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Abstract

Gollier and Weitzman (2010) show that if future consumption discount rates are uncertain and persistent, the consumption discount rate should decline to its lowest possible value for events in the most distant future. In this paper, I argue that the lowest possible growth rate of consumption per capita in the distant future is zero (assuming that humans do not die out). Substituting in the Ramsey rule shows then that the lowest possible consumption discount rate for the distant future is equal to the lowest possible utility discount rate of the population (according to the descriptive approach to parameterizing the Ramsey rule) or to the utility discount rate of the social evaluator (according to the prescriptive approach). In both cases, there are strong reasons to set the consumption discount rate for the distant future at a value which is virtually zero.

Keywords: Discount rate, climate change, cost-benefit analysis, prescriptive, descriptive

JEL Codes: O4, Q5

1 Introduction

Climate change, and environmental policy to slow it down or to abate its consequences, may involve huge costs and benefits in the distant future. So for climate change cost-benefit analyses (CBAs), the value of the consumption discount rate for distant future events is of crucial importance.

Gollier and Weitzman (2010) show that if future consumption discount rates are uncertain and persistent, the consumption discount rate in CBAs should decline to its lowest possible value for events in the most distant future.[1] Inspired by this theoretical insight, several researchers computed schedules of *declining (consumption) discount rates* (DDRs). One possibility is to take the position that the interest rate is a reasonable proxy for the consumption discount rate, and to derive a schedule of DDRs from the time series properties of the interest rate (a line of research started by Newell and Pizer, 2003, and followed by Groom et al., 2007; Gollier et al., 2008; and Hepburn et al., 2009). Another possibility is to use the Ramsey rule to express the consumption discount rate as a function of the growth rate of consumption per capita, and to derive a schedule of DDRs from the time series properties of consumption per capita (see, for instance, Gollier, 2008).

However, the data that are used to derive DDRs all start around or after the takeoff into sustained growth in consumption per capita that occurred roughly 250 years ago, after thousands of years of hardly any growth at all.[2] The possibility that this sustained growth will come to a standstill (or even reverse) during the next few centuries cannot be ruled out. And if this happens, it is likely to alter the time series properties not only of consumption per capita, but also of the interest rate. The possibility of such a reversal (or perhaps even a structural break) is not taken into account if the consumption discount rate for the distant future is based on data from the last two centuries.

I therefore propose in this paper an alternative strategy to compute the consumption discount rate for distant future events. I will argue that there

[1]Gollier and Zeckhauser (2005) and Farmer and Geanakoplos (2009) reach the same conclusion based on the implications of heterogeneous preferences and behavioral economics, respectively.

[2]Newell and Pizer (2003) and Groom et al. (2007) use US interest rate data starting in 1798. Gollier et al. (2008) use interest rate data for France starting in 1746, and for India, Japan and South Africa starting in 1800 or later. Hepburn et al. (2009) use interest rate data for Australia, Canada, Germany and the UK all starting in the 19th century. Gollier (2008) derives a schedule of DDRs based on a model estimated by Cecchetti, Mark and Lam (2000), who use consumption data for the U.S. starting in 1890. Acemoglu (2009) provides a well-documented overview of when the takeoff into sustained growth in consumption per capita occurred in various parts of the world.

are several reasons why the growth rate of consumption per capita in the distant future might be zero. Substituting in the Ramsey rule shows then that the consumption discount rate for the distant future is equal to the lowest possible utility discount rate of the population (following the *descriptive* approach to parameterizing the Ramsey rule), or to the utility discount rate of the social evaluator who is carrying out the CBA (according to the *prescriptive* approach). In both cases, and assuming that the risk on human extinction is negligible, there are strong reasons to set the consumption discount rate for the distant future at a value which is virtually zero.

The paper proceeds as follows: I briefly review the Ramsey rule in section 2. Section 3 focuses on the lowest possible distant future consumption growth rate. Substituting in the Ramsey rule in section 4 yields then the lowest possible distant future consumption discount rate. Section 5 draws some conclusions.

2 The Ramsey rule

Most economists agree that the consumption discount rate for CBAs should satisfy the Ramsey rule (see, for instance, Arrow et al., 2013), which disentangles the consumption discount rate ρ_t as the sum of two components: the utility discount rate δ (to capture the idea that most people seem to care less about future utility than about current utility);[3] and (the absolute value of) the elasticity of the marginal social value of consumption μ *times* the growth rate of per capita consumption g_t (to capture the idea that the marginal social value of per capita consumption decreases as societies grow richer):

$$\rho_t = \delta + \mu g_t \tag{1}$$

Opinions differ about how to parameterize the Ramsey rule, however. There are two approaches in the literature, the *descriptive* and the *prescriptive* approach (following Arrow et al., 1996). According to the *descriptive* approach (followed by, among others, Tol and Yohe, 2006; Nordhaus, 2007; Weitzman, 2007; and Mendelsohn, 2007), the consumption discount rate should be equal to the rate of return on capital (which is often, but not always, equated to the interest rate); observations of the rate of return on capital and the per capita consumption growth rate can then be used to estimate δ and μ, which are then interpreted as the population's revealed preferences for discounting future consumption streams (see, for instance, Anthoff, Tol and Yohe, 2009). According to the *prescriptive* approach, however, (followed by, among others,

[3]...also called the *pure rate of time preference* or the *subjective discount rate*.

Ramsey, 1928; Pigou, 1932; Harrod, 1948; Sen, 1982; Cline, 1992; and Stern, 2007), there are no convincing reasons to set the consumption discount rate equal to the interest rate; the consumption discount rate should therefore be derived from the Ramsey rule for given values for δ and μ - and determining these values is fundamentally an ethical issue, beyond the scope of positive economics.[4]

I will come back to this disagreement in section 4. But let us first focus on the growth rate of consumption per capita, which enters the second term at the right-hand-side of equation (1).

3 The consumption growth rate

In this section, I argue that the lowest possible value of the growth rate of consumption per capita in the distant future is zero, assuming that humans do not die out. There are several arguments for this.

First, over the broad sweep of human history, the growth rate of consumption per capita was virtually zero during thousands of years, and then rather suddenly switched to about 2% a year some 250 years ago. From a purely statistical point of view, these observations are insufficient to predict with any reasonable confidence what the per capita consumption growth rate will be during the next few centuries: the high growth rates of the past 250 years may prevail in the future, but we cannot exclude the possibility that per capita consumption growth will switch back to zero at some point.

Second, according to Gordon (2012), the source of the rapid economic growth during the past 250 years were three industrial revolutions, associated with some major technological breakthroughs.[5] But there is no guarantee that these technological breakthroughs will be followed by an endless stream of breakthroughs in the future; and without new major technological breakthroughs, per capita consumption growth will decline and converge to zero.

Third, of course it is reasonable to assume that technological breakthroughs

[4]...even though economic analysis can give some guidance by illuminating the implications of certain parameter values. See, for instance, Dasgupta (2008).

[5]According to Gordon (2012), the three industrial revolutions and their main breakthroughs are as follows: the first industrial revolution dates between 1750 and 1830, with the steam engine, cotton spinning, and railroads as its main breakthroughs; the second industrial revolution took place between 1870 and 1900, and is associated with the invention of electricity, the internal combustion engine, and running water with indoor plumbing; the third industrial revolution is the computer and internet revolution, which began around 1960, reached its climax in the late 1990s, and is currently subsiding.

are not purely exogenous, as Gordon implicitly assumes, but that they are the result of investment in R&D. But sustained investment in R&D does not guarantee sustained technological progress. If there are decreasing returns to knowledge, as in the semi-endogenous growth theories pioneered by Jones (1995), sustained technological progress requires sustained growth of labor input in the R&D-sector - which ultimately requires sustained population growth.[6] But an ever growing world population is unlikely, if not impossible; furthermore, population growth appears to slow down if income per capita is sufficiently above the subsistence level. So semi-endogenous growth models, combined with plausible demographic assumptions, predict that the growth rate of consumption per capita will eventually decline and fall back to zero. Note that this conjecture has some empirical support: Kremer (1993) shows that population and income data going back to 1 million B.C. roughly match the dynamics of a semi-endogenous growth model; and as the population growth rate is likely to decline in the future, Kremer concludes that the rate of technological progress will decline as well (even though he leaves open the question whether the population growth rate and the rate of technological progress will eventually converge to zero).

Fourth, climate change itself may undermine future economic growth. The implications of climate change are not well understood. But it cannot be excluded, for instance, that mitigation costs will crowd out investment in R&D, and bring economic growth to a halt.

I therefore conclude that the lowest possible value for the growth rate of per capita consumption in the distant future is at most zero. It may be lower, but then consumption per capita would steadily decline and eventually fall below the subsistence level, driving the human race into extinction. However, if extinction is certain to occur, it will drive up the utility discount rate to infinity, and surely not generate the lowest possible consumption discount rate. For

[6]For a while, growth of labor input in the R&D-sector can also be generated by a growing share of R&D employment in aggregate employment, or by an increasingly better educated workforce (measured, for instance, by the number of years of schooling). Jones (2002) presents a calibrated semi-endogenous growth model that suggests that these two factors explain more than 80% of growth in output per worker in the U.S. between 1950 and 1993. But neither the share of R&D employment in aggregate employment nor the number of years of schooling of the workforce can increase forever; so ultimately, sustained growth of labor input in the R&D-sector requires sustained population growth. Note also that Jones' (2002) computations imply that if the share of R&D employment and the educational attainment of the workforce do not continue to grow during the next few decades but stabilize at their current levels, the growth rate of output per worker can easily drop within a few decades to less than half of what we observed in the second half of the 20th century; so even with sustained population growth we may experience a substantial slowdown of technological progress.

this reason, and to avoid a number of dire philosophical and ethical intricacies, I will assume in the rest of the paper that humans do not die out.

4 The consumption discount rate

In the previous section, I concluded that, disregarding the possibility of human extinction, the lowest possible value for the growth rate of per capita consumption in the distant future is zero. I will now use the Ramsey rule (1) to derive the lowest possible consumption discount rate for the distant future, first according to the prescriptive approach, and then according to the descriptive approach.

Substituting $g_t = 0$ in equation (1) yields $\rho_t = \delta$, such that the lowest possible consumption discount rate for the distant future according to the prescriptive approach is simply equal to the utility discount rate of the social evaluator. According to adherents of the prescriptive approach, setting an appropriate value for the utility discount rate is an ethical issue, and it is up to the social evaluator to do this. However, many economists and philosophers consider it ethically indefensible to discount the utility of future generations, and plead for a value of δ that is as low as possible - perhaps even zero. So I conclude that if future consumption discount rates are uncertain and persistent, and if the risk of human extinction is negligible, most adherents of the prescriptive approach would argue for a distant future consumption discount rate that is virtually zero.

According to the descriptive approach, the value of δ should reflect the preferences of the population. Substituting $g_t = 0$ in equation (1) shows then that the lowest possible consumption discount rate for the distant future is equal to the lowest possible utility discount rate of the population in the distant future. It is anybody's guess what the preferences of the population in the distant future will be. But we cannot exclude the possibility that the representative household in the distant future will be persuaded by the arguments of economists such as Ramsey, Pigou, Harrod, Sen, Cline and Stern, such that the descriptive approach in the distant future yields the same value for δ as these economists' prescriptive approach.

So both adherents of the descriptive and the prescriptive approach may want to set the consumption discount rate for the distant future at a value which is virtually zero.

5 Conclusions

If future consumption discount rates are uncertain and persistent, if there is a chance that the growth of consumption per capita will come to a standstill during the next few centuries, and if the risk on human extinction is negligible, the consumption discount rate for the distant future should be set equal to the lowest possible utility discount rate of the population (according to the descriptive approach) or to the utility discount rate of the social evaluator (according to the prescriptive approach); in both cases, there are strong reasons to set the consumption discount rate for the distant future equal to a value which is virtually zero.

Unfortunately, extending this result into a complete schedule of DDRs suffers from Knightian uncertainty: if we accept that there is a chance that per capita consumption growth will come to a standstill during the next few centuries, we still do not know when this will happen and how likely it is; and there is no way to compute this risk from past observations. Schedules of DDRs are therefore inevitably based on subjective value judgements about the timing and the likelihood of long run economic stagnation, and can be anything between two extremes: at the one hand, the schedules derived by, for instance, Newell and Pizer (2003), Groom et al. (2007), Gollier et al. (2008) and Hepburn et al. (2009) (assuming that the descriptive approach holds and that future interest rates will be generated by the same stochastic process as during the last 200 years - implying that the probability of long run stagnation as experienced before the 18th century is zero); and at the other hand a schedule where the consumption discount rate almost immediately declines to a value close to zero (assuming that the utility discount rate is or will soon become virtually zero, and that there is a high probability of long run stagnation).

This conclusion is reminiscent of Weitzman (2009). Weitzman argued that deep structural uncertainty about the likelihood of extreme tail events introduces in climate change CBAs an element of "contentious subjectivity" (Weitzman, 2009, p.18). Long run economic stagnation during the next few centuries is yet another extreme tail event of which the likelihood cannot be pinned down by past observations, forcing us to move into what Weitzman called "the unknown territory of subjective uncertainty".

So perhaps we should reconsider the role of climate change CBAs: rather than using and presenting them as vehicles that try to give more or less objective answers to environmental policy questions, we may want to acknowledge upfront that they are inevitably value-laden,[7] and use them as tools to assess the implications of different value judgements.

[7] See also, for instance, Nelson (2008), Dietz et al. (2009) and Ackerman et al. (2009).

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