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Ambiguous tipping points[☆]

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ABSTRACT

We analyze the policy implications of aversion to Knightian uncertainty (ambiguity) about the possibility of tipping points. We demonstrate two channels through which uncertainty aversion affects optimal policy in the general setting. The first channel relates to the policy's effect on the probability of tipping, and the second channel to its differential impact in the pre- and post-tipping regimes. We then extend a recursive dynamic model of climate policy and tipping points to include uncertainty aversion. Numerically, aversion to Knightian uncertainty in the face of an ambiguous tipping point increases the optimal tax on carbon dioxide emissions, but only by a small amount.

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1. Introduction

Tipping points confront policy makers with the possibility of regime shifts. Policymakers usually have a thin or even nonexistent record of past regime shifts from which to gauge the possibility of triggering such a shift in the future. For instance, European countries deciding whether to tolerate the bankruptcy of a member state must consider the unfamiliar chance of tipping into a new regime of high bond yields and further crises. Political elites deciding whether to expropriate resources must consider the chance of triggering a rare mass uprising. And, in our example of primary interest, policymakers deciding how to regulate greenhouse gas emissions must consider the unexperienced chance of irreversibly tipping the planet into a less favorable climate system.

Many agents appear to dislike Knightian uncertainty (Camerer and Weber, 1992), and normative models of decision-making under uncertainty allow for such aversion (Traeger, 2010; Cerreia-Vioglio et al., 2011; Gilboa and Marinacci, 2013). Our policymaker demonstrates an aversion to low-confidence Bayesian priors in the framework of Traeger (2010), which relates closely to the recursive smooth ambiguity model of Klibanoff et al. (2009).[1] We analyze how aversion to Knightian uncertainty alters optimal policy in the presence of tipping points with unknown triggers. We numerically solve for the optimal tax on carbon dioxide emissions in the face of deeply uncertain climate tipping points.[2]

Lemoine and Traeger (2014) show that potential tipping points affect the optimal level of a policy control through two channels. We show how aversion to (Knightian) uncertainty about the threshold's location changes each of these channels.[3] First, the endogenous probability of tipping implies that the present policy influences the chance of tipping. Lemoine and Traeger (2014) call this channel the marginal hazard effect (MHE) and show that it leads the optimal policy to reduce the likelihood of a harmful tipping point. We show that uncertainty aversion further increases this marginal hazard effect if the tipping hazard is small (and decreases the MHE if the probability of tipping is large). A rule of thumb is that uncertainty aversion changes the MHE in a direction that reduces Knightian uncertainty. In our climate change application, the annual probability of tipping is small, so uncertainty aversion increases the contribution of the MHE to the optimal tax on carbon dioxide emissions.

Second, the marginal effect of today's policy on future welfare depends on whether a tipping point happens to occur. Lemoine and Traeger (2014) call this channel the differential welfare impact (DWI): it is proportional to the difference in the control's welfare impact in the pre- and post-tipping regimes. If the marginal welfare benefit of stronger policy is greatest in the post-tipping regime, then uncertainty aversion tends to strengthen policy through this second channel. In our climate example, tipping into a runaway climate can imply that strengthening policy generates higher payoffs in the post-tipping world. This effect would dominate if tipping risk was exogenous. However, the endogeneity of the tipping hazard adds an additional value to emission reductions in the pre-threshold regime, which can outweigh the increased harm from carbon dioxide emissions in the post-threshold world (i.e., in a world with a runaway climate). Our numeric application finds that uncertainty aversion makes the DWI reduce the optimal tax on carbon dioxide emissions. However, the reduction in the DWI is small in comparison to the effect of uncertainty aversion on the marginal hazard effect. Overall, uncertainty aversion increases the optimal tax on carbon dioxide emissions.

Our work sits at the intersection of four literatures. First, a primarily theoretical literature investigates the implications of uncertainty aversion for optimal savings and portfolio allocations. Our DWI contribution relates closely to a self-insurance motive identified in these settings (Gollier, 2011; Alary et al., 2013). Our MHE contribution relates closely to a self-protection motive (Snow, 2011; Alary et al., 2013; Maccheroni et al., 2013). Traeger (2011) relates these uncertainty aversion effects to the precautionary savings arguments under risk. Our framework differs in two ways from this literature. First, it is more complex because self-insurance and self-protection interact (including over time), and because our discrete regime shift complicates the trade-off for self-insurance. Second, our setting is simpler in that mitigation effort only affects the uncertain tipping hazard, whereas much of this literature has intertwined self-protection against uncertainty with self-protection against standard risk. For the MHE effect, our findings are closest to Snow (2011), who finds that uncertainty aversion always increases self-protection, which holds in our setting under an approximation for small to moderately large hazard rates. As Alary et al. (2013) explain, this result arises in our setting because mitigation effort reduces uncertainty. The self-insurance motive in our setting, captured by the DWI, differs more significantly from the analysis in this literature because of our discrete regime shift.

[1] We use the terms "Knightian uncertainty", "deep uncertainty", "uncertainty", and "ambiguity" interchangeably to describe a situation where the underlying probabilities are not known. We allow our decision-maker to exhibit higher aversion to situations with unknown probabilities. The smooth ambiguity model of Klibanoff et al. (2005, 2009) relies on subjective ambiguous priors over objective lotteries. By detaching ambiguity aversion from the particular hierarchical order of priors in the recursive smooth ambiguity model, the framework of Traeger (2010) allows us to separate the ambiguous probability of triggering a tipping point from stochastic shocks whose distribution is objectively known.

[2] Gjerde et al. (1999), Keller et al. (2004), and Lontzek et al. (2015) also numerically analyze the implications of endogenous climate tipping points. Whereas they model tipping points as directly reducing utility or output, we follow Lemoine and Traeger (2014) in modeling tipping points as directly shifting the underlying dynamics of the climate system. The implications for utility and output then depend on how the policymaker responds to the altered climate dynamics. van der Ploeg (2014) follows Lemoine and Traeger (2014) in modeling a tipping point as changing the dynamics of the carbon cycle.

[3] Our analysis of uncertainty aversion corresponds to an analysis of risk aversion in a setting in which tipping points are the only stochastic element and Epstein–Zin preferences disentangle risk aversion from intertemporal consumption smoothing motives.

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