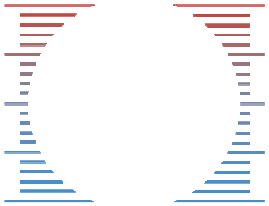

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Ambiguity and climate policy

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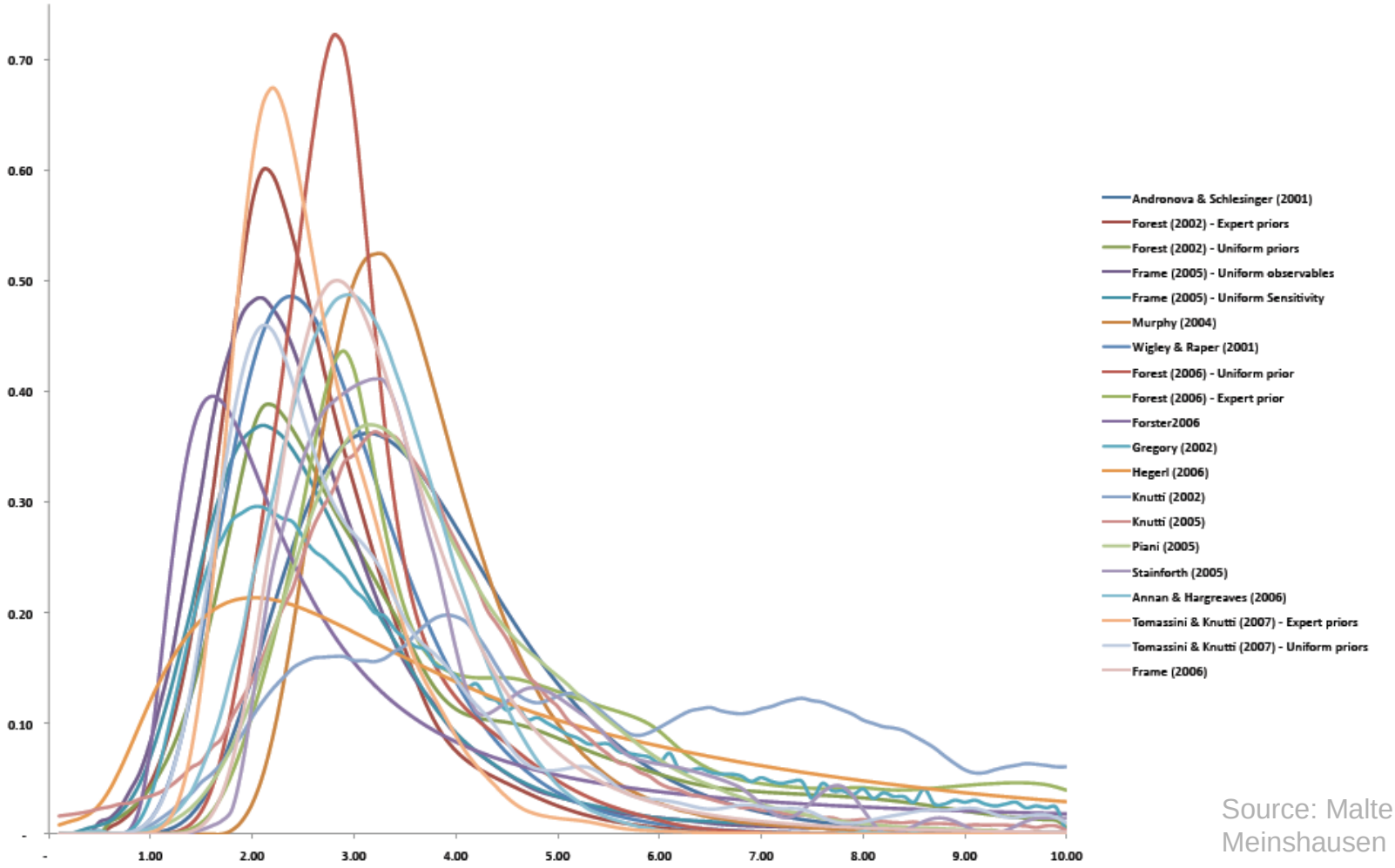
Brewing a ‘perfect storm’ of uncertainty about climate change

- Three factors come together:
  1. **Futurity** – future socio-economic trends that determine the path of emissions, as well as how numerous and well off we will be when the impacts of today’s emissions occur
  2. **Complexity** – the considerable complexity of the climate system, not to mention its linkages with ecosystems and the economy, which means that it is hard to know whether our models are a reasonable simplification
  3. **Non-linearity** – this greatly increases the significance of model misspecification
- See Lenny Smith, David Stainforth et al. (of CCCEP) on #2 and #3

Uncertainty about climate change: 20 estimates of the 'climate sensitivity'



Source: Malte Meinshausen

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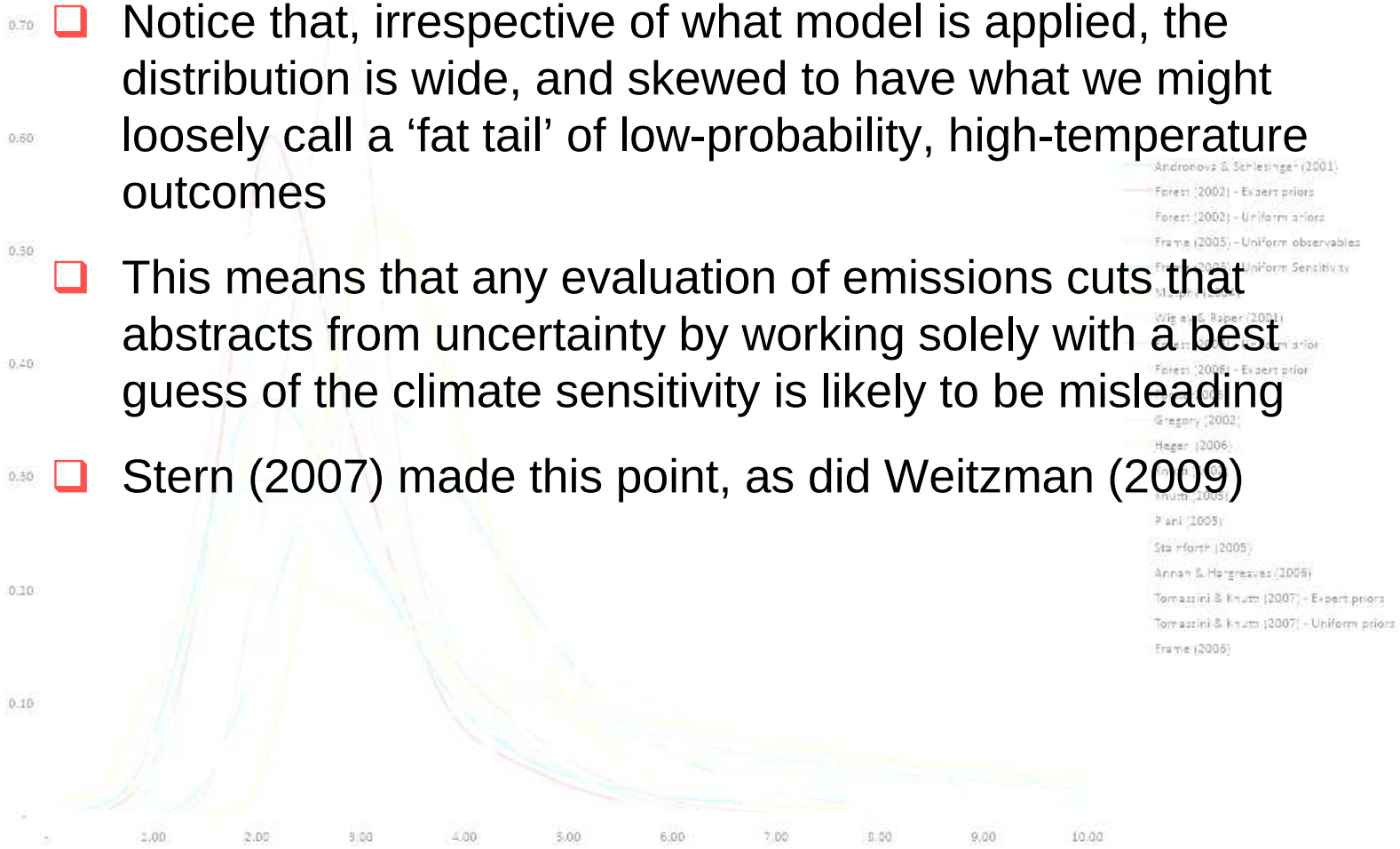
Observations about this chart #1 (not new)



- Notice that, irrespective of what model is applied, the distribution is wide, and skewed to have what we might loosely call a ‘fat tail’ of low-probability, high-temperature outcomes
- This means that any evaluation of emissions cuts that abstracts from uncertainty by working solely with a best guess of the climate sensitivity is likely to be misleading
- Stern (2007) made this point, as did Weitzman (2009)

The effect of risk and risk aversion

Modelling strategy	Present-valued cost of climate change (% of GDP)
Just make a best guess of each parameter (which is the mode of the distribution)	3.5
Deterministic, but take the mean of the distribution	8.0
Expected value of consumption (i.e. risk-neutral decision-maker)	10.4
Expected-utility (i.e. risk-averse decision-maker)	**11.1**

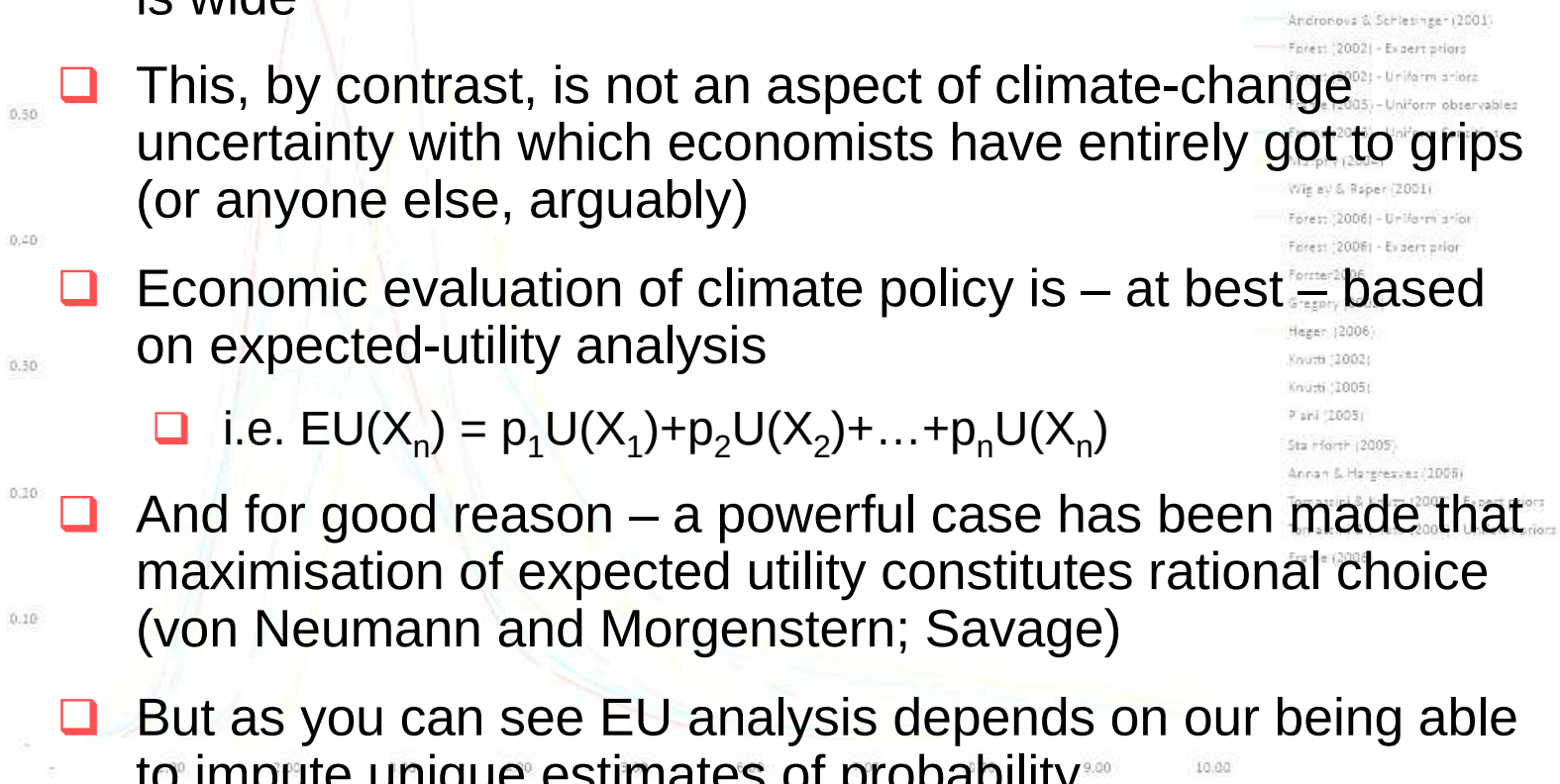
risk

risk aversion

Source: Dietz, Hope and Patmore (2007)

Observations about this chart #2

- Notice also that the various models disagree on what the distribution looks like precisely
- And that the spread between some sample pairs of models is wide
- This, by contrast, is not an aspect of climate-change uncertainty with which economists have entirely got to grips (or anyone else, arguably)
- Economic evaluation of climate policy is – at best – based on expected-utility analysis
  - i.e. $EU(X_n) = p_1U(X_1)+p_2U(X_2)+\ldots+p_nU(X_n)$
- And for good reason – a powerful case has been made that maximisation of expected utility constitutes rational choice (von Neumann and Morgenstern; Savage)
- But as you can see EU analysis depends on our being able to impute unique estimates of probability



Do we have unique estimates of probability?

- 20 conflicting estimates of the climate sensitivity would suggest not
- Break the state of scientific knowledge into two categories:
  1. Broad scientific principles, such as the laws of thermodynamics – virtually unimpeachable
  2. Detailed empirical predictions by way of models – unclear what model is best; none perfect
- Since category-two knowledge is indispensible for forecasting, we have model uncertainty

Why is this relevant?

- Because of the Ellsberg paradox…
- …according to which, rational choice in the face of ambiguity (i.e. uncertainty about probabilities) is characterised by ambiguity aversion
- This touches on a fundamental debate in the theory of decision-making under uncertainty
  - A 'strong Bayesian' sees the Ellsberg paradox as a contribution to positive, rather than normative, decision theory, analogous to Kahneman and Tversky's heuristics and biases
  - Rational choice is still defined by EU maximisation
  - But in this case people stick to their choices even when the violation of the sure-thing principle (i.e. behind EU maximisation) is pointed out to them
  - And evidence of ambiguity aversion has accumulated over many experiments, so it is relatively robust

Ambiguity and climate policy

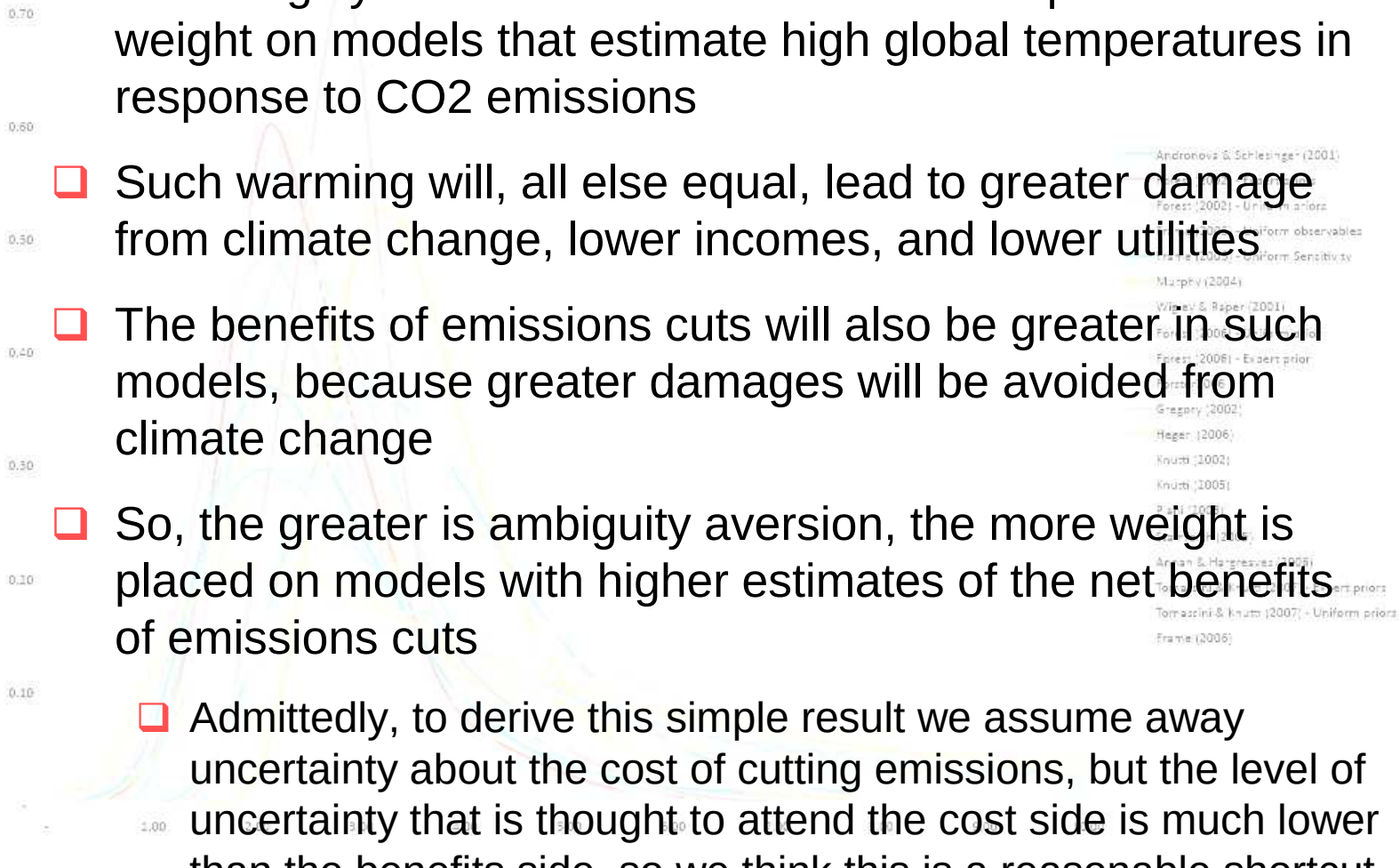
- Antony Millner (CCCEP and now UC Berkeley), Geoffrey Heal (Columbia, visited CCCEP) and I ask what effect does ambiguity aversion have on climate-change policy?
- Specifically, what effect does it have on the economic value of emissions cuts?
- We use the ‘smooth’ model of ambiguity aversion suggested by Peter Klibanoff, Massimo Marinacci and Sujoy Mukerji (*Econometrica*, 2005; *JET*, 2009)

How does the smooth ambiguity model work? An attempt at a non-technical explanation

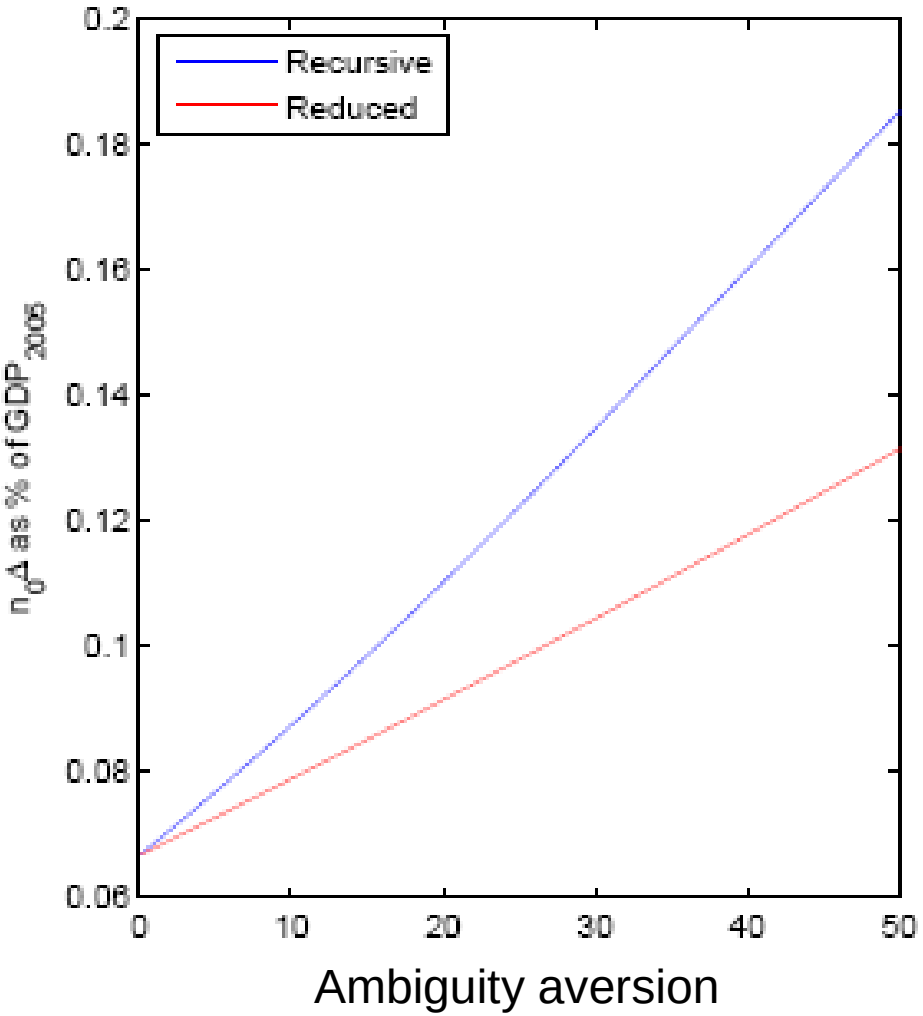
- Model essentially works in two stages:
  1. For each of a set of models you have, calculate expected utility, conditional on that model
  2. Assign each of the set of models itself a probability of being the correct model and calculate the expectation over the expected utilities estimated by all the models, assuming you are ambiguity averse
- Crucially, this implies that the more averse to ambiguity you are, the more weight you will place on models that generate low expected utilities
  - i.e. just like risk aversion, you worry disproportionately about the worst case
- Dynamic version of the model is more complicated, but basic intuition of taking expectations twice still holds

How does it work in the context of climate change?

- This roughly means that the decision-maker puts more weight on models that estimate high global temperatures in response to CO2 emissions
- Such warming will, all else equal, lead to greater damage from climate change, lower incomes, and lower utilities
- The benefits of emissions cuts will also be greater in such models, because greater damages will be avoided from climate change
- So, the greater is ambiguity aversion, the more weight is placed on models with higher estimates of the net benefits of emissions cuts
  - Admittedly, to derive this simple result we assume away uncertainty about the cost of cutting emissions, but the level of uncertainty that is thought to attend the cost side is much lower than the benefits side, so we think this is a reasonable shortcut

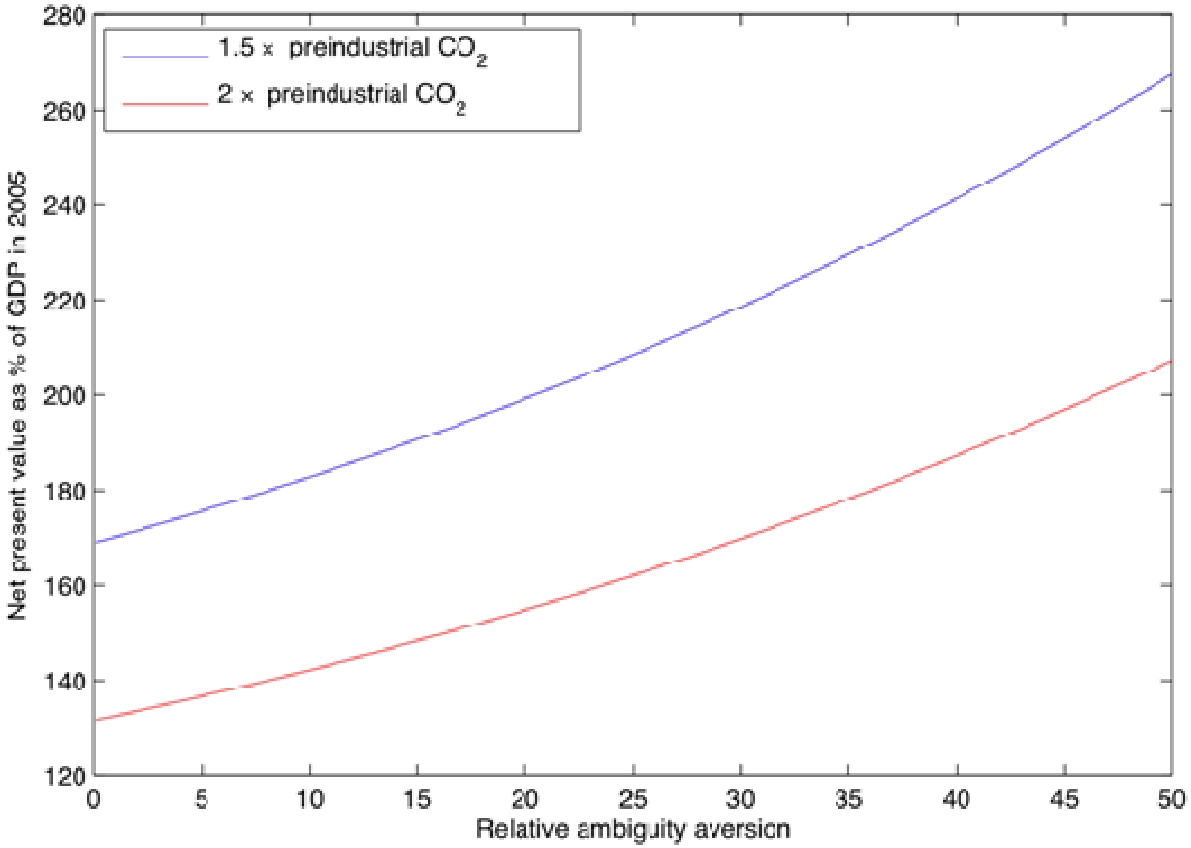


But how large is the ambiguity premium quantitatively? The case of modest damages



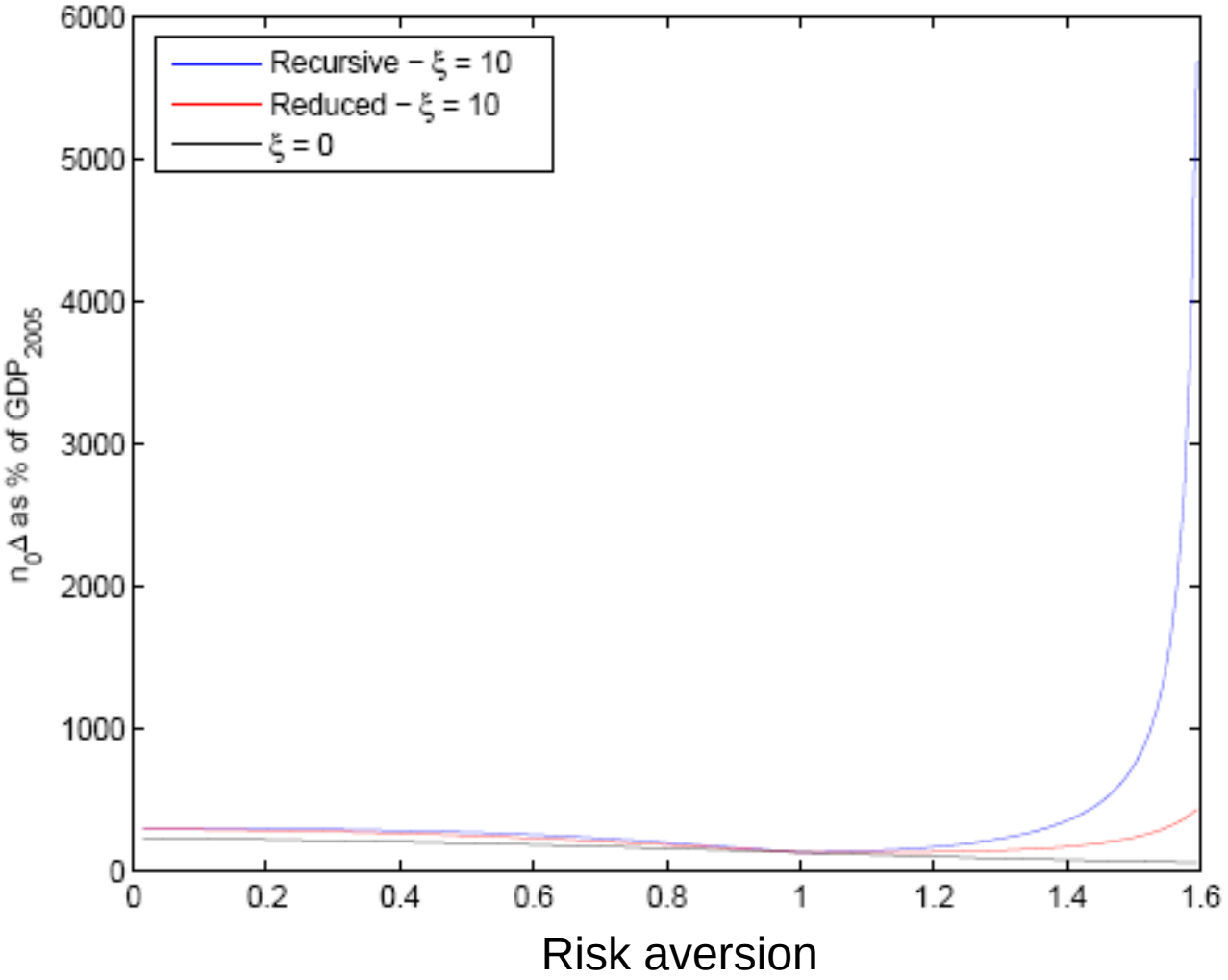
Source: Millner, Dietz and Heal (2010)

But how large is the ambiguity premium quantitatively? The case of threshold damages



Source: Millner, Dietz and Heal (2010)

And how does it compare to other related factors? Ambiguity aversion and risk aversion



Source: Millner, Dietz and Heal (2010)

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Significance

- Climate policy, like other environmental policies, is often justified based on the precautionary principle, for which uncertainty is one key component (the other is irreversibility)
- But the precautionary principle in politics has been (rightly) criticised as ambiguous (in the general sense) and even incoherent
- Economists have tried to fill the precautionary principle with analytical meaning, which is a useful exercise in and of itself (though not the only useful input of course)
- But in doing so we have relied on EU analysis, which is arguably unfit for purpose
- This is intended to be a step along the road to a realistic, but tractable, representation of uncertainty about climate change in rational decision-making

Conclusions

- So ambiguity aversion is another reason to mitigate climate change
- Hooray
- But the framework of ambiguity aversion is itself limited
- I can tell you the limitations, but I don't want to spoil the discussants' fun

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End

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