Comments on Martin Weitzman, "Additive Damages, Fat-Tailed Climate Dynamics, and Uncertain Discounting"

(Comments by Robert S. Pindyck)

This excellent paper is far-ranging in scope, and elaborates and extends some of the ideas that Weitzman has presented in earlier papers. It is generally well-written, and makes a substantive contribution to our understanding of the economics of climate change policy. I will not try to summarize the paper, but instead just offer a few comments and concerns.

"Deep Structural Uncertainty" and Fat Tails. In his 2009 *Review of Econ. and Stat.* article, Weitzman provided a strong argument for why "structural uncertainty" will imply fat tails. In particular, suppose there is some known thin-tailed distribution for climate sensitivity, but the variance of that distribution is unknown, and is estimated via Bayesian updating. In his earlier article, Weitzman showed that the posterior-predictive distribution for climate sensitivity is then fat tailed (i.e., the tails approach zero more slowly than exponentially). The relevance of this is that if welfare is based on a power social utility function of consumption, expected marginal utility becomes infinite, the willingness to pay (WTP) to prevent warming will be 100 percent. This is an important result, although it provides limited guidance for policy.

In this paper, Weitzman provides an additional argument for why the distribution for climate sensitivity is likely to be fat-tailed, and more generally, why climate sensitivity is so inherently uncertain. The argument is based on a simple feedback effect; see section 4 of the paper. Of course the implications for WTP remain the same. But it seems to me that this policy result – a WTP near 100 percent – could be argued in simpler terms, which also illustrates its weakness.

Suppose there is a tiny probability, $\epsilon > 0$, that unchecked global warming over the next century will have the catastrophic impact of driving consumption to zero, and there is a probability of $(1-\epsilon)$ that warming will have a negligible effect on consumption. If welfare is based on a constant relative risk aversion utility function, then expected marginal utility is infinite, and WTP = 100 percent. We don't need feedback effects or anything else – just an agreement that there is a very tiny (but positive) probability of a catastrophic (in the sense of driving consumption to zero) outcome. Most economists would agree that there is a tiny probability of such an outcome, but most economists would not agree that we should spend 99 percent of GDP to avert climate change. So what's wrong? It seems to me that the problem is with the utility function used to evaluate welfare. What do we mean when we say that marginal utility approaches infinity? Usually we don't think of consumption approaching zero as a "relevant" region of the utility function, i.e., the function just doesn't makes sense in that region. But if so, the very high WTP implied by fat tails can disappear, and at the very least will depend on how we model social utility for catastrophic outcomes.

Related to this, Weitzman discusses the issue of whether social utility should be an additive or multiplicative function of consumption and temperature. In most integrated

assessment models, utility is a function of consumption (usually a CRRA function), and temperature reduces consumption through some kind of loss function that multiplies consumption, i.e., $C = L(T)C_0$, where T is the increase in temperature, L(0) = 1, and L'(T) < 0. But this implies that utility can be written as a multiplicative function of C and T. If instead an additive function is used, estimated WTP will generally be larger. This is fine, but I think the argument for an additive versus multiplicative function is not very convincing as it stands. There is an earlier literature that treats the environmental good (such as air purity) as separate from ordinary consumption, with utility a function of both, and the elasticity of substitution possibly less than one. A CES utility with an elasticity of $\frac{1}{2}$ will lead to the kind of additive quadratic function Weitzman proposes in his example. However, I find it hard to see why temperature (as opposed to something that we experience directly like air or water quality) should enter utility directly. The argument has to be based on how temperature affects output via the aggregate production function. Modifying this section of the paper accordingly would make it much more convincing.