuvalu is seeking ways to evacuate its entire population.[17] Sea level rise could also cause dramatic losses in wetlands in the U.S.[18] Because the slope of coastal areas on the Atlantic

10. Brown, *supra* note 8. For further details on climate change effects in the U.S., see CAMILLE PARMESAN & HECTOR GALBRAITH, *Observed Impacts of Global Climate Change in the U.S.* (Pew Center on Global Climate Change 2004), *available at* http://ww.pewclimate.org/global-warming-in-depth/all_reports/observedimpacts.

11. *See, e.g.*, K. Hasselmann et al., *The Challenge of Long-Term Climate Change*, 302 SCI. 1923, 1924 fig.1 (2003) (predicting a two meter increase in sea level under a "business as usual" scenario by 2100, but only 20 centimeters under an optimum regulatory strategy).

12. IPCC, *supra* note 6, at 4.

13. IPCC, *supra* note 6, at 5.

14. *See* A. BARRIE PITTOCK, CLIMATE CHANGE: TURNING UP THE HEAT 264, 268, 278 (2005) (giving examples, including China, India, Pakistan, Bangladesh, and the U.S).

15. *See* ELIZABETH KOLBERT, FIELD NOTES FROM A CATASTROPHE: MAN, NATURE, AND CLIMATE CHANGE 123-24 (2006) (reporting a British governmental study indicating that what are now hundred-year floods could become routine by late in this century); *see also* Pittock, *supra* note 15, at 118 (stating that without adaptive measures, annual flood losses would increase from £ 1-24 billion in different scenarios).

16. *See* Dennis Culley, *Global Warming, Sea Level Rise, and Tort*, 8 OCEAN & COASTAL L.J. 91, 100-01 (2002).

17. *Id.* at 91, 92-93, 106.

18. *Id.* at 100-01.

and Gulf Coasts is low, a forty centimeter rise in sea level could result in as much as sixty meters of beach erosion, at a cost in the billions of dollars.[19]

To get a sense of the potential economic impact, consider the following estimates regarding sea level rise: A half-meter sea level rise would place $185 billion of property in jeopardy by 2100, and the cost of protecting developed areas from a half-meter rise is estimated to be in the range of $50 billion to $66 billion.[20] The IPCC found that it "is *very likely* that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent."[21] Additionally, weather events like tropical storms may increase in severity and more frequently become hurricanes. "Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical [sea surface temperatures] (SSTs)."[22]

The inevitable impacts of climate change will force society to invest in costly adaptation measures. Adaptation has not received nearly as much attention as mitigation, but we can already begin to see the outlines of adaptation needs. Of course, the scale of adaptation required is related to the degree of mitigation. If we do nothing to limit emissions, climate change will be more drastic and the costs of adaptation will be correspondingly higher.

The Pew Foundation collected much of the available information about adaptation strategies in a 2004 report.[23] With regard to the agricultural sector, the report describes the need to develop new agricultural plant varieties to deal with changing temperatures, rainfall, and pests. Since 1980, federal expenditures for agricultural research have plateaued, but substantial increases will probably now be needed.[24] Farmers will have to make risky decisions about when the climate has changed enough to justify

19. David A. Grossman, *Warming Up to a Not-So-Radical Idea: Tort-Based Climate Change Litigation*, 28 COLUM. J. ENVTL. L. 1, 12-14 (2003).

20. This estimate may be on the high side, but even if we discount by a factor of two, the figures are still impressive. WILLIAM E. EASTERLING III, BRIAN H. HURD & JOEL B. SMITH, COPING WITH GLOBAL CLIMATE CHANGE: THE ROLE OF ADAPTATION IN THE U.S. 14 (Pew Center on Global Climate Change 2004).

21. IPCC, *supra* note 6, at 12.

22. IPCC, *supra* note 6, at 12.

23. EASTERLING ET AL., *supra* note 21, at 1.

24. *Id.* at 20.

switching to new varieties and growing methods.[25] Moreover, agricultural production is likely to shift northward,[26] which is detrimental to states like Florida. Adaptation may also be required to cope with changes in the forestry industry, conservation management, and health hazards like heat stress.[27]

The Stern Report contains the most extensive discussion of adaptation costs. The Report estimates that:

> Infrastructure is particularly vulnerable to heavier floods and storms, in part because [member countries of the Organization for Economic Co-operation and Development (OECD)] invest around 20% of GDP or roughly $5.5 trillion in fixed capital each year, of which just over one-quarter typically goes into construction ($1.5 trillion – mostly for infrastructure and buildings). The additional costs of adapting this investment to a higher-risk future could be $15 – $150 billion each year (0.05% – 0.5% of GDP), with one-third of the costs borne by the U.S. and one-fifth in Japan. This preliminary cost calculation assumes that adaptation requires extra investment of 1% – 10% to limit future damages from climate change.[28]

While these amounts are not huge in comparison to the size of the economies involved, they are nevertheless very substantial burdens on particular actors. Furthermore, to these costs must be added the possible costs of harms that cannot be prevented through adaptation.

Thus, there are two key implications of the scientific evidence. First, climate change is almost certain and, second, it will impose heavy costs on society. The question that remains is whether the costs of climate change should fall where they may, or whether the costs should be shifted. Part II considers who should bear these costs, and concludes that at least some should be shifted to emitters.

III.
HOLDING EMITTERS RESPONSIBLE

As we have seen, climate change will incur large costs in a variety of forms: for emissions, for adaptation, and for harms that cannot be avoided through either method. This section considers

25. *Id.*
26. *Id.* at 21.
27. *Id.* at 3, tbl. 1.
28. NICOLAS STERN, THE STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE 417 (2007).

whether it is desirable to hold emitters responsible for any of these costs and whether it would be feasible to do so. Not only are there solid grounds for holding emitters responsible for at least some climate costs, but also it would be administratively feasible to do so.

A. *Who Should Pay?*

Several possible answers to the cost allocation question deserve exploration. It would be feasible to leave it to the beneficiaries of adaptation projects to absorb the costs, or to shift the costs to the entities that emitted greenhouse gases in the first place. Alternatively, the taxpayers could foot the bill or regions that experience benefits from climate change could be required to fund adaptation. Which alternative to favor is not an easy question. The choice between cost allocations involves a complex mix of judgments about incentives as well as difficult normative issues regarding issues of fairness and social solidarity.

The tort system and, by extension, other loss allocation schemes have several goals.[29] Probably the two most important goals are deterring harmful conduct (the efficiency or deterrence rationale) and corrective justice (restoring moral balance by rectifying harm). Loss distribution (providing insurance against social risks) is another goal, perhaps more important in social compensation schemes than in tort. A final set of goals are oriented towards society and include providing redress for social grievances or exhibiting social solidarity with victims.[30]

Providing an incentive to reduce emissions of greenhouse gases in the future is necessary, particularly because an effective regulatory scheme does not yet exist. This is a standard argument for adopting a prospective rule that imposes liability on harm-causing entities. Less obviously, there may also be useful incentive effects created by the prospect of retrospective liability. Although, it is obviously impossible to deter conduct that has already taken place, establishing a rule that requires compensation for past emissions can provide a precedent for future liability schemes that cover other emerging environmental harms. As

29. For discussion of these goals, see KENNETH S. ABRAHAM, THE FORMS AND FUNCTIONS OF TORT LAW 14-20 (2d ed. 2002).

30. For an insightful discussion of this solidarity rationale in the context of catastrophic natural events, see Stephen D. Sugarman, *Roles of Government in Compensating Disaster Victims*, ISSUES IN LEGAL SCHOLARSHIP (2007), *available at* http://www.bepress.com/ils/iss10/art1/.

Louis Kaplow pointed out some twenty years ago in a leading economic analysis of retroactivity issues, if a new rule reflects improved understanding of a problem, it should be applied retroactively to create an incentive for behavior changes anticipating the new rules.[31]

Any system of cost allocation will involve both direct effects on economic behavior as well as some transaction effects. In some circumstances, the process of reallocating losses may itself have social benefits. It may lead to the production of additional useful information, such as a better accounting of the harms caused by climate change or more complete information about which forms of adaptation are desirable. Alternatively, it may provide a sense of fair treatment to those who experience losses. On the other hand, in general, we would prefer to keep transaction costs as low as possible, so that social resources are not absorbed by the operation of the loss allocation system. In the extreme case, implementing a loss allocation system might cost society as much as the losses themselves, which is obviously undesirable.

In general, risk-averse individuals would prefer a known cost like insurance premiums to an uncertain loss, even if the magnitude of the expected value of that uncertain loss is less than the cost of the premiums. The insurance function is probably most valuable for the harms caused by extreme weather events such as hurricanes, where the victims' identity is inherently unpredictable. However, the case for insurance is weaker when harms are more predictable, such as the impact of gradual sea level changes on coastal areas. When harms are completely foreseeable, insurance markets have no role because everyone who would buy a policy would also collect for the loss, providing no room for loss spreading.

Even when losses are predictable and hence non-insurable, society may have an interest in loss-spreading. Those who come out on the losing side may be a source of social instability if they feel their losses are unfair. Thus, loss-spreading may help to contribute to social peace. In addition, loss-spreading may represent

31. Louis Kaplow, *An Economic Analysis of Legal Transitions*, 99 HARV. L. REV. 595 (1986). *See also* Saul Levmore, *Changes, Anticipations, and Reparations*, 99 COLUM. L. REV. 1657 (1999); Ann Woolhandler, *Public Rights, Private Rights, and Statutory Retroactivity*, 94 GEO. L.J. 1015 (2006); Kyle D. Logue, *Legal Transitions, Rational Expectations, and Legal Progress*, 13 J. CONTEMP. LEGAL ISSUES 211 (2003).

a form of solidarity towards fellow citizens. We might envision a kind of social compact in which fellow citizens have undertaken a mutual duty of assistance in the face of mishaps. Such an understanding may underlie our willingness to invest in emergency help for individuals who are stranded in the wilderness or on mountains or who are victimized by natural disasters, even when the expense is far in excess of what we would have paid to prevent the harm in the first place.

Corrective justice involves complex moral issues which are not likely to be resolved simply or to everyone's satisfaction.[32] Emissions of greenhouse gases were not made with the intent to cause harm to others. How culpable was this conduct? At the very least, it seems arguable that at some point failure to take reasonable precautionary measures to reduce emissions became negligent. Given the amount of misinformation that has been spread by industry-sponsored groups, as well as efforts within the U.S. government to suppress information over the last seven years, there is also at least the possibility of deliberate misrepresentations – as turned out to be the case in the tobacco industry about the risk of cigarettes. However, it may be justifiable to reallocate costs from innocent victims even if the parties who caused the harm were not at fault, based on relative shares of causation. [33]

The concept of unjust enrichment is another form of "just deserts" – giving individuals what is due to them. We might well think that those who have in some sense profited from a situation have some duty to recompense those who have lost out at their expense, particularly when those who have profited have been the cause of the loss to others. The law of restitution is built around this concept.

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32. Matt Adler's analysis suggests that the climate change situation may be an imperfect fit with philosophical theories of corrective justice, although it appears that the philosophical case for compensation at the international level seems stronger than at the local level. Matthew D. Adler, *Corrective Justice and Liability for Global Warming*, 155 U. .PA. L. REV. 1859 (2007). Adler's analysis is keyed to the technical philosophical concept of corrective justice, which seems to be more suited for analyzing conventional interactions between individuals rather than problems having the geographic and temporal sweep of climate change. We may need to broaden our ethical theories to deal with phenomena on the scale of climate change. I plan to explore the equity issues posed by climate change in more detail in forthcoming work.

33. For discussions of this concept of causation-based liability, see Francesco Parisi & Vincy Fon, *Causation And Responsibility: The Compensation Principle From Grotius to Calabresi*, 64 MD. L. REV. 108 (2005); Francesco Parisi & Vincy Fon, *Comparative Causation*, 6 AM. L. & ECON. REV. 345 (2004).

Finally, in formulating any social policy, we might be influenced by how it affects the distribution of income and wealth, and in particular by whether it hurts or harms the poor. In terms of climate change, the income redistribution function is probably strongest at the international level, where relatively affluent nations like the U.S. figure heavily as emitters and impacted victims may be poorer countries such as Bangladesh.

With these goals in mind, we can evaluate the desirability of particular compensation schemes. A complete discussion of the options is beyond the scope of this article, but a review of the case for the "Emitters Pay" principle is in order. Prior to the last quarter of the twentieth century, emitters may not have had strong grounds for believing that their conduct would cause serious harm. Nevertheless, the fact remains that they have caused harm and, in the process, emitters have enjoyed lower costs than they would have incurred by using alternative technologies or by reducing output. Thus, there may be a strong element of unjust enrichment, at least in some situations. For those concerned about culpability, apportioning responsibility on the basis of emissions after some cutoff date would be an appropriate response. One possible cutoff date could be 1992, when the U.S. and other nations entered a framework agreement to reduce greenhouse gases.[34] At that point in time, the international community had clearly identified the harm. Therefore, any source of emissions after that date was at least on notice of the damaging nature of the conduct. Thus, there is a plausible basis for reallocating adaptation costs to emitters.

In addition to just deserts, "Emitters Pay" could serve other social goals. As discussed earlier, the prospect of financial responsibility could serve as a valuable incentive for reducing emissions. This is especially relevant in the absence of a global system of emission mitigation. "Emitters Pay" may also serve subsidiary goals. Since climate change victims are frequently poorer than emitters, as seems to be true at least in the international sphere, "Emitters Pay" could serve a redistributive function. (Of course, in theory, we could also achieve this goal without regard to climate change by increasing foreign aid, but climate change provides an additional motivation for assisting poorer countries to the extent we have actually worsened their condition through our emissions.) Finally, emitters may be in a

34. *See* Brown, *supra* note 8.

good position to spread costs to shareholders or consumers, serving the loss-spreading function.[35]

This approach to compensation also has some support in international law. The U.S. and other countries have already agreed in principle to take some responsibility for adaptation measures in less developed countries. Article 4.4 of the United Nations Framework Convention on Climate Change provides that:

[D]eveloped country Parties and other developed Parties included in Annex II shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects.[36]

Thus, at least in principle, the U.S. and other signatories to the framework agreement already have agreed to assist with adaptation at the international level. It is also worth noting that the parties to the Kyoto agreement have embraced the use of an adaptation fund, which is financed by a share of the proceeds generated by the Clean Development Mechanism.[37]

"Emitters Pay" is not necessarily a perfect, one-size-fits-all strategy. It may not be a feasible response because of political opposition or an inability to keep transaction costs manageable. It also seems most appropriate for the period of transitioning to an effective mitigation regime. An appealing fallback is "Beneficiaries Pay," which has the advantage of minimizing rent-seeking and moral hazard. This principle places the costs of adaptation measures on the direct beneficiaries of those measures. Another alternative, "Public Pays," is rife with the risks of moral hazard and rent-seeking, but is better then "Beneficiaries Pay" at

35. Some concrete proposals have made for implementing the "Emitters Pay" principle internationally:

> Some commentators have proposed the use of adaptation levies. In particular, they suggest an air ticket levy may be particularly relevant given the low levels/exemptions from taxation from which it has benefited historically, and the projected growth in aviations emissions. Such a levy could distinguish between short- and long-haul flights and classes of travel, and could be argued to have advantages on grounds of both equity (taxing "luxury" emissions rather than "survival" emissions) and efficiency (using a price instrument rather than quantity).

STERN, *supra* note 29, at 559.

36. United Nations Framework Convention on Climate Change, May 9, 1992, S. Treaty Doc. No. 102-38, 1771 UNTS 107, *available at* http://unfccc.int/adaptation/items/2973.php.

37. *See* Dean Smith, *U.N. Climate Talks Make Some Progress on Adaptation, Joint Implementation*, 29 INT'L ENV'T RPTR. 867 (Nov. 15, 2006).

spreading risk and handling redistribution.[38] In practice, a mix between these systems may be best, with beneficiaries and taxpayers splitting costs. Thus, where shifting costs to emitters is not feasible or appropriate, other cost allocation principles may come into play.

B. *Designing a System to Shift Costs to Emitters*

The idea that emitters should pay for some of the harm caused by their actions may seem appealing in the abstract. It is appropriate, however, to ask whether shifting costs to emitters is really practical, or whether attempting to do so would simply ensnarl the global legal system in interminable litigation.

Although a perfect system is unattainable, it seems feasible to design a workable cost-shifting scheme. We might imagine a system along the following lines. Consider a possible international compensation commission. The commission would receive claims from countries that have incurred adaptation expenses such as strengthening sea walls or providing alternative sources of ecosystem services to replace lost wetlands. The commission would determine which adaptation expenses were reasonable, and would schedule them for compensation. Compensation might be directly obtained from an international fund, but an alternative payment system might be more appealing if an international trading system for greenhouse gases was in place. In this alternative way of financing compensation, a set number of greenhouse gas allowances could be set aside for the commission. The commission would transfer these allowances to pay claims and, in turn, the claimants could sell them to greenhouse gas emitters on the open market. The net effect would be that the sources doing the least to reduce their emission levels would have the greatest need to purchase additional emission permits. Such permits would indirectly provide compensation for the expenses of adaptation. Thus, a wealth transfer would take place

38. "Winners Pay" seems like the weakest of the allocation principles, at least as the main basis for allocating adaptation costs. The winners have merely been lucky, having drawn lucky numbers in the regional impact lottery; they have not been culpable in causing the problem. Thus, whatever appeal "Winners Pay" might have seems to be part of a general view that locational luck should not be a determinant of wealth. Accepting this principle would require massive international redistribution of a kind that does not seem to have much current traction; for example, oil revenues would have to be shared among the entire global population, and countries with good soil and climate would have to share in agricultural earnings.

from poorly controlled sources of greenhouse gases to the victims of climate change.

The international compensation commission is only one possible implementation of "Emitters Pay." For example, it is also easy to imagine a similar program being established within the U.S. or a program where compensation might proceed through a grant program rather than through adjudication. No plausible system will precisely measure harm and match victims with historic greenhouse emitters, but some form of rough justice seems plausible.

Compensation of this kind is not a utopian dream. The best international precedent for such a system is the United Nations Claims Commission (UNCC) which was established after the first Iraq War to handle claims against Iraq for war-related damages.[39] The United Nations Security Council held that Iraq "is liable under international law for any direct loss, damage, including environmental damage and the depletion of natural resources, or injury to foreign governments, nationals and corporations, as a result of Iraq's unlawful invasion and occupation of Kuwait."[40] Compensable environmental claims include:

> (a) Abatement and prevention of environmental damage, such as expenses directly related to fighting oil fires and stemming the flow of oil in coastal and international waters;
>
> (b) Reasonable measures already taken to clean and restore the environment or future measures which can be documented as reasonably necessary to clean and restore the environment;
>
> (c) Reasonable monitoring and assessment of the environmental damage for the purposes of evaluating and abating the harm and restoring the environment;
>
> (d) Reasonable monitoring of public health and performing medical screenings for the purpose of investigating and combating increased health risks as a result of the environmental damage; and
>
> (e) Depletion of or damage to natural resources.[41]

These provisions gave rise to intense dispute about compensation for damage to pure (non-marketable) environmental resources and for interim damages to those resources prior to

39. For information about the UNCC, see http://www2.unog.ch/uncc/.

40. S.C. Res. 687, ¶ 16, U.N. Doc. S/RES/687 (April 8, 1991).

41. U.N. SEC. COUNCIL, United Nations Compensation Commission Governing Council, *Report and Recommendations Made by the Panel of Commissioners Concerning the First Installement of "F4" Claims* ¶ 10, U.N. DOC. S/A.26/2001/16 (June 22, 2001), *available at* http://www2.unog.ch/uncc/reports/r01-16.pdf.

restoration. The UNCC ultimately held that these damages were compensable.[42] One method used to measure the value of resources was the cost of mitigation measures such as providing alternative resources, which was used as a way to measure the loss of ecosystem services.[43] The UNCC awarded approximately $5 billion dollars for 109 successful claims.[44]

There seems to be a growing international recognition that "environmental damages will often extend beyond that which can be readily quantified in terms of clean-up costs or property devaluation."[45] Thus, harm to "environmental values – biodiversity, amenity, etc. – sometimes referred to as 'non-use' values is, as a matter of principle, no less real and compensable than damage to property, though it may be difficult to quantify."[46]

The UNCC dealt with the fallout from a discrete and readily identifiable human event, where moral blame could be unambiguously assigned. Nevertheless, it has useful lessons for climate change. The environmental impacts of the Gulf War were multitudinous and varied, presenting considerable difficulty in terms of damage assessment. The UNCC's decisions are relevant

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42. Cymie Payne, UN COMMISSION AWARDS COMPENSATION FOR ENVIRONMENTAL AND PUBLIC HEALTH DAMAGE FROM 1990-91 GULF WAR, http://www.asil.org/insights/2005/08/insights050810.html.

43. The application of this method of damage assessment is described in a recent overview of the UNCC's decisions:

> Several claimants put a value on their temporary natural resource losses by proposing environmental projects designed to compensate for the loss of ecological services that the natural resources would have provided, had they not been damaged. Although the Panel viewed the proposed valuation methods using compensatory restoration projects as "relatively novel," it was willing to apply them "where there is sufficient evidence that primary restoration will not fully compensate for any identified losses." Accordingly, the Panel made awards that were quantified according to the cost of various compensatory projects: a cooperative rangeland management program to restore rangeland and wildlife habitat damaged by the influx of refugees into Jordan, and shoreline preserves in Kuwait and Saudi Arabia. In another case — Iran's claim for damage to rangelands from the presence of refugees — the Panel found it more appropriate to use the price of fodder to calculate an award rather than the value that Iran derived from lost ecological services.

Payne, *supra* note 43. For discussion of the concept of ecosystem services, *see* James E. Salzman, *Valuing Ecosystem Services*, 24 ECOLOGY L.Q. 887 (1997); Symposium, 20 STAN. ENVTL. L.J. 309 (2001); James Salzman, *Creating Markets for Ecosystem Services: Notes from the Field*, 80 N.Y.U. L. REV. 870 (2005).

44. Cymie R. Payne, *Environmental Damage at the United Nations Compensation Commission* (2007) (unpublished manuscript, on file with author).

45. U.N. GAOR, Report of the International Law Commission, 53d Sess., Supp. No. 10, cmt. art. 36 at 252, UN Doc. A/56/10 (2001).

46. *Id.*

precedent for extending compensation beyond harm to marketable resources to include environmental amenities. The UNCC's approach to determining damages also may provide a workable model in the context of climate change. By focusing on the expense of mitigating the environmental harm, the UNCC avoided difficult problems of identifying long-term environmental effects and valuing the resulting harms.

Closer to home, CERCLA provides a precedent for a rigorous cost-recovery system. CERCLA imposes liability on a range of potentially responsible parties including waste disposers and transporters, waste generators, and site owners. Liability covers the cost of clean-up and, under certain circumstances, damages to natural resources owned by governmental entities. Liability is strict and retroactive as well as being joint and several. Additionally, the requirements for proof of causation are minimal. Causation is demonstrated if a generator's waste was sent to the site, without any showing that that generator's waste has been part of the leakage problem. If this statute was followed as a model, entities at all stages of the carbon process from extraction through consumption would be jointly and severally liable for climate change "clean-up," retroactively and without any showing of fault. As we will see later, CERCLA does allow these costs to be shifted through contribution actions against other responsible parties, but leaves this reallocation largely to the tribunal's equitable discretion.[47] Whether we would want to follow this model is of course another question, but at least there is a clear precedent for assigning costs to emitters in our domestic legal system.

Providing redress is a central purpose of a liability system, but it is not the only purpose. Moral hazard is another factor in designing a liability system. One possible solution, which was attempted in the National Flood Insurance Program, is to couple compensation with acceptance of regulatory restrictions. However, the flood insurance program has been, at best, a partial success. Another option is to impose a duty to mitigate damages on injured parties. In other words, this would involve making an independent assessment of whether mitigation measures were reasonably necessary in light of alternatives or whether the injured party unduly exposed itself to risk. The UNCC process is instructive here. In principle, this provides a complete solution.

47. *See infra* text accompanying notes 57-67.

In practice, of course, it increases the complexity and expense of proceedings, as well as the risk of error.

Establishing techniques to ensure that compensation is limited to reasonable adaptation measures is part of the larger question of how to efficiently establish damages. In an administrative setting, the best solution might be a schedule of presumptive adaptation expenses, with a limited right for either side to introduce evidence of special circumstances. A damage schedule is unlikely to be perfectly accurate since it will reflect a compromise between precision and administrative ease. As a result, it may lead to under-compensation or over-compensation, both of which have clear fairness implications, and may also create an insufficient incentive for emissions controls or some degree of moral hazard for victims. But, workability is probably more important in this context than precision.

Although there is a natural tendency to fine-tune the system in order to come as close as possible to the optimum level of compensation, it is probably a mistake to do so. Determining exactly the right level of compensation in every case would be extremely expensive and time-consuming. It would consume expertise that could be more usefully employed to design mitigation and adaptation measures. Also, it would probably delay compensation to the point of diminishing its value to victims. It is better to have a rough and ready system of compensation that provides at least partial justice and operates efficiently.

Such a scheme could be implemented in many institutional forms. It could be the basis for liability determinations by domestic courts or international tribunals. Alternatively, an administrative compensation scheme might be used. Or the system could be given a more voluntary dimension through agreements by responsible parties to finance grants for remedial measures (perhaps as settlement of litigation or with the encouragement of tax benefits or subsidies.)

Ultimately, we may not choose to implement the "Emitters Pay" principle or we may choose to limit it to some subset of culpable emitters and easily proven damages. However, the "emitters pay" principle has enough appeal to make it worthwhile to consider how we would split responsibility among emitters.

IV.
FOUR QUESTIONS ABOUT APPORTIONING RESPONSIBILITY AMONG EMITTERS

Apportioning responsibility among emitters is a difficult problem. Some readers may question the point of the exercise, but I will assume for at least the purposes of this paper that "Emitters Pay" is appealing enough to deserve at least partial implementation. I will also assume that a cost-allocation scheme of the kind sketched above would be capable of handling claims with reasonable efficiency and accuracy. These issues will not be addressed in this section.

Another issue that I will not address here is where the responsibility should fall in the chain leading to emissions. For example, in the case of automobile emissions, we might think of putting responsibility on governments that failed to impose appropriate regulatory limits, on the owners of the oil reserves, on the supply chain leading to the pump, on car manufacturers, or on consumers. Even if we impose legal responsibility at one point in the chain, it is always possible that the economic incidence will fall elsewhere. Deciding where to impose liability in this chain depends on all of the factors described above: incentive effects, just deserts for culpable behavior, loss spreading, social solidarity, and distributional effects. CERCLA is the extreme solution, placing liability throughout the chain from waste production to eventual leakage. However, we might choose to focus liability in order to limit transaction costs.

For present purposes, we can merely assume that someone with a connection to emissions like a fossil fuel extractor, distributor, or user, or the producers of energy consuming technologies will be linked to each unit of greenhouse gases. We are also assuming that these "emitters" (whether or not they are the ones physically emitting the gas) will bear some share of the costs created by climate change, at least including some of the adaptation costs. We will focus on the question of how to divide the total cost in question among the various emitters. To simplify the discussion, I will assume that all the emitters in the "pool" are equally culpable in terms of state of mind, putting to the side what level of culpability (if any) should be required as a basis of responsibility. If some of the emitters are culpable enough to be held accountable, but less culpable than other emitters (who might have had more knowledge or engaged in deception), we

might want to make an equitable adjustment in responsibility shares.

Since greenhouse gases are completely mixed in the atmosphere and cause their harm globally, there is no way of physically linking any single emitter with any single impact. All emitters contribute to all impacts. Thus, the apportionment is a matter of morality and policy, not merely a question of scientific proof. I consider four aspects of this problem below.

A. *Total or Excess Emissions?*

Two categories of emitters might have the same current and historical emission levels, but it might be feasible to reduce one category's emissions much more than the other's. Whether we divide responsibility on the basis of actual emissions or of excess emissions (those that should have been reduced through mitigation measures) could make a considerable difference.[48]

Thus, a compensation scheme could base liability on a source's total emissions, or only on those emissions in excess of some "optimal" level. For instance, if we use 1990 as a cut-off date,[49] we could ask what level of reductions would have been imposed on a source by an optimal regulatory scheme beginning in that year. Alternatively, we could ask what number of greenhouse gas allowances that source would have acquired under a perfect market with an optimal cap.

Using excess emissions as the basis for liability is more closely linked with culpability. Emitters have some kind of responsibility for all of the harms caused by their emissions, but they seem most to blame for harms that they should have avoided through prudent mitigation measures. Thus, to the extent we want to shift cost to emitters on the basis of culpability, the excess emission approach seems preferable. Unfortunately, it may be less appealing on other grounds.

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48. Looking at total versus excess emission might also affect the total amount of costs that we would want to shift to emitters collectively, but this is an issue that I do not address in this article.

49. There are two arguments for using this date. First, it is roughly the time of the first Framework Convention on climate change, which the U.S. joined, so it marks international acknowledgement of the problem. Second, our emissions data before 1990 is less adequate. According to the World Resources Institute's report, "[p]olicy proposals that rely on historical emissions prior to 1990 face considerable barriers related to data quality and availability." Baumert et al., *supra* note 3, at X. The greatest uncertainties relate to CO2 production from land use change and forestry. *Id.* at 7.

First, we should note that, going forward, there is no difference between the two alternatives in terms of incentives. If we use excess emissions as the standard for liability, the source has an incentive to eliminate the excess emissions. If we use total emissions, the source will cut emissions to the point where the marginal harm caused by the emission equals the marginal benefit to the source of emitting. If excess emissions are defined economically (through cost-benefit analysis), the two should be identical. Essentially, from a deterrence perspective, so long as emitters are charged for their excess emissions, it makes little difference if they also pay for harms caused by their other emissions.

Second, calculating excess emissions requires determining the optimal path of emission reductions, which is bound to be controversial. This determination dictates whether past and present emissions are excess, or whether emission reductions should be partially deferred into the future. The determination depends heavily on the choice of discount rates, which essentially measure how much the present generation should be willing to sacrifice on behalf of future generations. There is no consensus even among economists about the correct rate, and some non-economists question whether discounting is appropriate at all when the welfare of future generations is at stake

Third, even given the optimal path of emission reductions, we would still have to figure out the optimal allocation of emission limits among sources. The whole point of using a market to do this, in a cap-and-trade scheme, is that this is something that governments cannot do very well. (Otherwise, we wouldn't need the trading part of the scheme; the government could just give everyone the right number of allowances from the outset.) So this step of the process is also fraught with difficulty.

Thus, the chances of being able to determine excess emissions with precision are dubious. Nevertheless, imposing full liability for all climate change on emitters, even harm caused by emissions they could not reasonably eliminate, may seem too harsh. It could defeat our interest in loss spreading by concentrating costs on a small group, and the liability might be so crushing that it would eliminate the ability of the sources to finance mitigation measures.

Therefore, it seems likely that we will try to make some provision for identifying excess emissions. This is not a foregone conclusion. For example, CERCLA imposes strict liability on potentially responsible parties without trying to determine how

much of the toxic release would have occurred even if they had exercised appropriate care. The level of fault only becomes relevant, if at all, in actions for equitable contribution.

If we do want to identify excess emissions in a rough way, we have several options. First, we could simply calculate a uniform percentage reduction for emissions at a given time based on the optimal cap, ignoring the allocation question. So if we determine that total emissions in 1995 should have been twenty percent lower than the actual level, we assess liability to each source based on twenty percent of its emissions. If actual regulatory schemes call for heavier reductions in some sectors than others, we could adjust liability for past events accordingly.

Second, based on the harm of emissions, we could try to establish what the charge for carbon emissions should have been in the year in question. We would then try to determine, either for particular sources or categories of sources, what lower carbon alternatives were available. If the source would have shifted to the lower level of emissions given a carbon tax, we would view any additional incentives as excess. In essence, we would be mimicking regulatory schemes which require regulators to establish the best available level of pollution control for various industries, the difference being that we would do so for purposes of assessing liability rather than imposing regulation. The experience with analogous regulatory schemes should give us pause. It has taken enormous effort for the EPA to establish these regulations for other forms of pollutants, and doing so for purposes of establishing liability levels would be a formidable task. However, for a few key industries that account for large amounts of emissions such as power generation, the task might be worthwhile.

In short, in the abstract, there are reasonably good arguments for using excess emissions as the basis for apportioning climate change costs among emitters. Doing so, however, may not be practical in many situations, will often involve very rough approximations, and is worth pursuing carefully at most in a few key industries.

B. *Average or Marginal Effect?*

The response to increased emissions does not seem to be linear. That is, we do not expect the result of doubling the current carbon dioxide effort to be twice as great as the harm caused by the current level of emissions. For this reason, the direct effect of adding "one more" atom of carbon dioxide is not the same as the

effect of each of the preceding emissions. This raises the question of whether costs should be allocated on the basis of the average or marginal impact of emissions.

The extent to which this is a problem is unclear. Current models seem to suggest that temperature change goes up more slowly than changes in atmospheric loading. On the other hand, damages might well go up more quickly than average temperature changes because of increases in weather variability. It is hard to know how the two effects will interact.[50] Conceivably, they might cancel, but it is at least as likely that they will not. If they do not cancel, then the average harm caused by a given amount of greenhouse gases will not necessarily equal the marginal impact of adding another unit of greenhouse gases. Where this is true, should we base determinations of responsibility on average or marginal harms?[51]

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50. A common assumption is that damages are a quadratic function of temperature increase past a certain point. *See* Mendelsohn et al., *Country Specific Market Impacts of Climate Change*, http://crga.atmos.uiuc.edu/publications/market_impact/text.html. For a discussion of the various models, see STERN, *supra* note 29, at 147, fig. 6.2. The Nordhaus model, which seems to be particularly well regarded by economists, "predicts that the cost of climate change will increase faster than global mean temperature, so that the aggregate loss in global GDP almost doubles as global mean temperature increases from 4°C to 6°C above preindustrial levels." *Id.* The reason for the nonlinearity is that Nordhaus posits an increasing possibility of abrupt climate shifts at higher average global temperatures. *Id.*

51. A similar issue might also arise if there are saturation effects. Any one emitter could argue that the marginal effect of its emission to an already saturated situation was zero, yet the emitters would collectively have caused the situation with some degree of overdetermination. This seems like an apt situation to apply a principle from tort law:

> The rule that has evolved is that, at least where both causes involve comparable blameworthiness, both actors are liable, even though the conduct of either one was not a *sine qua non* of the injury because of the conduct of the other. There is no reason why a polluter should be insulated from responsibility in a case where a traditional tortfeasor would not be.

Boeing Co. v. Cascade Corp., 207 F.3d 1177, 1183 (9th Cir. 2000). As the court explained:

> Take the philosophers' example above of the kitchen with a light switch at each end. When two people simultaneously flip both switches on, the light goes on. Neither person's conduct is a sine qua non, because the light would have gone on anyway. Neither individual's conduct made a difference to the outcome. [This] analysis would compel the conclusion that neither person caused the light to go on. [This] argument that liability can only attach to conduct that is a sine qua non of the harm, even for causally overdetermined harm, cannot be right, as the kitchen light hypothetical case shows. The problem with [this] argument is that where the result is overdetermined, each person's argument is as strong as the other's identical argument. If we accept one person's argument that he did not cause the light to go on, then we have to accept the identical and equally valid argument of the other person that he did not cause the light to go on. Each accurately points out that his

Nevertheless, it seems that every emitter at a given time should be assessed the same damages for each unit of carbon.[52] Suppose, for example, that there are increasing marginal harms from emissions. Then, each emitter is directly causing harm, but also indirectly causing harm by increasing the harmfulness of other source's emissions. This is a negative externality for which the source should be held responsible. Conversely, the marginal source has intensified the harm caused by other emitters. In short, the total harm is an indivisible product of the combined input of all the emitters, and all of them should be held equally liable.

Going forward, if we attach liability for emissions after the scheme is in effect, there is an economic argument for basing liability on the harm caused by the marginal unit of total emissions, allocated among sources based on their excess emissions. This would create an optimum incentive for emission reduction. As we have seen, however, our ability to determine excess emissions is quite limited. If we cannot determine excess emissions, then a source that decides to emit an additional unit knows that the marginal cost would be spread over all existing sources, so the source would not fully internalize the liability cost.

We could solve this problem by holding each of the sources liable for every marginal unit whether or not they emit it. From the point of view of emitters, this would be equivalent to an optimal carbon tax (assessed on either total emissions or excess emissions). This mechanism is less appealing in the context of apportioning responsibility, since it will collect more than the actual compensable harm caused by the emitters whenever marginal harm is greater than average harm (or in other words, when

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switching the light on was not a sine qua non of its going on. It is true that the light would have gone on anyway because of the other person's conduct. If conduct had to be a sine qua non even for this overdetermined result, then neither person's conduct caused the light to go on. But the light went on. And it did so by human agency, not spontaneously. So the conclusion that Cascade's argument compels, that no one caused the light to go on, is false. Because the correct answer has to be the same for the two individuals, by eliminating the false answer we have left only one possible answer which must be true: Each of the two persons caused the light to go on.

Id. at 1184-85. For the same reason, when a group of emitters contributes to saturating the atmosphere with a gas, all of them should be considered causal factors, even if the marginal contribution to the harmful effect is zero because of the saturation effect.

52. Either excess units or total units, depending on how the issue in the preceding section is resolved.

the marginal harm increases with the total emissions level). In contrast, if there is decreasing marginal harm from increased emissions, then the marginal emitter's liability for direct harm is reduced by other emissions. This could be considered a benefit for which the other emitters should be compensated through a reduced liability share.

If the basis for assessing responsibility is current emissions, the difference between marginal and average emissions will probably be small, because current emissions are small compared with the baseline of current atmospheric concentrations (which represent accumulated emissions over many years). On the other hand, if the baseline is cumulative emissions, marginal harm might be quite different from average harm.

Unless deterrence is the main goal, average harm is a more appropriate measure than marginal harm. Using average harm assures that that amount of compensation equals the amount of total harm, thereby satisfying a critical equity goal.

C. *Current or Cumulative Emissions?*

If we consider current emissions versus 1990 baseline emissions, there are some significant discrepancies. Over time, these discrepancies between historic emissions and current emissions will grow, as some sources are controlled more than others. For example, China's share of current emissions will grow much more quickly than its share of cumulative emissions (and atmospheric loading). Correspondingly, the United States' share of current emissions may fall much more quickly than its share of cumulative emissions. Should we use current or historic emissions as the basis for apportionment?

On deterrence grounds, we might want to use current emissions so as to provide the maximum incentive for control. Of course, if we think that emitters should have anticipated the possibility of a liability scheme, or if we are interested in forcing entities to similarly anticipate and respond to potential liability for new environmental problems, using cumulative emissions at least at the outset of the scheme would in effect retroactively charge emitters for past "current" emissions.

Putting deterrence aside, equitable consideration might suggest the use of cumulative emissions. Past emissions cause current harm to the extent that the carbon remains in the atmosphere. If marginal damages increase with overall atmos-

pheric loading, past emitters are also increasing the amount of marginal harm done by current emitters.

This issue seems to be related to the preceding one, at least as a practical matter. If we use current emissions as the basis for apportionment, marginal and average harm will be similar. On the other hand, if we use historic emissions, then harm is based on total contribution to current atmospheric loadings, so the difference between marginal and average harm becomes significant.

At least in part, the choice between historic and current emissions involves the question of retroactivity. To the extent that we view past emissions as having been free from any legal or moral restrictions, we might not want to allocate costs to those emissions. However, we might consider that at least some past emissions were culpable in the sense that they violated legal or moral restrictions, or we might find culpability irrelevant in this situation. On the other hand, if we do not allocate costs to past emissions, we will be placing a heavy burden on new sources of emission whose impact on current harm is small, but which will continue to impose costs so long as their emissions remain in the atmosphere. This brings us to the question of whether to base apportionments on current or projected harms.

D. *Current or Projected Harms?*

Since greenhouse gases remain in the atmosphere for long periods of time, the full harm from a current emission does not take place immediately. We could charge current emitters for harm on a continuing basis so long as "their" carbon remains in the atmosphere.[53] Alternatively, we could reduce future damages to present value and charge emitters immediately. Both alternatives have difficulties.

The problem with the first alternative is that it requires continually assessing and collecting damages from an emitter over a period of decades if not centuries. Apart from the transaction costs involved, this may be difficult simply because the time period for the harm may exceed the lifespan of some entities. Many corporations will go out of business over such time periods. A similar problem gave rise to the "orphan shares" problem

53. An analogy can be seen in CERCLA cases where declaratory judgments are used to allocate responsibility for clean-up costs that have not yet been incurred. *See* Boeing Co. v. Cascade Corp., 207 F.3d 1190. Of course, the time span involved in cleaning up a hazardous waste site is much less than the decades or centuries that greenhouse gases may remain in the atmosphere.

under CERCLA, even though the time periods involved were shorter. Indeed, the prospect of indefinite liability assessments could create an incentive for corporations to undercapitalize and siphon off profits, increasing the risk of insolvency.

The second alternative is also not free from difficulty. Projecting the future harm caused by an emitter will require knowing how many emissions will come from other future sources, unless the damages (whether in the form of requiring future adaptation or otherwise) turn out to be a simple linear function of emissions. There is also the significant problem of determining the correct discount rate to use for future harms.

Given these choices, we might try to split the difference by requiring current emitters to purchase long-term insurance, which would guarantee that at least some of their future responsibility would be covered as long as the insurance companies will remain solvent over long periods of time. From the emitters' point of view, this accelerates at least some of the costs of liability to the present, making it similar to the second alternative. Like the first alternative, however, it leaves to the future the actual calculation of damages. If the insurance coverage turns out to be too low or if the insurance company becomes insolvent, future efforts to collect against the emitter remain possible.

E. *The Restitution Measure as an Alternative*

Given the difficulties of basing the cost apportionment on the harm done by emitters, it may be worth considering an alternative approach. We have been assuming so far that emitters would be held liable for climate change harm based on their share of emissions. The alternative would seek to identify unjust enrichment by emitters and require them to disgorge those profits to an adaptation fund. This could be considered a variety of windfall profits tax, with the windfall being the opportunity to profit from inadequate mitigation measures.

EPA's civil penalty policies provide a model for such a scheme. EPA has developed a computer model known as BEN to calculate the economic benefit that a specific source has received by delaying the acquisition or use of pollution control equipment.[54]

54. See Jonathan Libber, *Penalty Assessment at the Environmental Protection Agency: A View From Inside,* 35 S.D. L. REV. 189, 193-197 (1991).

EPA's Science Advisory Board views these economic benefit calculations as the core of the agency's penalty policy.[55]

As with the proposal to base liability on "excess" emissions, this model requires that we determine what greenhouse gas control strategies should have been in place prior to the existence of any regulations. The EPA does not have to contend with this problem when it implements its penalty policy, since sources were subject to regulation and their exact responsibilities are often incorporated into permits.

Determining retroactive control targets on an economy-wide basis would be a formidable undertaking. However, it may be possible to determine what would have happened in key sectors such as energy and transportation if optimal control strategies had been in place. For example, we could consider how a carbon tax would have impacted demand and how such a tax might have prompted fuel shifts and technological changes. The advantage of this approach is that the problem of apportionment between sources takes care of itself, as emitters disgorge their excess profits to a compensation fund. The disadvantage is that source-by-source profit calculations are required. Also, at least some measures might have actually saved emitters money (for example, by lowering fuel bills), so that there was no excess profit from the delay.

F. *Lessons on Apportioning Responsibility from CERCLA*

Although there are genuine difficulties in apportioning responsibility among emitters in the context of climate change, these difficulties need not be fatal stumbling blocks. CERCLA provides one model for how to allocate responsibility even when precisely determining individual causal contributions is difficult. Although it would not make sense to blindly follow the CERCLA model in the climate change setting, CERCLA does show that the difficulties can be overcome where there is a will to do so. Because CERCLA casts its net of liability so broadly, defendants can vary widely in terms of their degree of causal responsibility and the culpability of their actions. Moreover, the passage of time at many sites and the difficulty of identifying the contributions of different discharges to the risks posed by a site

55. Environmental Protection Agency Science Advisory Board, An Advisory of the Illegal Competitive Advantage (ICA) Economic Benefit (EB) Advisory Panel of the EPA Science Advisory Board 10 (June 7, 2005), *available at* www.epa.gov/sab/pdf/ica_eb_sab-adv-05-003.pdf.

may create serious problems of proof. Nevertheless, courts applying CERCLA have managed to allocate liability despite these problems.

Under section 107(a) of CERCLA, a list of entities known as potentially responsible parties are liable for the costs of cleaning up hazardous waste sites. The list includes waste generators, transporters, disposers, and, with some exceptions, the owners of the land. The burden of proof to establish liability is not high. For instance, a generator may be liable without any showing that its waste has actually leaked or even remains at the site. "Absent proof that a generator defendant's specific waste remained at a facility at the time of release, a showing of chemical similarity between hazardous substances is sufficient."[56]

Liability under CERCLA is normally joint and several where each defendant is potentially liable for the entire amount, with the possibility of then seeking contribution from other defendants.[57] A few courts, however, have allowed apportionment of responsibility on the basis of equitable factors at the liability stage.[58] For example, in one case, a defendant was allowed to introduce evidence that the only waste it had taken to a site was a non-hazardous, non-toxic emulsion whose only toxic components were far below natural background levels.[59]

When joint and several liability is applied, that is not the end of the matter in terms of apportionment. Section 113(f) of CERCLA provides:

> Any person may seek contribution from any other person who is liable or potentially liable [under CERCLA.] Such claims . . . shall be governed by Federal law. In resolving contribution claims, the court may allocate response costs among liable parties using such equitable factors as the court determines are appropriate.[60]

Courts typically look to what are called the "Gore factors" to determine liability shares including the amount of waste, its de-

56. U.S. v. Monsanto, 858 F.2d 160, 169 (4th Cir. 1988), *cert. denied*, 490 U.S. 1106 (1989).

57. *See In re* Bell Petroleum Serv., Inc., 3 F.3d 889, 901 (5th Cir. 1993) ("equitable factors . . . are more appropriately considered in actions for contribution among jointly and severally liable parties, than in making the initial determination of whether to impose joint and several liability.").

58. *See* Lynda Oswald, *New Directions in Joint and Several Liability under CERCLA?*, 28 U.C. DAVIS L. REV. 299 (1995).

59. U.S. v. Alcan Aluminum Corp., 964 F.2d 252, 271 (3d Cir. 1992).

60. 42 U.S.C. § 9613(f) (2007). For a survey of recent decisions, see Nicholas J. Wallwork & Mark E. Freeze, *Spreading the Costs of Environmental Clean-Up-Contribution Claims under CERCLA and RCRA*, SM072 ALI_ABA 667 (2007).

gree of toxicity, the degree of the party's involvement in handling the waste, the party's degree of care, and the degree of cooperation with government authorities to prevent environmental harm.[61] For example, a party contributing only ten percent of the waste may be held liable for a third of the clean-up costs where the chemical it released was much more toxic and difficult to remove than the chemical released by another party.[62]

Trial judges necessarily enjoy a fair amount of discretion in apportioning costs under CERCLA:

> Congress intended to invest the district courts with this discretion in making CERCLA contribution apportionments when it provided, "the court may allocate response costs among the liable parties using such equitable factors as the court determines are appropriate." 42 U.S.C. § 9613(f)(1) (emphasis added).
>
> Essentially, appellant argues here that a narrow, technical construction must be given to the term "contribution," so that, as in common law contribution, contribution under the statute is limited to the percentage a party's improper conduct causally contributed to the toxicity of the site in a physical sense. This argument is without merit. On the contrary, by using the term "equitable factors"

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61. For a discussion of the Gore factors, see *U.S. v. A & F Materials Co.*, 578 F. Supp. 1249, 1256 (S.D. Ill. 1984). Note that courts consider some factors in CERCLA cases beyond those that would be typically applied in tort cases, such as the defendant's benefit from the clean-up and degree of cooperation. *See* Wallwork & Freeze, *supra* note 61, at 689. The Seventh Circuit has commented on the breadth of the court's discretion in CERCLA contribution cases, going even beyond the Gore factors:

> We have already pointed out the Gore Factors listed in *A & F Materials* as possible considerations for making an equitable allocation decision, but we emphasize that the Gore Factors are neither an exhaustive nor exclusive list. Like the Court of Appeals for the Sixth Circuit, we think a court may consider any factors appropriate to balance the equities in the totality of the circumstances. *See* U.S. v. R.W. Meyer, Inc., 932 F.2d 568 (6th Cir. 1991). And as examples, we catalog several federal court decisions listing factors to be possibly considered under section 9613(f)(1): *B.F. Goodrich Co. v. Murtha*, 958 F.2d 1192 (2d Cir. 1992) (court may consider an array of factors including the financial resources of the parties involved); *CPC International, Inc. v. Aerojet-General Corp.*, 777 F.Supp. 549 (W.D. Mich. 1991) (listing responsible party's degree of involvement in disposal of hazardous waste, amount of hazardous waste involved, and degree of care exercised by the parties as factors to consider in a contribution action); *Weyerhaeuser Co. v. Koppers Co.*, 771 F. Supp. 1420, 1426 (D. Md. 1991) (indicating as important factors the benefits received by the parties from contaminating activities and the knowledge and/or acquiescence of the parties in the contaminating activities); and *U.S. v. Bell Petroleum Services, Inc.*, No. MO-88-CA-05, 1990 U.S. Dist. LEXIS 14066, *9 (W.D. Tex. July 24, 1990) (court is not limited to apportionment in a contribution action on the basis of fault).

Env. Trans. Sys., Inc. v. Ensco, Inc., 969 F.2d 503, 509 (7th Cir. 1992).

62. Control Data Corp. v. SCSC Corp., 53 F.3d 930 (8th Cir. 1995).

> Congress intended to invoke the tradition of equity under which the court must construct a flexible decree balancing all the equities in the light of the totality of the circumstances.[63]

One key lesson of CERCLA is that cost apportionment involves complex determinations involving multiple social norms. In the CERCLA context, courts have never articulated a formula for how to make apportionments between responsible parties, settling instead for open-ended lists of relevant factors combined with trial court discretion. Given the much greater scale of the climate change problem, we may not be content with such ad hoc treatment. Rather, we may want to settle on some relatively mechanical formula for apportionment. The CERCLA experience suggests that no single formula is likely to appear uniquely desirable. Instead, given the complexities involved, we will have to choose among competing formulas that each have some appeal. The choice will probably involve some degree of imprecision. But, as demonstrated by CERCLA, a fairly imprecise approach to apportionment can be tolerable, so long as the relevant factors are at least taken into account.

Thus, we should not be too discouraged by the difficulties of devising a perfect apportionment scheme. CERCLA has gotten along with a very rough system for almost thirty years. Although there are plenty of criticisms of CERCLA on other grounds,[64] this aspect of CERCLA has proven quite tolerable.

V.
CONCLUSION

How serious are the apportionment problems in terms of climate change responsibility? At least as to some issues, this depends partly on the shape of the damage function, which we do not yet know. The closer the function comes to being linear where a single unit of greenhouse gases causes the same amount of harm regardless of how much other greenhouse gases are in

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63. U.S. v. R.W. Meyer, 932 F.2d 568, 572 (6th Cir. 1991). Thus, the court said:

> No exhaustive list of criteria need or should be formulated. However, in addition to the criteria listed above, the court may consider the state of mind of the parties, their economic status, any contracts between them bearing on the subject, any traditional equitable defenses as mitigating factors and any other factors deemed appropriate to balance the equities in the totality of the circumstances.

Id. at 572-73.

64. *See* Katherine N. Probst & Paul R. Portney, *Assigning Liability for Superfund Cleanups: An Analysis of Policy Options* (Resources for the Future 1992) (discussing criticisms of CERCLA and possible reforms).

the atmosphere, the easier it will be to make apportionments. While it is not likely that the damage function will be exactly linear, it might turn out that, in certain circumstances, a linear function is a good enough approximation so that we will be able to ignore some of the complexities of apportionment.

If, and this is a significant "if," we think that the case for allocating responsibility to emitters is otherwise strong enough, the complications of apportionment among emitters should not be a great deterrent for two reasons. First, we cannot expect to do perfect justice, and, second, we may well be able to come up with rough solutions that are reasonably acceptable. Since emitters will likely be held responsible for only a fraction of climate change damages, the risk that any emitter will be forced to shoulder an undue share is mitigated.

Returning to the questions posed at the beginning of this article, it is worth exploring some tentative answers. First, should emitters be responsible for the impact of all of their emissions, or only those that fall above some optimal control strategy? In principle, it seems better to divide responsibility based on excess emissions, but this may be very difficult to determine in detail. It may be best to make an effort at determination for only a few key sectors. (For these sectors, we might also consider use of a restitution standard based on the additional profits they enjoyed from excess emissions.) Outside of these key sectors, we might simply presume that emitters would have cut back on roughly the optimal path for the economy as a whole.

Second, should liability be based on the marginal effect of adding an extra ton of greenhouse gas, or on the average impact per ton of climate change at a given time? I would tentatively lean toward average impact on the basis of simplicity and because of equity considerations among emitters. But, from an incentive point of view, all emitters should be held responsible on the basis of marginal harm. Assuming, however, that some reasonably effective regulatory or tax scheme is in place, this becomes a secondary consideration.

Third, should liability be apportioned on the basis of current or cumulative emissions? In principle, past emissions should not be free of responsibility to the extent they are still causing harm, where the emitters are still available and still financially responsible. After an initial finding of liability, we may face the risk that these emitters will become insolvent or otherwise disappear. When the scheme is implemented, in order to avoid repeated ac-

tions against past emitters, we might treat past emitters in terms of future liability along the lines sketched below for current emissions.

Finally, how should we account for the future impacts of current emissions? My proposal here is that they should be required to purchase long-term insurance financed by borrowing in capital markets. This shifts the risk of the emitter's insolvency away from those bearing climate change costs toward the widest range of shareholders.

A synthesis of these answers provides the following principle for apportioning costs among emitters:

> Cost apportionments should be based on "excess" emissions, determined to be whatever limited degree of precision is feasible. The climate change costs at any given time should be allocated on the basis of an emitter's current share of total atmospheric loadings at that time (meaning the use of average rather than marginal harm, and of historic rather than current emissions). To minimize risks due to future insolvencies, emitters should also be required to purchase insurance covering their projected future share of costs.

It would not surprise me if further consideration were to require rethinking of some of these conclusions. These are complicated issues that will be with us for a long time and it seems unlikely that a single article could provide definitive answers. If this article and its two companion pieces help spark a debate on the problems it will be an important first step, regardless of the ultimate outcome of that debate.

It may well be that these issues will never be the subject of formal implementation and no explicit compensation mechanism will ever be established. Nevertheless, even if no explicit compensation scheme is established, arguments about responsibility will surely continue in the political arena. For example, in the run-up to the Kyoto Protocol, Brazil proposed that emissions targets be set on the basis of each country's responsibility for global temperature increase.[65] We surely have not heard the last of such proposals, domestically or internationally, and we should be able to consider their merits in an intelligent fashion. At the

65. Baumert et al., *supra* note 3, at 32. Setting emission targets based on historical responsibility for emissions rather than on current control costs and benefits might unnecessarily increase the cost of climate mitigation. A better approach would be to set an overall international cap based on an analysis of global costs and benefits, but then take historical responsibility for harm into account when making the initial allocation of permits. A related idea would be to use a carbon tax that is uniform internationally, but then redistribute the proceeds to attain equity.

same time, of course, we must realize that politics is a messy process, and that even if we can agree on the right outcome, getting there is another matter.

It may be tempting to dismiss cost apportionment as a secondary concern that is less important (not to mention less intellectually engaging) than determining our policy responses to climate change. It is not realistic, however, to decouple the question of what we should do from the question of who should pay. Coping with climate change is going to be a multi-generational task. Thus, for many years to come, society will be faced with the question of how to allocate the costs. We had best start thinking about those issues now.