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PRESCRIPTIVISM, RISK AVERSION, AND INTERTEMPORAL SUBSTITUTION IN CLIMATE ECONOMICS

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The question of how to discount the distant future has long been at the core of climate economics. It has also divided economists. Some argue for *prescriptivist* approaches to discounting, often calling for social discount rates of as low as 1% per year. Others argue strongly for *descriptivist* approaches and rates as high as 5% or more. A look to financial economics has since added another wrinkle, by pointing to the need to separate risk aversion from intertemporal substitution to calibrate real-world behavior, at times lowering effective descriptivist rates close to prescriptivist ones.

We attempt to reconcile some of these methodological differences by identifying three types of prescriptivism. Economists are frequently uncomfortable with what we term *parameter prescriptivism*, while being comfortable with both *axiom* and *policy prescriptivism*. That faces theoretical challenges. We argue that if *a priori* moral reasoning is not allowed to influence parameter values, then the results of one's analysis should not be framed as a prescriptive policy 'recommendation'. While descriptivist analysis *is* relevant to policy, we must be clear that it can only inform policy choices, not determine them. We use our framework to evaluate recent proposals in climate economics to replace the standard isoelastic utility function with Epstein-Zin preferences to allow for the separate treatment of risk aversion and intertemporal substitution.

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1. INTRODUCTION

It has been a decade since the publication of *The Economics of Climate Change: The Stern Review* (Stern, 2007), and the dominant controversy it sparked still rages on: Should distant climate damages be discounted based on *a priori* moral reasoning or, instead, on empirically observable phenomena such as prevailing market interest rates?

Given the central importance of discounting, the answer to this question is at the heart of much of climate economics. It dates back at least two decades, when Arrow, Cline, Maler, Munasinghe, Squitieri, and Stiglitz (1996), in a contribution to the *Second Assessment Report of the Intergovernmental Panel on Climate Change*, introduced the distinction between *prescriptivist* and *descriptivist* approaches to social discounting in welfare economic analyses of climate change. Prescriptivists claim that economic analyses of climate change should draw on *a priori* moral reasoning to weigh future benefits and costs against present ones. Descriptivists, in contrast, repudiate this philosophical approach and hold instead that economic models should embed only those values that actual individuals

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reveal in their own allocation decisions.

Adopting an explicitly prescriptivist stance, the *Stern Review* was generally praised by philosophers (e.g., Broome, 2012, 2008; Caney, 2014; Moellendorf, 2014) and strongly criticized by many economists (e.g., Nordhaus, 2008, 2007a,b; Weitzman, 2007a), with some notable exceptions (e.g., Dasgupta, 2008). In one representative criticism, Nordhaus (2007b) writes:

> [T]here is a major issue concerning the views that are embodied in the social welfare function adopted by the [*Stern*] *Review*. The *Review* takes the lofty vantage point of the world social planner, perhaps stoking the dying embers of the British Empire, in determining the way the world should combat the dangers of global warming. The world, according to Government House utilitarianism, should use the combination of time discounting and consumption elasticity that the *Review*'s authors find persuasive from their ethical vantage point. (p. 691)

Echoing this line of criticism, Weitzman (2007a) writes:

> An enormously important part of the "discipline" of economics is supposed to be that economists understand the difference between their own personal preferences for apples over oranges and the preferences of others for apples over oranges. (p. 712)

Many economists share Nordhaus's and Weitzman's stance on the relevance of *a priori* moral reasoning to welfare economics, and the divide between descriptivists (like Nordhaus and Weitzman) and prescriptivists (like Stern, Dasgupta, and virtually all philosophers) seems as entrenched as ever. By one count, the broader social discounting debate now includes over 600 distinct authors who, in the first 15 years after 2000, had published relevant peer-reviewed papers in leading economics journals (Drupp, Freeman, Groom, and Nesje, 2015).[1]

Our aim is to advance the debate between prescriptivists and descriptivists by drawing a distinction between three levels of prescriptivism. The first is the focus of so much debate: prescriptivism about key parameters in the social welfare function. We call this *parameter prescriptivism*. There are two others.

One can also speak of prescriptivism about the axioms from which one wishes to derive the very form of the social welfare function. Should these axioms be determined by appeals to revealed preference and 'consumer sovereignty'? Or must they pass the muster of *a priori* reflection and remain normatively valid even when frequently violated in individual behavior? The approach to axioms that prizes *a priori* grounding over revealed preference we call *axiom prescriptivism*.

Finally, one can ask: Should an economist's ranking of consumption streams (and associated greenhouse-gas emissions trajectories) be offered as a *prescription* for policy, that is, as a policy recommendation? Or should such rankings instead be treated as but one policy-relevant consideration among many? There is, after all, no conceptual or analytical inconsistency in claiming that consideration X is highly relevant to policy, while also refusing to recommend the policy that X would support *if* X were the only policy-relevant consideration. There may well be—and frequently are—other relevant considerations besides X. We use the term *policy prescriptivism* to refer to the view that the rankings yielded

[1] One further reason for this heightened interest in long-run discounting is that, with some exceedingly rare exceptions (Giglio, Maggiori, and Stroebel, 2015), it is not possible to observe long-run discount rates hundreds of years into the future. As Gollier (2012) observes, no asset currently priced in markets has payoff schedules quite like that of climate policy, providing some seemingly unique challenges for climate policy under grave uncertainty (Summers and Zeckhauser, 2008).

by social welfare functions ought to be interpreted as recommendations for public policy.

Our first aim, then, is to introduce a new conceptual framework that we believe can advance foundational debates in climate economics.

Our second aim is to put this conceptual framework to work by evaluating proposals to replace the standard isoelastic utility function most commonly employed in traditional climate-economy models (e.g., Nordhaus, 1992; Nordhaus and Sztorc, 2013) with Epstein-Zin preference specifications.[2] The Epstein-Zin framework allows for the separate treatment of risk aversion and intertemporal substitution (Epstein and Zin, 1991, 1989; Kreps and Porteus, 1978; Weil, 1990). Debates between prescriptivists and descriptivists have more commonly focused on the rate of pure time preference. In contrast, our discussion of how analysts might treat risk aversion and intertemporal substitution focuses on the forms of both utility and social welfare functions.

In the end, we suggest that all roads lead *away from* policy prescriptivism: whether one seeks to disentangle risk aversion and intertemporal substitution with the Epstein-Zin framework or with less radical adjustments to the standard discounted utilitarian social welfare function, there are strong reasons to treat the upshot as merely relevant to good policy-making, rather than decisive for it. Thus, while we do not attempt to calibrate any of the key parameters, we hope to demonstrate our conceptual framework's potential to advance the literature surrounding both well-worn and cutting-edge issues in climate economics.

2. THREE LEVELS OF PRESCRIPTIVISM

2.1. *Parameter Prescriptivism*

When Arrow, Cline, Maler, Munasinghe, Squitieri, and Stiglitz (1996) introduced the term "prescriptivism" into the lexicon of climate economics, they used it to name an approach to determining the social discount rate in economic analysis of climate change. Within a Ramsey (1928)-Cass (1965)-Koopmans (1963) optimal growth framework, this social discount rate is given by the well-known equation:

$$\delta = \eta g + \rho \tag{1}$$

Equation (1) expresses the marginal rate of substitution between consumption in adjacent time periods. It includes at least one observable parameter, g, the rate of growth in consumption. The other two parameters, η and ρ, represent the elasticity of the marginal utility of consumption and the rate of pure time preference, respectively. They are the parameters that introduce values into the analysis.[3]

DEFINITION 1 *Parameter prescriptivism is the view that the values relevant to η and ρ are to be supplied by a priori moral reasoning.*[4]

[2]Our framework might also offer insights into additional issues in climate change economics, for example the topic of "ecological discounting," in which different discount rates are applied to conventional consumption and natural goods (Guesnerie, 2004; Heal, 2009; Sterner and Persson, 2008).

[3]To say that g is observable is not to say that calibrating it is simple or obvious: g, too, typically necessitates projections into the (distant) future, which are inherently uncertain (Christensen, Gillingham, and Nordhaus, 2018). Note as well that g is the consumption growth rate. That implies the need to subtract climate damage projections from economic growth rates (Kelleher and Wagner, 2018).

[4]We certainly wish to allow that one but not both of η and ρ are to be supplied by a priori moral

Prescriptivism so-construed is defended by moral philosophers like Broome (2012, 2008) and economists like Dasgupta (2008) and, at least in part, Stern (2007). Descriptivism, by contrast, is the view that the relevant values are to be inferred from the allocation behaviors of individuals. It is easy to find staunch supporters of parameter descriptivism among (climate) economists (e.g., Nordhaus, 2007a,b; Weitzman, 2007a). Weitzman (2007a), for example, argues that by drawing on moral philosophy to select a low ρ, Stern was no longer engaged in the enterprise of economics.[5] Dasgupta, meanwhile, notes that while the *Stern Review* waxed philosophical about ρ, it also drew upon descriptivist studies of consumer behavior to support a fairly low value for η; Dasgupta (2008) therefore concludes that Stern's prescriptivist-descriptivist hybrid is "neither good economics nor good philosophy" (p. 159). In an apparent break with most other economists commenting on the *Stern Review*, Dasgupta goes on to offer his own prescriptivist analysis of the two value parameters in (1). Ultimately, however, he argues that "none" of the "various modelling avenues that offer a way out of the dilemma" is "entirely satisfactory" (Dasgupta, 2008, p. 141), and he concludes that: "Intergenerational welfare economics raises more questions than it is able to answer satisfactorily." (2008, p. 141)

As indicated by these disagreements between Dasgupta, Nordhaus, Stern, Weitzman and others, the prescriptivism-descriptivism debate typically focuses on the proper method for parameterizing (1). In other words, the debate typically concerns the truth or falsity of what we've termed *parameter prescriptivism*.

2.2. *Axiom Prescriptivism*

How to determine η and ρ is, however, just one theoretical question one may wish to settle with either prescriptivist inquiry or its descriptivist rival. Taking a step back from the issue of parameter values, a more fundamental question is how we got to the Ramsey equation in the first place. For one thing, there is no Ramsey equation without an intertemporally additive social welfare function. But why should the social welfare function take this additive form? Ramsey simply assumed the utilitarian social welfare function, but more modern approaches invoke axioms that together logically imply additivity.

Yet this raises a problem for those who reject parameter prescriptivism. For it is unlikely that the study of consumer behavior will reveal a widespread and firm commitment to the required axioms. Heal (2005), for example, has shown how the two leading axiomatizations—one from Koopmans (1960), the other from Harsanyi (1955)—invoke axioms that are easily violated by existing preferences. In Koopmans's case, two key axioms "rule out all other than the most trivial patterns of intertemporal complementarities" (Heal, 2005, p. 1114). In Harsanyi's case, the additive structure of the social welfare function requires the assumption that both the individual and the social preference relation obey the axioms of expected utility theory. This paints those arguing against parameter prescriptivism into a corner, for we can now ask: If one must embrace *axiom prescriptivism* simply to justify an additive social welfare function, why should it be contrary to the discipline of economics to embrace parameter prescriptivism when parameterizing the Ramsey equation?

reasoning. If that is the case, then we should speak of "parameter prescriptivism with respect to" a given parameter in a social welfare function.

[5] See the quotation from Weitzman (2007a) in section 1 above. In contrast, see Weitzman (2012), which defends the use of $\rho = 0$.

DEFINITION 2 *Axiom prescriptivism holds that the axioms underlying a given functional form should be selected on the basis of a priori reasoning, not on the basis of empirical observation.*

Giving up on axiom prescriptivism undermines the reason for focusing on the Ramsey parameters in the first place. A social welfare function is nothing more than a function that represents an ordering. In the context of climate change, the ordering is a 'betterness' ordering over consumption streams (Broome, 2012; Dasgupta, 2008). The axioms express constraints on that ordering, from which it can be inferred that the ordering can be represented by a function that sums (discounted or undiscounted) subutilities. Meanwhile, the Ramsey parameters, which reflect the shape of the utility function and the rate of pure time preference, further express the conception of betterness that is embodied in the specific ordering of streams represented by that welfare function. Hence both axioms and parameters are expressions of the underlying conception of betterness with respect to which consumption streams are to be ranked.

The challenge for the parameter descriptivist is, therefore, to explain why his conception of betterness contains both prescriptivist and descriptivist elements. Given that both the ordering's axioms and the Ramsey equation's parameters are components of the underlying conception, why should it be in line with the "'discipline' of economics" (Weitzman, 2007a, p. 712) to adopt prescriptivism about axioms, yet contrary to the discipline to adopt prescriptivism about parameters? Just asking this question would seem to shift the burden of proof onto those who wish to work with the Ramsey equation but who reject prescriptivism about its value parameters.

PROPOSITION 1 *Axiom prescriptivism is a necessary basis for invoking any particular social welfare function—and certainly any additive social welfare function that gives rise to the Ramsey equation.*

To illustrate the importance of this proposition, let us consider a potential response from the defender of parameter descriptivism: Suppose he admits that one must be an axiom prescriptivist to allow for a discussion of the Ramsey equation's value parameters in the first place, but then he claims that *a priori* moral reasoning *itself* calls for descriptivist approaches to the Ramsey equation's value parameters. Here he might invoke the very idea of democracy as an analogy. That is, he might argue that just as democracy is an *a priori* defensible moral ideal that nevertheless allows revealed preferences to play a key role in shaping public policy, so too should economics look to consumer behavior to parameterize the Ramsey equation. On this view, axiom prescriptivism properly determines the *form* that social preferences must take, but the *content* of those preferences should be provided by the values that get revealed by observing individuals and their real-world behavior.[6]

Even if this is a *prima facie* plausible response to the dilemma we have constructed for those who subscribe to axiom prescriptivism while opposing parameter prescriptivism, the parameter prescriptivist has a ready reply. It is Broome (2012)'s direct reply to Weitzman (2007a), and it begins by taking the descriptivist's analogy with democracy seriously.

[6]That is also an argument often encountered among those who support an entirely different conception of betterness, arguing for the use of Epstein-Zin preferences instead of standard isoelastic ones, a topic we turn to in section 4.

Broome notes that there are at least two roles an individual might play in a democracy. First, she can use her vote to directly influence an electoral outcome—the analog of revealed preferences shaping economic evaluations. Second, she can formulate arguments and put her "views out into the marketplace of ideas, where they play their part in public deliberation" (Broome, 2012, p. 110). In that second role, experts can fully admit that people have their own preferences about how to trade off benefits and costs in their own lives, and yet at the same time she can strive to systematize and bring to light *a priori* moral considerations bearing on what preferences *ought* to prevail concerning intergenerational issues like climate change. While the proper role of scientists in public policy-making is frequently debated, and for good reason (Jasanoff, 2009, 2004), it is clear that scientists and experts do have a role to play in democratic discourse that goes beyond merely casting one's own vote. Some legitimate roles allow for reasons drawn from moral philosophy, while some others might not. We, like Arrow, Cline, Maler, Munasinghe, Squitieri, and Stiglitz (1996), Broome (2012), Heal (2009), and others, believe that economists can play both roles—one that involves systematizing people's preferences as they are, and one that involves systematizing *a priori* moral arguments about what social preferences ought to be (Kelleher, 2017). Each role requires drawing on a distinct conception of betterness to construct orderings over consumption streams. The former will perhaps employ a 'mixed' conception (e.g., prescriptivism about axioms and descriptivism about parameters), while the latter will employ a thoroughgoing prescriptivist conception.

2.3. *Policy Prescriptivism*

Yet even if one believes that the mixed approach is a legitimate enterprise for welfare economics, there is a third and final sort of prescriptivism one must consider. Unlike the first two kinds of prescriptivism, this third does not concern the use of *a priori* moral reasoning in economic analysis. Instead, it concerns whether or not the results of economic analysis—the betterness order of consumption streams—should be interpreted as a policy *recommendation* or, alternatively, merely as an *input* into the policymaking process.

Think of a physician writing a prescription for a patient. Typically, that prescription amounts to more than a mere input into the patient's thinking. Instead it is an actual recommendation. *Policy prescriptivists* believe that the results of an economic evaluation are likewise recommendations.

DEFINITION 3 *Policy prescriptivism holds that the results of economic analysis are to be viewed as recommendations for policy.*

In the next section we examine policy prescriptivism in more detail.

3. POLICY PRESCRIPTIVISM AS A TEST FOR CLIMATE ECONOMICS

Climate economics, not unlike welfare economics more broadly, has an uneasy relationship with policy prescriptivism. Stern (2007), for example, claims that a welfare economic exercise employing a social welfare function "has no room. . . for ethical dimensions concerning the processes by which outcomes are reached" (p. 32). Stern adds:

> The breadth, magnitude and nature of impacts imply that several ethical perspectives, such as those focusing on welfare, equity and justice, freedoms and rights, are relevant. . . . [D]ifferent ethical perspectives may point to different policy recommendations. (Stern, 2007, p. 25)

All of this would seem to commit the *Stern Review* team to policy non-prescriptivism, given that the *Review*'s analysis is predicated upon its specific, ethically incomplete welfare function. And yet the *Review*'s headline conclusion is not merely that its conception of betterness helps to support an optimal carbon tax of $85 per ton CO_2, but that "prompt and strong action is…clearly warranted" (p. 641). This presumed link between betterness and "clearly warranted action" suggests that the *Review* team is assuming policy prescriptivism, even as it concedes that its account of betterness ignores morally crucial dimensions.[7]

A similar situation plays out in Nordhaus (2008)'s book *A Question of Balance*. When discussing the *Stern Review*, Nordhaus explains that Stern's approach has strong affinities with the utilitarian tradition in moral philosophy. Nordhaus then notes that rival "ethical stances" (p. 176), such as those prizing sustainable growth paths or Rawlsian "maximin" thinking, would have yielded "vastly different prescriptions about desirable climate-change policies" (p. 177). "None of these alternatives is seriously considered by the *Stern Review*, but even without choosing between them, it should be clear that alternative ethical perspectives are possible" (p. 177). And yet, without exploring these other ethical stances himself, Nordhaus concludes on the basis of his DICE model that "ideal" and "optimal" climate policy allows a 3.4°C rise in temperature in 2200 as compared to a 1900 baseline (p. 195). Thus, despite flagging good reasons for abandoning policy prescriptivism whenever an economic analysis avoids serious engagement with ethical theory, Nordhaus appears to ignore his own criticism of Stern and adopts policy prescriptivism himself.

As the cases of Stern and Nordhaus indicate, the trend among climate economists is to embrace policy prescriptivism by casting their results as recommendations for policy. This is not surprising for a field whose roots trace to Frank Ramsey's seminal paper "A Mathematical Theory of Saving," which sought to answer a very practical question: "how much of its income should a nation save?" (Ramsey, 1928, p. 543). Likewise, climate economics gives the name 'optimal tax' or 'optimal price' to the shadow price of CO_2, or greenhouse-gas emissions more broadly, along the consumption path that maximizes the social welfare function, and the figure is clearly put forward as a scientifically informed answer to the quite practical public policy question, 'What ought a nation (or group of nations) *do*?'

Moreover, policy prescriptivism often enters climate economics as an explicit consideration bearing on the proper choice of parameters. As an illustration, take the common argument that the rate of pure time preference, ρ, must be greater than zero, lest the investment demands on the current generation become overly burdensome. For example, declaring that "Not discounting is discounting at 0%, and it isn't good," Pearce, Groom, Hepburn, and Koundouri (2003) says that, "The logical implication of zero discounting is the impoverishment of the current generation" (pp. 124-5). Pearce et al.'s argument is that adopting $\rho = 0$ would lead to orderings of consumption streams that favor future generations and require crushing sacrifices today. This is a quite common argument in favor of $\rho > 0$ among (climate) economists (e.g., Arrow, 1999; Moore, Boardman, Vining, Weimer, and Greenberg, 2004; Nordhaus and Sztorc, 2013; Pearce, Groom, Hepburn, and

[7]Subsequently, Stern himself has argued that quantitative modeling outputs are not the only reason for why rapid climate action is indeed warranted, but that qualitative—and ethical—claims about more climate action are at least as important (Stern, 2015).

Koundouri, 2003).[8]

Rejecting $\rho = 0$ on grounds of a resulting high optimal CO_2 price presupposes a commitment to policy prescriptivism, for if the results of a welfare analysis of climate change were mere policy inputs—just one set of considerations among others that are also relevant—there would be no pressing need to select value parameters that ensure the ordering produced by the analysis coheres with intuitions about what 'reasonable' public policy should seek to achieve.

Whereas climate economists often tacitly assume policy prescriptivism, philosophers routinely assume its opposite. That is, philosophers often assume a conceptual distinction between evaluating consequences (e.g. distributions of well-being) and evaluating more complete descriptions of the world that make reference to both consequences and to the processes leading up to them. This commitment underlies philosophers' preference for $\rho = 0$. It also inoculates them against economists' objections to such a low rate of pure time preference.

To explain this further, consider possible two states of the world. One involves five living people and one dead person. The other, *ceteris paribus*, involves one alive and five dead. Without any knowledge of or reference to the process that has led to the particular outcomes in question, the first distribution seems clearly preferable. But what if the former can only be achieved by killing one person to procure organs needed to save the other five? Many would consider it morally preferable (if tragic) to let the five die by refusing to actively kill one. Economists might counter that an example like this appears concocted, but the key conceptual point remains: there is a morally plausible distinction between ranking *outcomes* and making all-things-considered moral judgments about which *actions* to undertake. When making all-things-considered judgments about what ought to happen, an evaluation of outcomes is arguably always *necessary*, but it is not always sufficient, as the organ-procurement thought experiment seeks to show. A plausible ranking of outcomes may not capture all morally relevant factors.

Let us therefore distinguish between (1) *ranking outcomes* (or *prospects*, i.e. probabilities over outcomes) by summing the total (expected) individual well-being they contain, and (2) *determining what ought to be done* by summing the total (expected) well-being of all possible actions. The latter is utilitarian*ism*; the former is the "utilitarian principle of distribution" (Broome, 1995, p. 16). Utilitarianism is the view that what ought to be done should be determined entirely on the basis of the well-being contained in the outcomes of possible actions. By contrast, a principle of distribution *itself* takes no stand on what ought to be done. It is agnostic as to whether rankings of outcomes (or prospects) exhaust the set of policy-relevant considerations. This distinction allows one to accept a utilitarian principle of distribution without accepting utilitarian*ism*. That, in fact, was the stance adopted by none other than John Harsanyi, who is widely credited with having provided an axiomatic defense of utilitarianism: Harsanyi rejected utilitarianism while defending a utilitarian principle of distribution on the basis of his famous aggregation theorem (Harsanyi, 1977).

Returning now to the debate between philosophers and economists on the rate of pure time preference, when philosophers defend a zero rate of pure time preference, they fre-

[8]Adopting $\rho = 0$, meanwhile, has a number of prominent proponents, beginning with Ramsey (1928) and including, in rough chronological order, Pigou (1932), Solow (1974), Broome (1992), Heal (2009), Weitzman (2012), and Gollier (2017, 2012).

quently do so only within the context of a principle of distribution—that is, only within the context of a framework that is agnostic with respect to the proper way to construct all-things-considered rankings of possible actions (Kelleher, 2017). This enables philosophers to insist that when a non-discounted utilitarian social welfare function points in favor of steep consumption losses for the current generation, that is not a decisive objection against it. This is because philosophers frequently view social welfare functions as the formal embodiment of principles of distribution, and so when a social welfare function "points in favor" of steep consumption losses, this, philosophers would say, is not the same as the welfare function *recommending* steep consumption losses. Because principles of distribution do not *themselves* make all-things-considered recommendations, philosophers routinely view social welfare functions as informative but not policy-prescriptive. Since other countervailing moral considerations may well override or dilute the normative force of a principle of distribution, philosophers are typically not concerned that an undiscounted ranking of outcomes will favor consumption streams in which the present generation's consumption is very low.

One upshot to all this is that, within the context of a utilitarian social welfare function, it is possible to embrace the combination of axiom and parameter prescriptivism without being logically compelled to accept utilitarian policy proposals. If one interprets axiom and parameter prescriptivism as positions bearing only on the content of principles of distribution, then their import for practical decision-making remains an open question. The only way that utilitarian*ism* follows from a utilitarian *principle of distribution* is if the principle of distribution is deemed to be the one and only policy-relevant consideration. As we have noted, Harsanyi rejected utilitarianism so understood, and so do a great many philosophers who engage with climate change economics.[9]

PROPOSITION 2 *It is possible to reject policy prescriptivism while accepting both axiom and parameter prescriptivism.*

4. SEPARATING RISK AVERSION AND INTERTEMPORAL SUBSTITUTION

In this section we hope to illustrate the usefulness of our conceptual framework by examining recent proposals in climate economics to replace the standard "isoelastic" utility function with so-called "Epstein-Zin" (EZ) preferences (Lemoine and Rudik, 2017). The main benefit proffered by the EZ framework is that it allows one to separate risk aversion and inequality aversion. We shall not attempt to derive values for the parameters we discuss, nor will we make any categorical pronouncements concerning which parameters and functional forms ought to take center stage in climate economics. Instead, we draw on our conceptual framework to identify and explore some oft-neglected issues raised by the Epstein-Zin approach. In the end, our discussion suggests a potentially surprising conclusion, namely that no matter how one wishes to separate risk aversion and inequality aversion in climate economics, doing so may come with the cost (if it is a cost) of

[9] As Harsanyi put it: "Let me end with a disclaimer. I think the utilitarian theory I have described in principle covers all interpersonal aspects of morality. But I do not think it covers all morality. There are some very important moral obligations it fails to cover because they are matters of individual morality and of individual rationality. Perhaps the most important such obligation is that of intellectual honesty, that is, the duty to seek the truth and to accept the truth as far as it can be established—regardless of any possible positive or negative social utility this truth may have" (Harsanyi, 1977, pp. 655–6).

adopting policy non-prescriptivism as well.

Mainstream approaches to climate economics employ a discounted utilitarian social welfare function in which individual utility functions, U_i, are presumed to be identical, fully measurable, interpersonally comparable, and of an isoelastic form, typically given by a version of:

$$U_i(C_i) = \frac{{C_i}^{1-\eta}}{1-\eta}. \tag{2}$$

The curvature of U, represented by η, reflects constant relative risk aversion (CRRA).

In the standard framework, the CRRA parameter determines not only how consumption is weighed across states of nature but also how it is weighed across times. Because of this, and because the timespans relevant to climate policy evaluation cover several generations, η is frequently characterized as a parameter reflecting 'social inequality aversion' (Nordhaus, 2008, p. 60). That is, prior to the application of any pure time preference, η reflects the declining degree to which increases in the consumption of any individual, now or in the future, increase overall social welfare. If individuals in the future are projected to be better off than individuals today, then an η greater than 0 gives less social weight to a consumption increase for future people than for an identically-sized increase given to people today. In that sense, $\eta > 0$ reflects aversion to interpersonal consumption inequalities.

Confining our attention for the moment to consumption fluctuations within a single individual's life, the standard isoelastic utility function forges an inverse link between individual risk aversion (i.e. aversion to inequality across states of nature) and an individual's intertemporal elasticity of substitution (i.e. aversion to inequality across times) (Deaton, 1992, pp. 19–21). This follows from an assumption that an individual's welfare ordering over consumption streams is separable across both states and times (Broome 1991, chap. 4; Weil 1990, p. 33).

When we broaden our focus to the evaluation of social welfare, the standard discounted utilitarian social welfare function assumes that the social welfare ordering over consumption streams is likewise separable across both states of nature and different *people*. The result is a social welfare function that embodies ironclad links between individual risk aversion, individual aversion to intrapersonal consumption fluctuations across time, social risk aversion, and social inequality aversion.

A common objection to the utility function given in (2) is that it lacks 'realism'—i.e., a correspondence with the structure of preferences as they are revealed in real-world behavior (Ackerman, Stanton, and Bueno 2013, p. 75; Kaufman 2012, pp. 578–84). In particular, the fixed link between risk aversion and intertemporal substitution is said to be 'unrealistic' in the sense that it is not borne out in the observed behavior of real-world individuals—whether in health and retirement decisions (e.g., Barsky, Juster, Kimball, and Shapiro, 1997) or decisions in financial markets.

In the latter context, equities pay significantly larger returns than risk-free bonds, yet the large discrepancy is unexplained by standard economic theory.[10] Attempting to explain this discrepancy has spawned an active literature in financial economics, resulting

[10]Since 1871, U.S. treasuries have returned around 1.6 percent annually, whereas equities have earned around 6.4 percent (Shiller, 2000). The difference, 4.8 percent, is the equity risk premium, which goes hand-in-hand with the risk-free rate and equity volatility puzzles (Mehra and Prescott, 1985; Weil, 1989).

in two broad attempted resolutions to this set of puzzles. One focuses on high-impact, low-probability events (Rietz, 1988).[11] The other focuses on utility function specifications.[12] The Epstein-Zin (EZ) utility function is a prominent attempt to span these two proposed resolutions, in part by permitting the explicit and separate treatment of risk aversion and intertemporal substitution.

Epstein and Zin (1991, 1989) adopt a recursive utility representation in which a representative agent maximizes:

$$U_t = \left[(1-\beta)\, c_t^{\gamma} + \beta \left[\mu_t \left(\tilde{U}_{t+1}\right)\right]^{\gamma}\right]^{1/\gamma} \tag{3}$$

which, in turn, depends on the agent's expected future lifetime utility:

$$\mu_t \left(\tilde{U}_{t+1}\right) = \left(E_t \left[U_{t+1}^{\alpha}\right]\right)^{1/\alpha}.^{13} \tag{4}$$

In this formulation, the pure rate of time preference is given by $(1-\beta)/\beta$, the coefficient of relative risk aversion at a given point in time is given by $1-\alpha$, and the elasticity of intertemporal substitution is given by $1/(1-\gamma)$. When $\alpha = \gamma$, EZ utility simplifies to the standard isoelastic utility specification, but that is indeed a special case.

In light of our prior discussion, it might be easy to assume that defenses of EZ utility must be motivated by what we have dubbed parameter descriptivism. Perhaps most of the economists who have levied the criticism do indeed reject parameter prescriptivism and would like the behavior of the utility function's parameters to match what is observed in the real-world behavior of individuals. But it is important to see that one need not be a parameter descriptivist to criticize the strong link between intrapersonal risk aversion and intertemporal substitution that is imposed by isoelastic utility. For one can always ask whether, from a prescriptivist's *a priori* point of view, there is any good reason to endorse the strong link, and indeed it has seemed to at least some philosophers that while there are good *a priori* reasons to treat states of nature as separable (*pace* the Allais paradox), it is much less plausible to treat times within a life as separable. Broome (2004, pp. 218–29), for example, explains that when times are separable across a life, it is then not possible to say that a life goes better or worse as a result of its temporal *pattern* of consumption.

[11] See Barro (2009, 2006), Barro and Jin (2011), Martin (2012, 2008), and Weitzman (2007b) for more recent explorations. Weitzman (2009) and Barro (2015), among others, apply the same logic to pricing climate risk. For broader climate-economic discussions of extreme climatic risks and the implications for pricing carbon, see, for example, Brock and Hansen (2017), Burke, Craxton, Kolstad, Onda, Allcott, Baker, Barrage, Carson, Gillingham, Graff-Zivin, Greenstone, Hallegatte, Hanemann, Heal, Hsiang, Jones, Kelly, Kopp, Kotchen, Mendelsohn, Meng, Metcalf, Moreno-Cruz, Pindyck, Rose, Rudik, Stock, and Tol (2016), Convery and Wagner (2015), Kaufman (2012), Kopp, Shwom, Wagner, and Yuan (2016), Pindyck (2013b,a), Stern (2013), Wagner and Weitzman (2015), and Weitzman (2011).

[12] Campbell and Cochrane (1999) focus on habit formation as an explanation. Andries, Eisenbach, and Schmalz (2018) proposes an alternative explanation based on time-varying risk aversion. Epstein and Zin (1991, 1989) and Weil (1990) form the basis for much of the rest of that literature, presenting a recursive utility representation that allows for separating risk across time and states of nature.

[13] Weil (1990) offers a different variant of Epstein-Zin preference, which Ha-Duong and Treich (2004) adopt for evaluation of climate risk. In that variant, consumption c_t from equation (3) is replaced by $\mu_t\left(\tilde{c}_{t+1}\right) = \left(E_t\left[\tilde{c}_t^{\alpha}\right]\right)^{1/\alpha}$, mirroring our equation (4). That formulation allows for consumption to be uncertain within each period, adding yet another layer of complexity. Aase (2016) offers yet another variant of Epstein-Zin preferences, among many others.

Separability of times, for instance, rules out the possibility of a life going better simply because it avoids wild swings of quality over time, or when it begins poorly and steadily improves (rather than the other way around).

So that is our first point: even if real-world economists are motivated by parameter descriptivism when they defend a certain functional form, it is possible to want something like EZ utility for prescriptivist reasons of the sort that philosophers examine and marshal. One can therefore be interested in the EZ form without first being interested in 'realism'.

Our second point is just the point we have stressed around parameter descriptivism and its implications for prescribing policy: even if the EZ functional form is theoretically well-grounded (a question we address further below), any attempt to then calibrate the EZ parameters descriptively should immediately be conjoined with policy non-prescriptivism. For if a climate economist wishes to rank consumption streams using EZ utility outfitted with parameters yoked to the actual behavior of individuals, it is always reasonable to ask why that is the ranking that should determine public policy. It is one thing to argue for the policy-*relevance* of revealed preference and hence for parameter descriptivism within welfare economics; it is quite another to claim that *a priori* moral reasoning is *never* policy-relevant. We therefore agree with Hume (1740) that it is never possible to derive an 'ought' statement from a series of 'is' statements. But this is precisely what happens when parameter descriptivism is reflexively conjoined with policy prescriptivism.

Our third point concerns axioms. So far, we have presented the case in favor of EZ utility in terms of parameters, that is, in terms of reasons to prefer parameters that behave in certain ways and that are (or are not) inextricably linked to one another. But, per Proposition 1 and the discussion around it, the existence of any set of parameters in a given utility or social welfare function is itself a function of the axioms underlying that particular functional form. This is as true of the EZ approach (Kreps and Porteus, 1978; Epstein and Zin, 1991, 1989; Weil, 1990), as it is for the discounted utility framework (Harsanyi 1955; Koopmans 1960; Dasgupta and Heal 1979, chap. 9). Parameters are just one dimension of a utility or social welfare function's form, and that one therefore must not lose sight of the other important dimensions. For example, note that the EZ framework is a *pure* representative agent framework. By this we mean that the social welfare function necessarily takes the form of a single person's utility function and thus cannot capture the distinctly *social* dimension of population, especially that a population that changes over time. (*Impure* representative agent frameworks, by contrast, still aggregate multiple agents into one within the model—e.g. when population is constant and all agents at a given time have the same consumption levels—but there are still multiple such agents that appear in the model—e.g. one representative agent per time period.[14,15]) By adopting

[14]Sometimes "representative agent" is used in the literature simply to mean what we have called parameter descriptivism. Here we use "representative agent model" as it is used in the classic analysis by Kirman (1992), to refer to a model in which the preferences and "choices of all the diverse agents in one sector—consumers for example—can be considered as the choices of one 'representative' standard utility maximizing individual whose choices coincide with the aggregate choices of the heterogeneous individuals" (p. 117).

[15]In the climate economics literature, it is sometimes claimed that the leading integrated assessment models (IAMs) adopt a representative agent form. See, e.g., Kaufman (2012, p. 580) and Traeger (2014, p. 629n1). But this is so only if the claim is that the leading IAMs are what we have labeled impure representative agent models. For the discounted utilitarian social welfare functions used in DICE (Nordhaus, 2008, pp. 205,207), RICE (Nordhaus and Boyer, 2000, p. 15), PAGE (Hope, 2011, p. 28), and FUND

a pure representative agent orientation, the EZ form prevents the analyst from modeling the fact that any climate policy involves gains for some individuals and losses for others. We consider this a significant knock against the EZ framework's relevance for climate economics, which is a normative welfare economic discipline. If in positive economics the EZ form provides for useful explanations and predictions, in particular as they relate to incorporating deeply-seated climate uncertainty (Lemoine and Rudik, 2017), that is surely a feather in its cap. But welfare economics is about evaluating states of affairs, not about explaining the past or predicting the future. The possible states of affairs at issue are ones in which different people—and different numbers of people—will be alive and either thriving or not. A cogent evaluation of those states of affairs cannot reasonably neglect these population-level phenomena.

It is therefore somewhat ironic that the main impetus for using the EZ framework in climate economics is the desire to be more 'realistic' by disentangling risk aversion and inequality aversion. For the EZ form is compelled to conflate both *individual* and *social* risk aversion and *individual* and *social* inequality aversion. Arguably, a superior way to disentangle these key concepts is to replace the standard utilitarian social welfare function with a *prioritarian* social welfare function, and then to embed that within an expected utility framework. Consider the following prioritarian social welfare function that separates the four concepts that the EZ form conflates into two. For ease of exposition, we assume there is no pure time preference and that social inequality aversion over time is simply a special case of social inequality aversion across individuals (regardless of when they live):

$$V_a = \sum_{s \in S} \left[\pi_s \cdot H \left(\sum_{i=1}^{N} G(U_i \left(C_{ia}^s \right) \right) \right]. \tag{5}$$

This social welfare function ranks possible actions a, not outcomes. It does so by first ranking possible outcomes according to the deterministic prioritarian social welfare function $V = \sum_{i=1}^{N} G(U_i \left(C_{ia}^s \right)$, where C_{ia}^s is individual i's lifetime consumption in state s given action a.[16] This social welfare function sums the utility of individual lifetime consumption *transformed* by a concave function expressing social aversion to interpersonal inequality in lifetime well-being. The social welfare function for risky actions then further applies a transformation H to possible outcomes to reflect social risk aversion, before summing the translated value of each possible outcome s weighted by its respective probability π_s.

This social welfare function separates individual and social risk aversion by incorporating both U_i and H, and it captures social inequality aversion with a concave G. It does not yet speak to whether the temporal well-beings of individuals—the well-beings asso-

(Anthoff, Tol, and Yohe, 2009, pp. 3–4) all include a variable for population level and can capture the phenomenon of a diverse and changing population—either at the global level across time or within and across times in the case of regionally disaggregated models like FUND and RICE. Because these social welfare functions aggregate the utilities of many different individuals, these IAMs manifestly do not employ the conceit of a single representative agent whose orderings over her own utility possibilities determine the structure and character of model's betterness orderings. By contrast, the axioms underlying the EZ framework are so restricted to claims about a single representative agent's orderings of utility streams. This essential feature of the EZ functional form makes it a pure representative agent framework.

[16] C_{ia}^s is most plausibly thought of as a vector of consumption at different times.

ciated with individual consumption at given times—are additively separable across each person's life, but it does allow for that. If times are additively separable across a life, then that opens the door to the link between individual risk aversion and individual intertemporal substitution that Epstein-Zin advocates find so problematic. But by referring only to lifetime consumption, (5) also allows for individual lifetime *well-being* to be responsive to the particular pattern of the individual's well-being at different times. That in turn allows for an individual's intertemporal elasticity of substitution to differ from her risk aversion concerning her *lifetime* well-being (Broome, 2004, pp. 215, 224). The latter reflects her ranking of risky prospects over lifetime well-being.[17] The social welfare function in (5) therefore allows for the conceptual and formal separation of individual and social inequality aversion (and thus intertemporal substitution) as well as individual and social risk aversion.

Suppose one finds (5) attractive on *a priori* grounds. Not only does it permit the separation of many conceptually distinct components of individual and social welfare across both certain outcomes and states of nature, but it is also allows for *a priori* arguments to be given for or against giving different values to the parameters that determine the shape of the H, G, and U functions.

Formulation (5) is a form of "expected utility prioritarianism" (Adler, 2012, p. 496), but it is not the only possible version of expected utility prioritarianism. Consider instead the following social welfare function (which for convenience omits H by assuming it is the identity function):

$$V_a = \sum_{i=1}^{N} G\left[\sum_{s\in S}\left[\pi_s \cdot U_i\left(C_{ia}^{s}\right)\right]\right]. \tag{6}$$

Whereas (5) first applies a concave transformation G to the utility of outcomes, adds these across individuals, and then weights the sum by the probability of a given outcome's occurrence, (6) first finds each individual's expected utility, applies a concave transformation to that quantity, and then sums these transformed utilities across all individuals. The social welfare function in (5) is known as "ex post prioritarianism,"[18] while (6) is known as "ex ante prioritarianism" (Adler, Hammitt, and Treich 2014, p. 84; Adler and Treich 2015, pp. 299–301).

Now suppose, as is common, that prioritarians wish to apply a concave transformation to individuals' von Neumann-Morgenstern utilities when evaluating non-risky outcomes. If this is the case, it follows that when moving to the social evaluation of *risky* actions, each version prioritarianism violates at least one of the seemingly weak premises of Harsanyi's aggregation theorem (Fleurbaey, 2010; Greaves, 2015; Harsanyi, 1955). Specifically, *ex post* prioritarianism violates the Ex Ante Pareto principle, which holds that if one individual prefers prospect A to prospect B while all other individuals are indifferent between them, then prospect A is socially superior to prospect B.[19] Meanwhile,

[17]There is no contradiction in having an individual's lifetime well-being in a given state of the world be a non-additively separable function of her temporal well-beings, but then having the expected utility of lifetime well-being be additively separable across states of nature.

[18]Or more accurately, by virtue of the H function, "ex post transformed prioritarianism." See Adler and Treich (2015, pp. 299–301) and Adler, Hammitt, and Treich (2014, p. 84).

[19]This version of the Ex Ante Pareto principle is expressed in terms of individual and social preferences,

ex ante prioritarianism violates both the Sure Thing Principle from the standpoint of social evaluations of risky prospects as well as a plausible "Principle of Avoidance of Foreseeable Regret (Fleurbaey 2010, p. 650; Greaves 2015, pp. 37–9). The last principle holds that a criterion should not judge a risky prospect better than a non-risky prospect when the very same criterion judges that the sure outcome in the non-risky prospect is better than each of the possible outcomes in the risky prospect. But this is precisely what *ex ante* prioritarianism permits in risky contexts.

One axiom-prescriptivist response to these conflicts with Harsanyi's aggregation theorem would be to decide which of the untoward implication of expected utility prioritarianism one finds palatable enough to stomach. But, following Greaves (2015, pp. 34–5), another response is to suggest that even if prioritarian considerations are morally relevant to ultimate *policy choice*, they should be excluded from economic evaluation of climate outcomes and policies. One principled, axiom-prescriptivist argument for this move might be that tractability (if not plausibility) in economic evaluation requires a social welfare function that is additively separable across individuals, and that Harsanyi's aggregation theorem provides the most compelling axiomatization of that property.[20] It is, for example, strange to hold that when evaluating prospects involving different possible profiles of future well-being, one must take into consideration the profiles of well-being enjoyed by those who are already dead. But this, for example, is precisely what (5) requires when the H function is non-linear (Fleurbaey, 2010, p. 665).

Thus, if one accepts Harsanyi's aggregation theorem on axiom-prescriptivist grounds, and if one also believes that it is important for *policy* to give some moral priority to those whose utility is lowest, then one possibility is to defend the use of non-prioritarian social welfare functions in *economic analyses* of climate change while defending the relevance of prioritarian considerations at the level of *policy making*. This would, in effect, amount to adopting policy non-prescriptivism, which (as we have noted) is Harsanyi's general stance. He held that economic analysis should take a utilitarian form, and that morally relevant non-utilitarian considerations should be treated as complements to the economic ranking exercise, not components of it. In other words, Harsanyi proposed that welfare economics repudiate utilitarian*ism* while at the same time concerning itself exclusively with what we have called the utilitarian principle of distribution.

All this, in turn, jibes with our Proposition 2, which says that one can accept prescriptivism about axioms and parameters without thereby having to accept prescriptivism about policy. If axiom and parameter prescriptivism are taken to concern the theoretical choices within economic analysis, and if there are reasons to acknowledge a gap between the considerations relevant to economic rankings and the considerations relevant to *all-things-considered* rankings of possible actions, then one can reject a policy prescriptivist interpretation of economics without rejecting axiom- or parameter-prescriptivism.

In this section we have used recent proposals to adopt the EZ functional form to illuminate two routes to policy non-prescriptivism within climate economics. First, one can combine the EZ functional form with parameter descriptivism. In that case, policy non-prescriptivism follows if one takes proper heed of the Humean qualm about deriving an

but the principle can also be expressed in terms of individual well-being (which can allow for the possibility that a prospect is better for an individual even if the individual does not prefer it).

[20]In the intertemporal context, it is highly relevant that one of the Koopmans axioms, namely continuity in the sup norm, has a built-in bias against future well-being (Broome, 1992, pp. 104–5).

'ought' from an 'is'. Second, one can reject the EZ form and seek a demographically superior approach to disentangling risk aversion and inequality aversion. In that case, policy non-prescriptivism arguably follows because of the violations of Harsanyi's aggregation theorem entailed by each version of expected utility prioritarianism. So regardless of one's stance on whether EZ is the correct way to disentangle risk aversion and intertemporal substitution, one is led away from policy prescriptivism and toward the seemingly humbler stance of policy non-prescriptivism.

5. CONCLUSION

Economists are quite clearly more comfortable describing and calibrating observed behavior than grounding normative pronouncements in *a priori* moral reasoning. Moral philosophers, of course, operate quite differently. This leads to intense methodological debates, as evidenced by questions surrounding the appropriate discount rate at the core of much of climate economics. In this article we have distinguished between three types of prescriptivism—for axioms, preferences, and policies—and we have argued that these distinctions can shine new light into a longstanding debate.

We have argued that economists' penchant for *parameter descriptivism* necessitates the adoption of what we call *policy non-prescriptivism*, since *policy prescriptivism* without *parameter prescriptivism* risks violating Hume's admonition that an 'ought' cannot be derived from an 'is'. The exception to this rule is when the 'ought' is the ought of democratic decision-making: If the populace, in fact, chooses policy A in a fair and democratic way, then it quite plausibly ought to be undertaken. But there are other roles that economic analysis can play besides merely systematizing a populace's actual preferences. No feature of the technical tools of optimal growth theory precludes their application in analyses intended to combine moral considerations and empirical facts about how the world is and might be. For example, we have suggested that the tools of optimal growth theory can be used to articulate what we have called principles of distribution, which remain agnostic on the policy question of what actions should ultimately be undertaken.

Thus, the analytical outputs of economic analysis need not prescribe public policy. They can—and arguably should—be seen as mere inputs into policy-makers' decisions.[21] As we have also shown, even mere inputs—i.e. non-decisive but still relevant considerations—can themselves be prescriptive or non-prescriptive with respect to their axioms and parameters. In the end, it seems impossible for climate economists to endorse non-prescriptivism 'all the way down', for only certain sets of axioms will justify using any one particular social welfare function in the first place.

In saying all of this, we are not asking economists to be philosophers, or vice versa. We instead wish only to clarify what is required before one treats the results of an economic analysis as a well-founded policy pronouncement, and why analytical results might not entail any policy pronouncements in the first place. At the same time, we hope that our distinction between *parameter* and *axiom prescriptivism* helps to remove some qualms on the part of economists when it comes to 'picking' parameters, since economists typically have no qualms with picking (or at least relying on) chosen axioms required for additive separable social welfare functions.

[21]This appears to be the stance of the U.S. National Bureau of Economic Analysis (NBER) and its high-profile working paper series. NBER scrubs submitted working papers for any explicit policy recommendations.

In the end, it is still true that a dizzying array of judgment calls must be made. That goes for calibrating parameters used within the traditional isoelastic utility's Ramsey equation as much as for calibrating Epstein-Zin preference specifications. Both require judgment calls on the part of the analyst. Making those judgments should be acknowledged as just that: one of many decisions necessary on the way from identifying physical climate damages to evaluating their impact on society to using those evaluations to support public policy decisions. The challenges are indeed steep. To meet them we must find ways to push the economics and philosophy of climate change both together and forward in useful ways. At the very least, we hope we have shown that—and how—this might be done.

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