Decomposing the social discount rate

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Abstract

Recent modelling of the costs and benefits of climate change has renewed debate surrounding assumptions regarding the social discount rate in analysing the impacts of environmental change. Previous literature segments the social discount rate into being influenced by two key factors; the rate of pure time preference and the elasticity of marginal utility of future consumption. These components of the social discount rate reinforce the linkages between the choice of social discount rate and intergenerational distribution. In an extension of previous work by the author on intergenerational distributional preferences, this paper discusses the relationship between intergenerational equity and the social discount rate. The work has significant policy implications given the sensitivity of Cost Benefit Analysis outcomes to assumptions regarding the social discount rate.

Keywords: Intergenerational equity, Social discount rate

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1.0 Introduction

It is with trepidation that I have forged into the literature regarding the social discount rate. The literature is complex and extensive, yet significant questions remain unresolved. Despite this, decision–makers are faced with the challenge of analysing the impact of policy alternatives which inherently involve the comparison of benefits and costs across time periods. Economic theory suggests that in order to incorporate these intertemporal changes into a decision-making framework, the future costs and benefits should be discounted and compared in net present value terms. This acknowledges that there is both an opportunity cost of capital and that people may have preferences about the timing of costs and benefits.

The debate in the literature regarding the appropriate social discount rate is reflected in the divergence of approaches in practice. For example, the Australian government recommends a social discount rate of 7 percent (with sensitivity analysis at 3 percent and 11 percent) for policy appraisal, while the Garnaut report applies social discount rates of 1.35 percent and 2.65 percent (Department of Finance and Deregulation 2007; Garnaut 2008). In part, this variance may reflect arguments within the literature suggesting that lower discount rates are more appropriate over longer time horizons (See, for example, Weitzman 1998). Nevertheless, the question of the choice of discount rate remains vexed for policy-makers. Pannell and Schilizzi (2006) suggest a complete resolution of the issues surrounding discounting will require integration of efficiency, equity and uncertainty considerations.

This paper addresses one aspect of the integration of efficiency and equity in determining the social discount rate. A central aspect of incorporating equity in the choice of social discount rate is the trade-off between consumption today and consumption in the future. High discount rates may result in decisions that make inadequate provision for future generations. Conversely, failure to discount can also adversely impact the well-being of future generations. Hence, a key question in the choice of social discount rate is the intergenerational equity impacts of policies with intertemporal benefits and costs.

The focus in this discussion is on the social discount rate rather than an individual discount rate.[1] Marglin (1963) argues that governments should not base their policy and project decisions on the

[1] Empirical estimates of individual discount rates suggest higher rates than the social rates discussed in this paper. For example, Windle and Rolfe (2004) in a choice experiment with two types of payment vehicle, a lump sum and an annual payment, find a personal discount rate of 37%.

basis of a discount rate founded on individual time preference, as investment generates public-good type benefits which would be under-supplied if decisions were based on individual time preference.

There are two possible approaches to estimating the social discount rate in public policy and project appraisal; the social rate of interest on consumption and the social opportunity cost of capital. The Ramsey condition illustrates that, in an optimal economy, these will be equal as market forces will result in the matching of consumption patterns and investment spending (Ramsey 1928). This assumes a world without market failure, tax or risk. This paper adopts a social rate of interest on consumption approach reflecting the strong relationship between intergenerational equity and the components of the social rate of interest on consumption. Analysis of assumptions employed regarding the components of the social rate of interest on consumption indicates that intergenerational equity preferences are often considered in the estimation of social discount rates. This is evidenced in the explanation of social discount rate estimation in the major policy studies responding to climate change (Stern 2007; Garnaut 2008).

An alternate method of incorporating intergenerational distribution preferences in policy analysis is proposed in this paper. The paper explores the sensitivity of social discount rates to the explicit application of intergenerational distributional weights. As with the social discount rate, the theory behind the estimation of distributional weights in Cost Benefit Analysis is based on the notion of an intertemporal social welfare function (Bergson 1938; Samuelson 1947). Specifically, the paper discusses the implications for the estimation of net present values of the application of intergenerational distributional weights. The weights used in the analysis were estimated using the stated preference method of choice modelling and reported in Scarborough and Bennett (2008).

Intergenerational-equity adjusted social discount rates are derived through the application of intergenerational distributional weights to discount factors. This approach explicitly decomposes the efficiency and equity components of the social discount rate. It has two distinct advantages; the ability to distinguish equity and efficiency criteria and transparency in the incorporation of intergenerational distributional preferences.

The paper is structured as follows. Section 2 provides a brief background of the theoretical components of social discount rate estimation using a consumption welfare model. Section 3 discusses the disparity in some of the social discount rates applied in major studies and proposed in the literature. This discussion highlights the assumptions made regarding each component of the

social discount rate based on an intertemporal social welfare model. Section 4 discusses the relationship between intergenerational equity and the social discount rate and outlines the derivation of intergenerational equity-adjusted social discount rates. The conclusion in section 5 highlights the need for more research on intergenerational equity preferences and how they are incorporated in social discount rates and policy analysis.

2.0 The consumption welfare model

From the consumption side, there are two components which influence the social discount rate; the social rate of pure time preference and the marginal elasticity of utility with respect to consumption. These are both significant parameters in estimating the costs and benefits of environmental change (Dasgupta 2007). Based on the estimation of an intertemporal social welfare function, the social rate of interest on consumption *r*, is given by the relation, $r = \delta + \eta g$, where δ is the social rate of pure time preference, η is the elasticity of marginal (social) utility – the percentage change in welfare derived from a percentage change in consumption (or income)- and *g* is the growth rate of per-capita consumption or income over time (Arrow *et al*. 2004). Weitzman (2007) points out that δ and η are value judgements which are likely to vary between individuals, while *g* depends on technological progress and resource accumulation in the economy. Each is discussed in further detail.

2.1 The social rate of pure time preference (δ)

The social rate of pure time preference is the rate at which future utility is discounted simply because it is in the future. Inherent in the determination of the social rate of time preference is the assumption that people are myopic in that they prefer consumption now rather than later. Patience and waiting is considered a negative and when given a choice between the consumption now or later of two equal goods the rational person will choose current consumption. Pearce *et al.* (2006) acknowledge that rates of impatience are notoriously difficult to estimate.

An important distinction in considering time preference is the likely divergence between individual and social time preference. In most public policy settings, it is the social, rather than individual, rate of time preference that is relevant. The social rate of time preference is compounded as it also influences the distribution of utility between generations, with the individual not necessarily being the recipient of future utility changes. Hence intergenerational equity is influenced by the choice of social time preference and social decision-making (Arrow and Kurz 1970). While one individual can

only add infinitesimally to future wealth, a collective agreement to do so will increase everyone's wealth.

Also influencing the social rate of time preference is the opportunity cost of capital. Estimation of the opportunity cost of capital is confounded with respect to environmental policy as there may be a difference between the opportunity cost of capital for durable goods and the opportunity cost of capital for natural capital.

2.2 The marginal elasticity of utility with respect to consumption (η)

The second element in the consumption welfare model of the social discount rate is the elasticity of marginal utility of consumption (η); the percentage change in the welfare derived from a percentage change in consumption (or income). This reflects the changing marginal utility of consumption with the passage of time, and is decomposed into a rate of growth of consumption per capita and an elasticity of utility with respect to consumption (Schelling 1995).[2]

Estimating the value of η is complex as the benefits and costs of a given policy or project will be measured in terms of monetary values, rather than in terms of utility. Generally, the expectation is that on average the marginal utility of consumption will decline over time as a result of rising consumption per capita. Economists have traditionally assumed that future generations are likely to have higher levels of income and declining marginal utility. Effectively then discounting is often justified with the assumption that future people will be better off than people today.

Given the comparison between consumption now and consumption in the future, this component of the discount rate is often interpreted as an intergenerational equity measure. For example, Garnaut (2008) suggests the elasticity of marginal utility of consumption "is as a measure of society concern for equity in income distribution". Arrow *et al*. (2004) reinforce the interpretation of η as a social preference for equality of consumption among generations.

There is debate in the literature regarding the extent of declining marginal utility in the future. For example, evidence from the happiness literature suggests differences in the extent of the decline in marginal utility for income as opposed to the consumption of environmental goods (Ng 2006).

[2] At an individual level, Pearce *et al.* (2006) suggest that the intuition behind η is that it expresses an individual's aversion to fluctuations in their income levels.

Layard (2005) argues that "If someone could buy the same standard of living as his parents, we cannot assume that he would get the same happiness from it. In fact, our evidence shows that he would generally get less happiness, because he expected a better standard of living."

2.3 The rate of growth in aggregate consumption (g)

The final component influencing the consumption based social discount rate is the rate of growth in aggregate consumption, *g.* This is dependent on forecast growth in income in the economy. For example, the UK Treasury uses a value of 2 percent per year for the rate of growth over time. This is based on work by Maddison (2001) which shows per capita growth in the UK to be 2.1 percent between 1950 and 1998. In Australia, Garnaut(2008) assumes a rate of growth in aggregate consumption of 1.3 percent for Australia. Randall (2006) points out that if $\delta=0$ *and* $\eta=1$*, then* $r=g$ and the social discount rate should approach the growth rate of the economy.

3.0 Discount rates in practice and estimates in the literature

In practice policy-makers require a realistic benchmark for policy analysis and the opportunity cost of capital is often used as a proxy discount rate. For example, the Australian Government Best Practice Regulation Handbook states that "the preferred approach is to base the discount rate on market-determined interest rates, which indicate the value to the current population of future net benefits." (Department of Finance and Regulation 2007, p. 120). Important considerations if the opportunity cost of capital approach to estimating the social discount rate is applied are the sources of capital and the weighting given to each source of capital. A problem with this approach is that prices generated by capital markets may not be consistent with social optimality (Quiggan 2008).

Evidence of the disparity of social discount rates applied in policy analysis is provided in Table 1 which includes the components of social discount rates applied in analysis or suggested in the literature by prominent researchers. One example of the importance of estimates of the social discount rate is illustrated in research assessing the implications of global warming and the policy responses to climate change. For example, in analysing the efficient and inefficient approaches to slowing global warming, the approach of Nordhaus (2007) is to use the estimated market return on capital as the discount rate. In the DICE model a time preference rate (δ) of 1.5 percent per year and a marginal utility of consumption (η) of 2.0 are assumed. Nordhaus indicates that these estimates have been revised in the current version of the model and move the model closer to one that

displays intergenerational neutrality.[3] He makes the important observation that the two parameters need to be viewed in tandem.[4]

Table 1: Examples of social discount rate estimates

	Pure rate of time preference (δ) *(percent per annum)*	**Marginal elasticity of utility (η)**	**Rate of growth in aggregate consumption (g)** *(percent per annum)*	**Social discount rate (r)** $r = \delta + \eta g$ *(percent per annum)*
Nordhaus(2007)	1.5	2	2	5.5
Stern (2007)	0.1	1	1.3	1.4
Garnaut (2008)	0.05	1 and 2	1.3	1.35 and 2.65
Arrow *et al* (2004)	0.5	2-4	1.5	3-6
Weitzman (2007)	2	2	2	6
UK Treasury Green Book (0-30 years)	1.5	1	2	3.5 %

[3] Nordhaus also takes care to reinforce that these estimates measure the importance of the welfare of future generations relative to the present and refers to future utility not future goods or dollars as this study has emphasised.

[4] In the DICE model the same outcome is achieved with the assumption of a lower time preference rate of 0.1 percent and a higher marginal utility of consumption of 2.9.

The disparity in the estimates of the social discount rate in the models assessing the impact of climate change is apparent when the assumptions of the DICE model are compared with those of the Stern Review in the UK and the Garnaut Report in Australia (Stern 2007; Garnaut 2008). In his analysis of climate change policy, Stern assumes a time preference rate (δ) of 0.1 percent per year, consumption elasticity (η) of 1.0 and rate of growth in aggregate consumption (g) of 1.3 percent per annum. These assumptions yield an estimated value for the social discount rate of 1.4 percent per annum.[5] In Australia, the Garnaut review judges that a near-zero pure rate of time preference is appropriate (0.05 percent) and assumes two alternative values for the marginal elasticity of utility (1 and 2). With an average annual growth in Australian per capita income of 1.3 percent, the two social discount rates applied by the review are 1.35 percent and 2.65 percent.

Arrow *et al.* (2004) also suggest low values of time preference (δ), in the range of 0-0.5 percent per annum, arguing that caring about future generations justifies this low value. Based on Hall's (1988) time series estimates, they propose that plausible values for the intertemporal elasticity of consumption (η) might lie in the range of 2-4**.** Arrow *et al.* (2004) explain this inference by contending that individuals "derive a positive externality, outside of the marketplace, from the welfare of future generations". With a growth rate of 1.5 percent, they speculate that the social discount rate is between 3-6 percent.

Another estimate of the social discount rate is provided by Weitzman (2007) who suggests a "trio of twos" giving a social discount rate of 6 percent. He emphasises that this rate can be the result of a number of parameter combinations.

The UK Treasury suggest a rate of 3.5 percent (H. M. Treasury 2003). UK Treasury concludes that the evidence suggests that the elasticity of the marginal utility of consumption is around 1.[6] This implies that a marginal increment in consumption to a generation that has twice the consumption of the current generation will reduce the utility by half. In an applied study, Viscusi *et al.* (2008) conducted a choice experiment to estimate the discount rate of respondents when faced with policy alternatives which would improve water quality. The time period of the experiment was only 6 years and they estimated the delay of the benefit rather than variation in timing of cost. The results suggest 12.7 percent for a 2 year delay, 8 percent for a 4 year delay and 7.9 percent for a 6 year delay. These studies provide a brief overview of the range of opinions regarding the estimation of the parameters influencing the magnitude of the social discount rate.

[5] Responses to these assumptions in the Stern Review are divided and concisely summarised by Baker *et al.* (2008).

[6] Pearce and Ulph (1999) estimate a range from 0.7 to 1.5 with 1.0 being defensible. Cowell and Gardiner (1999) estimate η as being just below or just above one.

4.0 Intergenerational equity and discounting

A common thread in the discounting literature is the intergenerational distributional impacts of discounting. The choice of discount rate influences consumption and investment decisions now and in the future. When future consumption is discounted it is the utility of future generations that is being impacted. Hence, concern for future generations is often expressed as an argument against the application of "market" discount rates. This is also reflected in the likely disparity between individual and social discount rates. As Schelling (1995) points out discounting one's own future well-being is different from discounting future people's well-being.

Pearce *et al*. (2006) suggest that discounting appears to be inconsistent with the rhetoric and spirit of sustainable development where the emphasis is on economic and social development paths that treat future generations with far greater sensitivity than has hitherto been the case. They suggest that the problem is that given discounting appears to have a very strong theoretical rationale, how can this be made consistent with the moral objections that arise when discounting is applied in practice? One response is that the rationality of discounting is morally superior to the objections about intergenerational fairness or equity. Alternatively some authors, such as Broome (2004), argue that if discounting is not consistent with moral concerns for future generations, the practice should not be adopted.

This paper argues that concerns regarding the well-being of future generations can be addressed through the application of intergenerational distributional weights rather than low social discount rates. As Portney and Weyant (1999, p.6) observe, many of those bothered by discounting the "distant future" appear to confuse economic efficiency with distributional equity. *"That is, they seem to forget that a policy action may be unattractive on distributional grounds even if it passes the efficiency test."*

In considering the utility of future generations, distributional equity can be incorporated in policy analysis through the application to benefits and costs across generations of intergenerational distributional weights. That is, in a social as opposed to an individual context, the intergenerational equity-adjusted present value of benefits and costs is the discounted future value multiplied by the distributional weight:

$$PV = \propto * \frac{1}{(1+r)^t} * FV \qquad [1]$$

where α is the distributional weight, r, the social discount rate, PV the equity-adjusted present value and FV the future value.

The equity adjustment is made through the application of distributional weights which reflect distributional preferences. The theory of the application of distributional weights in a Cost Benefit framework as a means of incorporating equity in the decision-making calculus is well established in the welfare economics literature. (See, for example, Maler 1985, Johansson 1993, and Pearce 2006) The distributional weights are dependent on two components; the change in social welfare if the utility of individuals increases marginally, that is how individuals "rank" in the social welfare function and the expected marginal utility of consumption of individuals. In practice, social justice preferences will most likely be in terms of groups within society who share common characteristics rather than individuals. Rawls (1971) suggests that public debate is frequently framed in terms of concentrating on groups rather than individuals. In this instance, the relevant groups are different generations.

There has been a reluctance to incorporate explicit distribution weights in Cost Benefit Analysis partly due to difficulties in both estimation and the decision regarding whose social justice preferences should be considered. In response to these challenges, Scarborough and Bennett (2008) illustrated that it is possible to elicit community distributional preferences using the stated preference method of choice modelling. In a choice experiment designed to estimate intergenerational distributional preferences, they found that, over two generations, the community has positive preferences toward future generations. The estimated distributional weights were approximately 1.6 over one generation and 2.2 over two generations. There was variance in the findings depending on the specification of the generations and the model used for estimation.

The application of these distributional weights would mean, for example, that a project with a current cost of $100 and a future benefit in 25 years time of $200, would not be feasible in net present value terms with a 5 percent discount rate. (NPV of benefit is $75.) However, with the application of a distributional weight of 1.6 the future benefit is $120 and the project becomes feasible.

Table 2 compares intergenerational equity-adjusted social discount rates derived from the application of intergenerational distributional weights with unadjusted social discount rates. The intergenerational equity-adjusted social discount rates have been derived by multiplying relevant

discount factors by intergenerational distributional weights. The adjusted discount factors have been reported in terms of the corresponding discount rate.

Table 2: Examples of equity-adjusted discount rates

Discount rate	Number of years	Distributional weight	Equity-adjusted discount rate
3%	25 years	1.6	1.1%
5 %	25 years	1.6	3.0%
7%	25 years	1.6	5.0%
3%	50 years	2.2	1.4%
5%	50 years	2.2	3.3%
7%	50 years	2.2	5.3%

This decomposition of social discount rates illustrates that, for example, the application of a 1.4 percent social discount rate in Garnaut (2008) could be interpreted as a 3 percent social discount rate with the application of a distributional weight of 2.2 positively favouring benefits occurring two generations or fifty years in the future. This explicit approach to incorporating intergenerational equity in policy analysis increases the transparency of policy analysis and decision-making. It enables the segmentation of the efficiency and equity criteria of decision-making. In Table 2 the approximate weights estimated in Scarborough and Bennett (2008) have been used as an example, however, this approach could also be used to explore the sensitivity of the social discount rate to assumptions with respect to the magnitude of the intergenerational distributional weights.

This segmentation of the efficiency and equity components of the social discount rate also raises a myriad of issues. If intergenerational equity-adjusted social discount rates were employed in policy analysis, this strengthens the argument for adopting the opportunity cost of capital approach to estimating the social discount rate (Randall 2006). An adjustment for intergenerational equity applied to a capital based social discount rate would circumvent possible "double counting" of time preferences and intertemporal marginal utilities associated with incorporating intergenerational equity adjustments to a consumption based social discount rate.

A further complication is the approach to uncertainty. As indicated earlier, Pannell and Schilizzi (2006) are correct in concluding that the resolution of issues concerning the social discount rate requires integration of efficiency, equity and uncertainty. There has been significant discussion in the literature regarding allowing for uncertainty in the estimate of the social discount rate. The approach adopted by Weitzman (2007) to account for uncertainty about future interest rates is to average the probabilistic discount factors. Weitzman shows that as the time periods extends towards infinity; the discount rate converges on the lowest possible discount rate. Similarly, Gollier (2002) recommends that as growth is uncertain over the long run, the discount rate should decline over the long run. While further research is required, it is possible that the extent of positive intergenerational equity preferences toward future generations may decline after two generations in line with the decrease in genetic footprint. Hence the role of uncertainty in the estimation of the social discount rate may increase over longer time horizons, while the adjustment for intergenerational equity may decline as the horizon extends.

Knetsch (2005) also raises the issue that people may appear to value and discount different actions, goods and wealth components differently. He concludes that while the evidence of some particular patterns of time preferences is a good deal weaker than others, it seems clear that people do not use a single rate to discount the value of all future outcomes. Further research is also needed to see whether these differences are also reflected in the distributional weights and how this interacts with the social discount rate. It is quite possible that the distributional weights are sensitive to the numéraire with, for example, marginal utility of consumption of environmental goods being different to marginal utility with respect to income.

6.0 Conclusion

This paper explores the integration of intergenerational equity preferences into the estimation of the social discount rate. It proposes that if our desire is to incorporate positive intergenerational

equity preferences towards future generations in social discount rates, then intergenerational equity-adjusted discount rates can be derived by incorporating a distributional weight in the calculation of net present values. This ensures that the intergenerational equity preferences are explicit in the policy analysis rather than being incorporated through implicit manipulation of the social discount rate. Furthermore, it averts the possibility that equity objectives and confounded with efficiency objectives.

Although there is a significant body of rigorous research and debate on the estimation of social discount rates, there is a need for further research on intergenerational equity preferences, particularly over longer time horizons, so that these preferences can be integrated into the understanding and application of social discount rates.

Further work is also needed on the divergence between the opportunity cost of capital and consumption welfare model approaches to estimating the social discount rate. If intergenerational preferences are to be incorporated in an equity-adjusted social discount rate it may be that the opportunity cost of capital is the more appropriate starting point for the social discount rate.

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