Fat Tails and Climate Change:
Catastrophic Failures in Risk Management, 5

William Leiss (July 20, 2011)

The phrase "fat tails" became familiar to some people after the storm broke in 2008's global financial crisis. A fat tail refers to the probability and consequences of a possible event that is outside the bounds of our normal expectations, as defined either by our prior experience or by accepted theories – for example, theories of the behaviour of financial markets.[1] More specifically, it refers to the probability of an adverse event (such as a financial crisis) that is both *more likely* to occur than is "normally" expected, and that if it should occur could have *catastrophic dimensions*. [See www.fattails.ca and the lovely 2010 animated graphics in *The Economist*: http://econ.st/n9xYZq.]

Fat tails are very important for risk estimates dealing with the likelihood and outcomes of adverse events of all kinds. Some of the controversy about the global financial crisis that began in 2007/8 has to do with what our "normal" expectations are for the collapse of banks and other financial institutions that are "too big to fail." (This is now referred to as "systemic risk" or "systemically important financial institutions, markets, and instruments."[2]) Some of the major banking players claimed, after the event, that what happened in late 2008 was so remotely improbable that no rational person could have forecast it. What they forget to mention is that since their risk models completely ignored systemic risk, where hidden correlations among asset classes lurked, they had no idea they even had to manage this risk.[3]

Climate change risk poses a somewhat different form of this same problem. The key risk here is represented by the process known as "radiative forcing," whereby higher levels of atmospheric CO_2 and other greenhouse gases, such as methane, trap more of the sun's energy as it strikes the earth. The current "best estimate" of temperature increase in response to a doubling of atmospheric CO_2 since 1750 is somewhere in the range between

[1] See the discussion in my book, *The Doom Loop in the Financial Sector, and Other Black Holes of Risk* (University of Ottawa Press, 2010), pp. 90-93, and the PPT presentation, "Blindsided by Risk" (June 2011): http://leiss.ca/wp-content/uploads/2011/06/Blindsided-by-Risk.pdf.

[2] IMF and others, "Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations" (October 2009): http://bit.ly/roLSRQ.

[3] Joe Nocera, "Risk Mismanagement," *The New York Times Magazine*, 2 January 2009: http://nyti.ms/nkeBtJ and especially Andrew Haldane, Bank of England, "Why banks failed the stress test" (February 2009): http://bit.ly/qIJBva.

+2.0°C and +4.5°C (or 3°C ± 1.5°C). This is, obviously, a fairly substantial range, and if the increase were to be in the upper part of the range (the "extreme tail"), the effects on the environment that now sustains human productivity on the planet could be severe.[4] What one would like to do under these circumstances is to reduce the degree of uncertainty that is represented in the wide distribution between the lower and upper levels of the range. But at least one main obstacle is the nature of what is known as "climate sensitivity."

Climate sensitivity is the interaction between changes in radiative forcing and changes in the climate response to it (http://en.wikipedia.org/wiki/Climate_sensitivity), e. g., in global average temperature. But the nature of climate sensitivity makes it unlikely to expect that we will be able to reduce this degree of uncertainty, no matter how much more climate science knowledge we accumulate. Roe and Baker note:[5]

> [T]he data that we have on extreme climates [for example, the Eocene warmth and Proterozoic "snowball Earth"] suggest that the climate system may have been acutely sensitive to radiative forcing during some intervals of Earth's history. Our results imply that dramatic changes in physical processes are not necessary for dramatic changes in climate sensitivity, provided that those changes in processes can all align in the same direction toward increased sensitivity [i.e., are correlated].

They conclude that "the climate system is [now] operating in a regime in which small uncertainties in feedbacks are highly amplified in the resulting climate sensitivity."[6] These feedbacks are what produce the "fat [extreme] tail" on the high side of the estimates for the likely impacts from rising GHG concentrations. *This is the "kicker" in their analysis: If we are now in the "regime" described just above, then even small changes in radiative forcing from GHG emissions could have very large future impacts.*

Current CO_2 global average concentrations are about 390ppm.[7] The *Climate Change 2007* report from IPCC notes: "The atmospheric concentration of carbon dioxide ... now

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[4] Some current policy positions, for example in the European Union, seek to limit the temperature increase to no more than 2.0°C. Andrew Weaver et al., "Long term climate implications of 2050 emission reduction targets," *Geophysical Review Letters*, vol. 34, L19703 (2007, 1-4), seek to show just how difficult that minimum target (at the *bottom* of the range) will be to achieve, arguing that "even if emissions are eventually stabilized at 90% less than 2006 levels globally (1.1 GtC/year), the 2.0C threshold warming limit advocated by the European Commission is eventually broken well before the year 2500" (p. 3).

[5] Gerard H. Roe and Marcia B. Baker, "Why is climate sensitivity so unpredictable?" *Science*, vol. 318 (26 October 2007), pp. 629-632.

[6] For an explanation of these feedbacks see: http://www.epa.gov/climatechange/science/futuretc.html.

[7] Ppm = parts per million; ppmv = parts per million volume.

exceeds by far the natural range over the last 650,000 years (180 to 300ppm) as determined from ice cores."[8]

One sensible reaction to large uncertainties in the estimation of future adverse impacts of any kind would be to increase the margin of safety or margin for error – a precautionary approach in case the extreme tail of the range comes to pass. Toward this end we would now be reducing global greenhouse gas emissions [GHGs], or at least trying to keep them at the same level as they are; or, if we cannot do that (and obviously we cannot), it would mean at least starting to slow the *rate of increase* in GHGs. But taking the globe as a whole, we humans are doing the *exact* opposite:[9]

> The increase of all GHG gasses has been particularly rapid since 1950. The first 50 ppm increase above the pre-industrial value of carbon dioxide (CO_2) for example, was reached in the 1970s after more than 200 years, whereas the second 50 ppm was achieved in about 30 years. In the recent 10 years the highest average growth rate has been recorded for any decade since atmospheric CO_2 measurements began (IPCC, 2007). This increase was nearly entirely caused by human activities....

Levels of carbon dioxide in earth's atmosphere at the beginning of the industrial era around 1750 are estimated to have been 260-280ppm. Based on realistic current projections of steady or accelerating growth in such emissions, it is likely that we will hit 450ppm by 2015 and twice the preindustrial levels (550ppm) a decade later, if not sooner. Given the time it will take to reverse the massive, still-growing infrastructure in fossil-fuel energy production, it is not entirely out of the question that unless drastic changes are made we will reach 3 or 4 times preindustrial levels before the end of this century.

One academic specialist concludes the abstract of his recent technical paper with this decidedly droll comment: "Effectively, civilization is in a double-bind. If civilization does not collapse quickly this century, then CO_2 will likely end up exceeding 1000 ppmv; but, if CO_2 levels rise by this much, then the danger is that civilization will gradually tend towards collapse."[10]

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[8] Intergovernmental Panel on Climate Change: Volume I, p. 2. See also: http://en.wikipedia.org/wiki/Carbon_dioxide_in_Earth's_atmosphere

[9] European Environment Agency, "Atmospheric Greenhouse Gas Concentrations" (November 2010): http://bit.ly/pMz6Qf . For a comprehensive study, see: U. S., National Research Council, *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades and Millennia* (2011): http://www.nap.edu/catalog.php?record_id=12877 [free PDF].

[10] T. J. Garrett, "Earth System Dynamics Discussion," 2, 315-354 (2011): http://tinyurl.com/3ecsf89

In the face of intractable uncertainties, we have decided to continue rolling the dice, in the hope that maybe such a disaster won't happen after all. Is this indifference to climate change risk in some perverse way a rational response? The climate models predict that the most serious impacts from continued radiative forcing will occur after 2100. Does our indifference perhaps reflect some quirk in the deep evolutionary structure of the human brain, which makes it impossible for us to take seriously a threat to the well-being of future generations? One should admit that it is difficult to ask people to spend real money now for *possible* benefits they will never see in their own lifetimes, and maybe not even in their children's lifetimes.

These are properly labelled "possible benefits" either because what we spend now may be too late to do any good, or because the problem may disappear of its own accord through some means we are unable to identify at the moment, or because the threat of human-induced major global warming may be a "hoax" perpetrated by climate scientists. The last-mentioned reason at least provides some ironic humour and might be regarded as entertaining, if the stakes weren't quite so high.[11]

Our indifference to the risk of climate change and its possible "fat tail" amounts to a massive wager we have made in nature's casino. We might want to remember that we don't make the rules there.

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[11] For a fine commentary on this silliness see Gary Gutting, "On experts and global warming," *The New York Times*, 13 July 2011: http://nyti.ms/qTJP04 .