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Beyond the Ramsey model for climate change assessments

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ABSTRACT: The Ramsey optimal growth model contains a class of ethical frameworks popular among economists for assessing climate change. This essay critiques the Ramsey model, highlighting shortcomings in it and describing how to go beyond it towards more nuanced assessments through more accurate utility approximation and more diverse climate change mitigation strategies. This essay also critiques the 2 popular approaches for defining the model's ethics, prescriptivism and descriptivism, both in and beyond the Ramsey model context. The descriptive approach is found to hold serious flaws and should be rejected. Despite the model's various shortcomings, the climate change assessments using it provide a valuable applied ethics tool and bolster the case for climate change mitigation.

KEY WORDS: Climate change · Ethics · Ramsey growth model · Utilitarianism · Discounting · Utility approximation · Carbon tax

INTRODUCTION

The climate change phenomenon spans the entire planet. Its impacts may be felt for hundreds of millennia (Archer 2005). Those who can mitigate climate change are generally not the same as those who must adapt to climate change if it is not mitigated (Schelling 1999). The effects of climate change can be quite severe — for many, it is a matter of life and death (Confalonieri et al. 2007). Thus, climate change poses an ethical problem of great magnitude.

How bad climate change is and, in turn, how much we should do about it depends on our choice of ethical framework. According to some frameworks, such as the deep ecology of Næss (1973), it is a crisis of epic proportions that demands great action to avoid. According to other frameworks, such as that of Benatar (2006), climate change may actually be a good thing if it is expected to prevent more individuals from coming into existence, in which case, we should be trying to cause *more* climate change.

One class of ethical frameworks popular among economists for assessing climate change is the Ramsey optimal growth model (Ramsey 1928). The assessments it underlies include Manne et al. (1995), Nordhaus (2007), and Stern (2007). These assessments build climate change into broader models evaluating trade-offs between consuming resources now and investing them for future consumption. The assessments typically express recommended mitigation effort level in the form of a global carbon tax rate, the value of which depends heavily on how the assessments parameterize the Ramsey model's optimization criterion.

The Ramsey model's optimization criterion defines its underlying ethical view. The criterion takes utility[1]

[1]Utility here means well-being, welfare, or quality of life and, thus, refers to a cognitive phenomenon experienced by sentient individuals. Many, including most of the works discussed here, only value utility experienced by humans. This is an ethical stance and is distinct from the scientific questions of which non-humans experience utility and how strong this experience is (Ng 1995)

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to be the sole phenomenon bearing intrinsic value. This places the Ramsey model in a separate class from ethical frameworks in which other phenomena, such as ecosystem fitness (as in deep ecology), or, the performance of certain types of actions (as in deontological ethics), hold intrinsic value. The criterion is also not necessarily egalitarian with respect to all utility (as is utilitarianism), and, as this essay discusses, uses an approximation of utility which neglects several important phenomena. Thus, the decision to use the Ramsey model for assessing climate change or other problems reflects an ethical judgment, as does the decision to perform such assessments in the first place.

Two approaches dominate how Ramsey model users select the parameters that define the model's optimization criterion, and, in turn, the recommended carbon tax rate. One, called the 'prescriptive' approach, selects parameters to match a preferred ethical framework (prescription): utilitarianism. The other, called the 'descriptive' approach, selects parameters to match a preferred observation of behavior (description): aggregate market activity (Arrow et al. 1996). The 2 approaches yield significantly different carbon tax rate recommendations, with the prescriptive approach's recommendation being 10 times higher. The descriptive approach, however, is at present the more popular one among economists (Nordhaus 2007).

This essay will critique the Ramsey model and suggest how to go beyond it towards more sophisticated models. The first section provides an overview of the Ramsey model, including how the prescriptive and descriptive approaches parameterize it. The second section discusses shortcomings of the Ramsey model and their affect on climate change recommendations. The third section discusses what ethical frameworks the prescriptive and descriptive approaches give when pulled out from the Ramsey model context. The last section summarizes these results and places them in the perspective of broader applied ethics and climate change response efforts.

THE RAMSEY MODEL

The Ramsey model was originally formulated as a tool for deriving the rate at which an individual or group should consume available resources now instead of investing them for future consumption (Ramsey 1928). This classic model has since achieved wide popularity (Dasgupta 2005). Its simple structure is based on a class of ethical frameworks defined by 2 parameters: the utility discount rate, and the elasticity parameter.

The utility discount rate, δ (also known as the rate of pure time preference, or, the social discount rate), nominally describes the rate at which utility is judged to change value as time progresses. It is distinct from (though often confused with) the monetary discount rate, which describes the rate at which money changes value as time progresses. Setting $\delta = 0$ reflects the ethical view that utility has equal value regardless of when it is experienced; setting $\delta > 0$ reflects the view that utility loses value as time progresses; setting $\delta < 0$ reflects the view that utility gains value as time progresses. Lowering δ raises the Ramsey model's recommended carbon tax by increasing the importance of future climate change impacts.

Often-contentious debate on how to define δ has persisted since Ramsey's original publication (Frederick et al. 2002). Many, including Ramsey himself, consider the selection of anything other than $\delta = 0$ to be 'ethically indefensible' (Ramsey 1928 p. 543). Many others have argued for using $\delta > 0$, citing a variety of reasons. Among climate change assessments, these reasons include that there is a non-zero possibility that future utility will not be experienced (Stern 2007), that a large sacrifice would otherwise be recommended (Dasgupta 2005), and that, under certain circumstances, humans appear to prefer that positive experiences occur sooner (Nordhaus 2007)[2]. As Cowen & Parfit (1992) note, the first of these reasons confuses the likelihood of an outcome occurring with its value if it does occur, the second reason has nothing to do with time, and the third, as discussed below, has nothing to do with the utility of other individuals. Thus, decisions to set $\delta > 0$ in climate change assessments have captured more than just views on the relative value of utility occurring at different points in time.

The elasticity parameter, η (also known as the elasticity of marginal utility, or, the curvature parameter), describes the approximated relation between consumption (c) and utility (u), assumed to be an isoelastic function:

$$u(c) \approx \frac{c^{1-\eta}}{1-\eta} \quad (1)$$

This relation is often expressed as an equality instead of an approximation, even though the approximation is technically correct. Either way, disagreement exists on whether or not to strive for an accurate value for η. Non-accurate η values can be selected to reflect ethical views in which the distribution of utility among individuals matters. A greater-than-accurate η reflects the view that utility holds more value if experienced by

[2]Humans do not always appear to prefer that positive experiences occur sooner. Attempts at measuring the rate of such preference yield wildly varying results (Frederick et al. 2002)

low-utility individuals; a lower-than-accurate η reflects the view that utility holds more value if experienced by high-utility individuals. Lowering η raises the recommended carbon tax by raising the value of consumption by future individuals, who, in the model, are expected to consume more than present individuals.

The elasticity parameter has also been discussed in the context of spatial (intra-temporal) distribution. Since the Ramsey model values all contemporaneous utility equally and approximates everyone's utility with the same isoelastic function, it holds that the optimal spatial distribution of consumption is egalitarian. Higher η values make spatial equality more important. Some advocates for high η values have been criticized for not also recommending massive wealth redistribution from today's rich to today's poor (Stern & Taylor 2007). One response to this dilemma is to introduce 'Negishi weights', which devalue the utility experienced by the poor in order to avoid recommending such redistribution (Nordhaus & Yang 1996). An alternative response is to recommend more spatial redistribution (Schelling 1999).

The 2 parameters δ and η combine to form the Ramsey model's optimization criterion:

$$\int_{t_0}^{\infty}\sum_{n=1}^{N} e^{-\delta t} u(n,t,c)\,dt \approx \int_{t_0}^{\infty}\sum_{n=1}^{N} e^{-\delta t}\frac{c(n,t)^{1-\eta}}{1-\eta}\,dt \qquad (2)$$

Here, t_0 is the time at which the decision in question (consume or invest) is made; n is the index number for each individual under consideration; N is the total number of individuals under consideration; t is time.

Many Ramsey model implementations, including Manne et al. (1995) and Nordhaus (2007), omit the summation in Eq. (2). This clusters all contemporaneous individuals into one 'generation' and thereby neglects distribution among them. Other formulations include a summation, but still cluster together (smaller) groups of contemporaneous individuals. For example, Nordhaus & Yang (1996) cluster contemporaneous individuals belonging to the same country, neglecting intra-national distribution.

Many Ramsey model implementations, including all computational implementations, replace the integral in Eq. (2) with a summation, clustering all consumption within a time period. For example, Manne et al. (1995) uses 10 yr time periods for the first 60 yr and 25 yr time periods thereafter. This serves to neglect intra-time period distribution. However, this mostly results in the neglect of distribution within the same individuals instead of between different individuals.

While the clustering of individuals and points in time may lead to model inaccuracies, it is a feature necessary to make modeling problems tractable. Separate handling of each of the 6.5 billion contemporary humans, let alone the trillions of contemporary sentient non-humans and countless future individuals is at present an unreasonable modeling task, as is the handling of smaller time periods (such as 1 s) necessary for near-complete accuracy. Thus, actual Ramsey model implementations must cluster individuals and time periods or else fall victim to 'analysis paralysis', although reducing model clustering will yield more accurate results, especially when assessing problems like climate change which have strong distributional effects. Finally, noting what clustering has been done is an important step to the proper interpretation of model results.

In addition to how they cluster individuals and time points, Ramsey model implementations are also defined by their selections of δ and η. While clustering is a computational necessity, δ and η selections reflect ethical decisions[3]. The prescriptive approach selects δ and η to match utilitarianism. It thus sets δ = 0 and selects an accurate η; η = 1 is typical (Stern & Taylor 2007)[4]. The descriptive approach selects δ and η to match observations of aggregate market behavior through the relation:

$$\rho = \delta + \eta g \qquad (3)$$

Here, ρ is the rate of return on investment; g is the rate of growth of consumption. The descriptive approach is flexible on the specific values for δ and η as long as ρ and g match observed values. Descriptivists' observations lead to $\rho \approx 4\%\ \mathrm{yr}^{-1}$ and $g \approx 1.3\%\ \mathrm{yr}^{-1}$. Meanwhile, prescriptivists' choices for δ and η, using $g \approx 1.3\%\ \mathrm{yr}^{-1}$, suggest an inaccurate $\rho \approx 1.4\%\ \mathrm{yr}^{-1}$ (Nordhaus 2007).

As noted above, there exists a noteworthy quirk in the descriptive approach in the discrepancy between the ethics underlying actual market investment decisions and the ethics that the approach extracts from these decisions. Market investment decisions generally reflect trade-offs between one's current utility and the future utility of *one's self*. However, descriptivists use these decisions to derive how to invest in climate change mitigation, which increases the future utility of *others*. As Schelling (1999 p.100) writes, 'Any model that treats greenhouse gas abatement as a matter of investing now in order to reap future benefits, as in domestic environmental programs, is simply inappropriate.' Thus, the descriptivists appear to be making the wrong description.

[3]As Nordhaus (2007) notes, some models have adjusted δ to compensate for a computational need to set η = 1. This procedure yields similar results as would varying η

[4]The δ = 0.1 % yr^{-1} used by Stern (2007) was chosen to reflect the annual possibility of humanity going extinct. This choice confuses the value of future utility with the probability of it being experienced, but has negligible effect on model results if the extinction possibility is approximately constant with respect to time during the time period being modeled

The impact on carbon tax recommendations from a change in the descriptive approach depends on what the approach is changed to. Schelling (1999) suggests that observations of foreign aid budgets are appropriate. This would dramatically lower carbon tax recommendations, as foreign aid budgets are much smaller portions of income than are savings. One alternative approach would instead use the foreign aid budgets that citizens preferred were in place, which, in the USA, are about 10 times higher than the actual foreign aid budget (UMD-PIPA 2001). Another alternative approach would include all money for which the individual(s) contributing the money receive no benefit. In addition to foreign aid, this would include much of, if not most, charity donations and public money spent on such things as education and long-term environmental and historic preservation. While this approach might or might not yield a higher carbon tax recommendation than the dominant descriptive approach, it would yield one much higher than that of Schelling's foreign aid scheme.

Thus, within the Ramsey framework, substantial room for improvement exists in implementing clustering and in the descriptive approach. However, as the next section shows, the Ramsey model itself has major shortcomings, each of which significantly affect climate change response recommendations.

RAMSEY MODEL SHORTCOMINGS

The Ramsey model approximates utility as an isoelastic function of consumption (Eq. 1). This approximation is based on the intuition that a dollar is worth more to a poor person than it is to a rich person. Despite this intuition's appeal and broad popularity, however, it contains several serious shortcomings. Each shortcoming discussed here has significant implications for recommended climate change response, including the carbon tax rate as well as non-carbon tax policies.

One major shortcoming of the isoelastic approximation is its neglect of ecosystem services. This broad category includes such phenomena as waste decomposition and scenic beauty (Costanza et al. 1997). Because these phenomena do not involve monetary exchanges, they often go uncounted, despite their great contribution to humanity's utility. One effort (Tol 1994) extending a Ramsey model to include such non-market 'intangibles' found that doing so tripled the recommended carbon tax. This result matches other studies which find that including ecosystem services roughly triples gross world product (Costanza et al. 1997).

Since climate regulation is an ecosystem service, a carbon tax is a penalty for ecosystem service deterioration. However, a more comprehensive ecosystem service deterioration penalty would mitigate climate change even further. This is in particular because of deforestation, which both causes greenhouse gas emission and devalues other ecosystem services, such as the control of erosion and the provision of beautiful scenery (Costanza et al. 1997). A carbon tax would deter some deforestation; a comprehensive penalty for ecosystem service deterioration would deter deforestation and thus mitigate climate change even more.

Another major shortcoming of the isoelastic approximation is its neglect of certain important aspects of human psychology. One such aspect is relative wellbeing, i.e. that utility depends not only on one's absolute consumption level but also on one's consumption level relative to others. The isoelastic approximation ignores this phenomenon, assuming that one individual's consumption does not affect another's utility. Though theoretically elegant, this is a strong assumption in a world full of envy and conspicuous consumption. Evidence of relative wellbeing comes from a wide variety of places, including the Japanese phenomenon of *karoshi* (literally, death from overwork), helmet requirements in hockey leagues, promotion rates among American World War II soldiers, and survey data examining the relationship between income and happiness. Despite the wealth of evidence for, and the intuitive sensibility of, relative wellbeing, the concept has long been absent from most economic analyses (McAdams 1992).

Another aspect of human psychology important to climate change assessments is hedonic adaptation. Individuals undergoing hedonic adaptation experience only a temporary change in utility level after a life-changing event (such as an income increase) occurs, after which they revert back (adapt) to a 'set-point' level. As with relative wellbeing, substantial evidence exists suggesting that hedonic adaptation occurs. The question appears to be not whether it occurs but how complete the adaptation is. Easterlin (2006) finds that hedonic adaptation is particularly strong for monetary events and less strong for non-monetary events such as marriage and health. Thus, climate change assessments that include relative wellbeing and hedonic adaptation would likely yield higher carbon tax recommendations by reducing the estimated value of aggregate consumption and increasing that of health.

A closer look at human psychology points to at least one other means of climate change mitigation: smart growth city planning. Survey data on human happiness suggests, unsurprisingly, that humans tend to enjoy commuting to and from work less than most other activities (Layard 2003). City planning efforts to reduce commute times may, thus, both make current humans happier and reduce our greenhouse gas emissions by lowering the building and transport sectors' energy consumption. That such city planning may make contemporary humans happier would be especially likely if, due to hedonic adaptation, we experience only temporary utility increases upon moving into larger residences. In this case, designing cities with smaller residences and shorter commutes would be a win–win climate change response entirely overlooked by the Ramsey model.

A final major shortcoming of the isoelastic approximation is its neglect of non-humans. The approximation is a function of consumption, but while all living organisms consume, non-human consumption does not appear in the GDP estimates used in Ramsey model implementations. More importantly, while (to the best of contemporary human knowledge) not all living organisms experience utility, some non-humans do. Exactly which non-humans experience utility remains an open question, but studies have suggested that these include fish (Chandroo et al. 2004) and even insects (Lockwood 1987). Also uncertain, but crucial, is how to compare utility levels across species. Despite these uncertainties, given the extensive ecosystem destruction that climate change is expected to cause, including non-humans in climate change assessments would likely increase carbon tax recommendations. However, without knowing which species experience utility or how to make quantitative interspecific utility comparisons, we cannot know how high the increase would be.

Including non-human utility suggests another policy option that would indirectly mitigate climate change: the setting and enforcement of higher livestock treatment standards. In addition to increasing the utility experienced by the livestock animals, this would mitigate climate change via an increase in animal product prices. Higher animal product prices function as an indirect carbon tax given the livestock sector's significant greenhouse gas emissions. Thus, a carbon tax would deter some livestock production; higher standards would deter more.

Without considering alternative mitigation strategies, the utility approximation refinements discussed here all raise carbon tax recommendations. However, implementing alternative mitigation strategies, including those discussed here, would lower the recommendations. This is because non-linearities in the human–climate system result in larger impacts per unit greenhouse gas emission when atmospheric greenhouse gas concentration is higher (Schneider et al. 2007). Non-carbon tax mitigation efforts also reduce individuals' exposure to higher carbon taxes. Thus, a diverse portfolio of mitigation strategies has advantages on both societal and individual scales.

Quantifying utility remains a difficult, imprecise task. However, an approximation of utility more nuanced than the Ramsey model's isoelastic function would greatly improve our assessments of climate change and point to diverse means of mitigation. As the next section shows, doing so also leads important insights into the prescriptive and descriptive approaches used to parameterize the Ramsey model.

PRESCRIPTIVISM AND DESCRIPTIVISM REVISITED

The prescriptive and descriptive approaches discussed above are methods of determining δ and η, the parameters that define the Ramsey model's optimization criterion. Given the model's shortcomings, it is worth revisiting the 2 approaches outside the model. Doing so illuminates the ethical thinking underlying the approaches and suggests that one, descriptivism, should be rejected.

Outside the Ramsey model, prescriptivism becomes utilitarianism. A 'rule' utilitarian might recommend a carbon tax whose level is determined in a fashion similar to the Ramsey model analyses but with a more nuanced utility approximation. An 'act' utilitarian sensitive to the usefulness of rules may support this as well. However, the act utilitarian would also seek an estimate of the utility cost of greenhouse gas emission in order to recommend that we take only those greenhouse gas-emitting actions for which the additional utility gained from the act exceeded the additional utility lost from the corresponding emission. Such an estimate would be of interest not only to act utilitarians but also to the numerous supporters of ethical frameworks for which utility is a component.

Descriptivism, on the other hand, becomes nihilism outside the Ramsey model. This is because descriptivism matches its ethical framework to whatever behavior happens to be observed. Under this approach, one can do no wrong. The optimal murder rate or level of racism (the latter of which descriptivists might approximate with a racial discount rate) would be whatever we happened to display. Carbon tax or other climate change response recommendations would be meaningless, because the optimal adherence to these recommendations would, again, be whatever we happened to display. As Ramsey model descriptivists do indeed make serious recommendations, they should reject this approach as counter to the spirit of their project. If they refuse to accept utilitarianism, then they should develop an alternative approach for their work.

One alternative approach descriptivists could consider is to aim for the ethical framework that society in aggregate supports. This may be more in the spirit of the descriptivists' project to infer an ethical framework from contemporary society. However, such a framework may little resemble that of the Ramsey model, given that about 85% of current humans support a religion (Kashner 2007). Furthermore, this framework excludes non-humans and future humans, a great many of whom are impacted by climate change. Inference of the ethical views of these individuals, with whom we cannot communicate, is no easy task, and may be sufficiently difficult to scuttle the entire descriptivist project.

CONCLUSIONS

Assessing the Ramsey growth model provides important insights into both the climate change response problem and the underlying ethics used to evaluate societal problems in general.

While the Ramsey model may provide a simple framework for assessing social problems, its isoelastic utility approximation neglects several important phenomena: ecosystem services, human psychology, and non-human utility. Including these phenomena causes changes in carbon tax recommendations and points to several other means of climate change mitigation: penalizing deforestation, supporting smart growth city planning, and setting and enforcing higher livestock animal treatment standards. This work thus suggests how future climate change assessments could include more nuanced utility approximations and mitigation strategies.

Pulling the prescriptive and descriptive approaches out from the Ramsey model context shows that prescriptivism becomes utilitarianism and descriptivism becomes nihilism. As Ramsey model descriptivists are non-nihilist, this result suggests that descriptivism, as implemented in the Ramsey model, should be rejected. While alternative approaches to descriptivism exist, these likely yield ethical frameworks that differ substantially from the Ramsey model's and may also hold fatal flaws given the difficulty of extracting the views of everyone affected by global problems such as climate change. Descriptivists should thus either adopt utilitarianism or develop an alternative approach.

While the Ramsey model may lack accuracy (as, at some level, do all models), it is fair to ask whether it is, nonetheless, useful.

The Ramsey model has served to exacerbate confusion about how we should evaluate problems, especially long-term, global problems. Much confusion on the utility discount rate's nature and belief in the isoelastic utility approximation's accuracy already exist; efforts to overcome these are hindered by the moral certainty with which Ramsey model users champion their various approaches. This certainty also inappropriately marginalizes other ethical frameworks. Finally, the model has had mixed impact on popular climate change mitigation discussion, sometimes strengthening support for mitigation (e.g. see Leonhardt 2007) and sometimes not (e.g. see Giles 2007).

On the other hand, the model represents some of the most sophisticated and significant exercises in applied ethics to date. In doing so, it is raising the profile of applied ethics in general and efforts to mitigate climate change in particular. Future projects can thus build on its successes and learn from its failures, leaving us with more powerful tools for ethical analysis.

It should be stressed that the Ramsey model prescriptivists and descriptivists both recommend a carbon tax. This agreement bolsters the growing consensus in favor of increased climate change mitigation. Surely, few ethical frameworks, other than nihilism or that of David Benatar, would recommend otherwise.

Ultimately, climate change is just one of several global challenges humanity may face over the upcoming century (Rees 2003). Our current efforts to assess and respond to climate change as a planet may also serve to prepare humanity for these other challenges. In this case, these efforts should be furthered even regardless of how severe the climate problem turns out to be. Indeed, our very survival may depend upon it.

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