The Australian Journal of
Agricultural and Resource Economics

Journal of the Australian Agricultural and Resource Economics Society

The Australian Journal of Agricultural and Resource Economics, 55, pp. 145–158

Intergenerational equity and the social discount rate

Helen Scarborough[†]

Recent modelling of the costs and benefits of climate change has renewed debate regarding assumptions for the social discount rate in analysing the impacts of environmental change. Previous literature suggests two key factors influence estimates of the social discount rate: 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. This paper addresses the question of the relationship between intergenerational equity and the social discount rate and promotes the application of intergenerational distributional weights as a means of incorporating intergenerational equity preferences in policy analysis. Intergenerational equity-adjusted social discount rates are derived as a means of decomposing the intergenerational equity aspect of the social discount rate. The work has significant policy implications for projects with long time frames given the sensitivity of Cost Benefit Analysis outcomes to decisions regarding the social discount rate.

Key words: intergenerational equity, social discount rate.

1. Introduction

There is an extensive and complex body of literature analysing the social discount rate. Despite this, significant questions remain unresolved, and decision-makers are still faced with practical challenges when analysing the impact of policy alternatives that inherently involve the comparison of benefits and costs across time periods. Economic theory suggests that to incorporate these intertemporal changes into a decision-making framework, the future costs and benefits should be discounted and compared in 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 about the appropriate social discount rate is reflected in a divergence of approaches in practice. For example, the Australian government recommends a social discount rate of 7 per cent (with sensitivity analysis at 3 per cent and 11 per cent) for policy appraisal, while the Garnaut report applies social discount rates of 1.35 per cent and 2.65 per cent (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

[†] Helen Scarborough (e-mail: scars@deakin.edu.au) is a Senior Lecturer, Faculty of Business and Law, Deakin University, PO Box 423 Warrnambool, Victoria, Australia.

doi: 10.1111/j.1467-8489.2011.00532.x

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. The discussion is in terms of the real rather than nominal 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 on individual discount rate. (Empirical estimates of individual discount rates suggest these are higher than social rates, with Windle and Rolfe (2004), for example, estimating personal discount rates as high as 37 per cent.) Marglin (1963) argues that governments should not base their policy and project decisions on the 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 two provides a brief background of the theoretical components of social discount rate estimation using a consumption welfare model. Section three 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 four 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 five highlights the need for more research on intergenerational equity preferences and how they are incorporated in social discount rates and policy analysis.

2. The consumption welfare model

From the consumption side, there are two components that 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 that 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.

The social rate of time preference is compounded as it also influences the distribution of utility between generations, both future and contemporary, 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 elasticity of marginal 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 utility 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).

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 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). Layard (2005, p.139) 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.'

High values of η imply a preference for current consumption and a low value of η 'underweights the welfare of the current generation, at the expense of succeeding generations who will be much richer' (Quiggin 2008a).

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 per cent 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 per cent between 1950 and 1998. In Australia, Garnaut (2008) assumes a rate of growth in aggregate consumption of 1.3 per cent 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. 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 to estimate the social 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) If the opportunity cost of capital approach to estimating the social discount rate is adopted, important considerations include 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 (Quiggin 2008a).

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 (Dynamic Integrated model of Climate and the Economy) model, a time preference rate (δ) of 1.5 per cent per year and a marginal utility of consumption (η) of two 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. He makes the important

Table 1 Decomposition of selected social discount rate estimates

	Pure rate of time preference (δ) (per cent per annum)	Marginal elasticity of utility (η)	Rate of growth in per capita consumption (g) (per cent per annum)	Social discount rate (r) $r = \delta + \eta g$ (per cent 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

observation that the two parameters need to be viewed in tandem. In the DICE model, the same outcome is achieved with the assumption of a lower time preference of 0.1 per cent 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 per cent per year, consumption elasticity (η) of one and rate of growth in aggregate consumption (g) of 1.3 per cent per annum. These assumptions yield an estimated value for the social discount rate of 1.4 per cent per annum. Responses to these assumptions in the Stern Review are divided and concisely summarised by Baker *et al.* (2008). In Australia, the Garnaut Review judges that a near-zero pure rate of time preference is appropriate (0.05 per cent) and assumes two alternative values for the marginal elasticity of utility (one and two). With an average annual growth in Australian per capita income of 1.3 per cent, the two social discount rates applied by the review are 1.35 per cent and 2.65 per cent.

Arrow *et al.* (2004) also suggest low values of time preference (δ), in the range of 0–0.5 per cent 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 two–four. 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 per cent, they speculate that the social discount rate is between three and 6 per cent.

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 per cent. He emphasises that this rate can be the result of a number of parameter combinations.

The UK Treasury suggest a rate of 3.5 per cent (H.M. Treasury 2003). UK Treasury concludes that the evidence suggests that the elasticity of the marginal utility of consumption is around one (see Pearce and Ulph (1999) and Cowell and Gardiner (1999)). This implies that a marginal increment in consumption to a generation that has twice the consumption of the current generation will reduce the utility gain by half. Quiggin (2008a) also suggests that Treasury used the discount rate to adjust for risk, and although adjusting for risk in this way has long been recognised as inappropriate, it persists owing to its political convenience.

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 a discount rate of 12.7 per cent for a 2 year delay, eight per cent for a 4 year delay and 7.9 per cent 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. They reinforce the practical difficulties for policy-makers in determining a social discount rate and the need for further research in estimating the parameters of the social discount rate.

4. 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, and younger contemporary, 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 context, the intergenerational equity-adjusted present value of benefits and costs is the discounted future value multiplied by the intergenerational distributional weight:

$$PV = \alpha \times \frac{1}{(1+r)^t} \times FV \quad (1)$$

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

The equity adjustment is made through the application of intergenerational 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). There has been a reluctance to incorporate explicit distribution weights in Cost Benefit Analysis partly because of 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 the community sampled had positive preferences towards future generations, with a generation being defined as 25 years. Choices between the distribution associated with the status quo and changes in environmental policy resulting in distributional changes were presented to respondents. The attributes of the policy options that were varied were the levels of utility of members of three currently living generations. The measure of interest is the social marginal rate of substitution (SMRS) or the willingness of respondents to trade-off a change in the utility of one group for a change in the utility of another group.

The SMRS reflects distributional weights that 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.

The two components of the distributional weight highlight an important distinction between the application of distributional weights to incorporate intergenerational equity preferences in policy analysis and the use of the social discount rate for intergenerational equity considerations. Discussion on incorporating intergenerational equity considerations in the estimation of η focuses on discussion of the estimation of marginal utility in future years; however, this fails to incorporate the social justice component of intergenerational equity which is an integral aspect of the distributional weight.

Analysis of the distributional preferences of the community highlighted the application of two conflicting social welfare principles facing respondents in determining their distributional principles, a preference for equality as assumed in a classical utilitarian social welfare framework and a positive weighting towards the utility of future generations. Estimation of the curvature of the social welfare function in light of these conflicting decision strategies is summarised in Scarborough *et al*. (2009). These results suggest that the social welfare function reflecting intergenerational distributional preferences may be more complex than the classical utilitarian function which is often assumed (see, for example, Quiggin 2008b) and more in line with a social welfare function with an inequality parameter as discussed in Harrison (2010).

The distributional weights estimated by Scarborough and Bennett (2008) are summarised in Table 2.

The distributional weights were estimated using both multinomial logit and mixed logit models. Results of a Poe *et al*. (2005) test indicated that the differences between the welfare parameters derived from the multinomial and the mixed logit models are not statistically significant, and the multinomial results have been adopted here for further analysis.[1] The estimated intergenerational weights are 1.4 and 1.6 over one generation, depending on the ages of the generations and 2.2 over two generations. While these estimates cannot be considered definitive, they provide valuable insights into intergenerational distributional preferences.

For example, the application of these distributional weights would mean 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 per cent discount rate (NPV of benefit is \$75.). However, with the application of a distributional weight of 1.4 on the future benefits accruing to those in one future generation, the equity-adjusted net present value is \$105 (and with a distributional weight of 1.6 is \$120) and the project becomes feasible.

[1] The Poe *et al*. (2005) test results are published in Scarborough and Bennett (2008).

Table 2 Estimated intergenerational distributional weights reported in Scarborough and Bennett (2008)

	Aged 25/Aged 50 mean and 95% confidence interval*	Newborn/Aged 50 mean and 95% confidence interval*	Newborn/Aged 25 mean and 95% confidence interval*
Multinomial logit model	1.63 (0.94, 3.76)	2.23 (1.25, 5.26)	1.37 (0.89, 2.14)
Mixed logit model	1.75 (0.59, 4.71)	2.34 (1.00, 5.83)	1.36 (0.77, 2.67)

*The mean Social Marginal Rates of Substitution (SMRS) are calculated using the unconditional parameter estimates for the mixed logit model and; the Krinsky and Robb (1986) method for the multinomial logit model.

Table 3 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.

This decomposition of social discount rates illustrates that, for example, the application of a 1.4 per cent social discount rate in Garnaut (2008) could be interpreted as a 3 per cent 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. While in Table 3, the weights estimated in Scarborough and Bennett (2008) have been used as an example, this approach can also be used

Table 3 Examples of intergenerational equity-adjusted social discount rates

Discount rate (%)	Number of years	Discount factor (*df*)	Distribution weight (*DW*)	Adjusted discount factor (*Adf*)*	Equity-adjusted discount rate (%) (*Ar*)†
3	25	0.4776	1.4	0.6686	1.6
5	25	0.2953	1.4	0.4134	3.6
7	25	0.1843	1.4	0.2580	5.6
3	25	0.4776	1.6	0.7642	1.1
5	25	0.2953	1.6	0.4725	3.0
7	25	0.1843	1.6	0.2948	5.0
3	50	0.2281	2.2	0.5018	1.4
5	50	0.0872	2.2	0.1918	3.3
7	50	0.0339	2.2	0.0745	5.3

*$Adf = df^* DW$.

† $Ar = \frac{-\ln(df)}{t}$.

to explore the sensitivity of the social discount rate to assumptions with respect to the magnitude of the intergenerational distributional weights.

The 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. If this approach is adopted, the argument could be posed that the 7 per cent social discount rate recommended by the Department of Finance and Deregulation in Australia and based on a capital return approach, be weighted to incorporate intergenerational equity preferences. For benefits accruing to those one generation in the future if this weight was 1.6, the appropriate intergenerational equity-adjusted social discount rate would be 5 per cent.

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 extend 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 medium run (between 50 and 100 years) and decrease further over the very long run (over 200 years). While further research is required, it is possible that the extent of positive intergenerational equity preferences towards 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 intergenerational 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.

5. 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 are 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 estimating the social discount rate.

References

Arrow, K. and Kurz, M. (1970). *Public Investment, The Rate of Return, and Optimal Fiscal Policy*. Resources for the Future, Washington, DC.

Arrow, K., Dasgupta, P., Goulder, L., Daily, G., Ehrlich, P., Heal, G., Levin, S., Mäler, K.-G., Schneider, S., Starrett, D. and Walker, B. (2004). Are we consuming too much?, *Journal of Economic Perspectives*, 18(3), 147–172.

Baker, R., Barker, A., Johnston, A. and Kohlhaas, M. (2008). The Stern Review: an assessment of its methodology. Productivity Commission Staff Working Paper, Melbourne.

Bergson, A. (1938). A reformulation of certain aspects of welfare economics, *Quarterly Journal of Economics*, 52(2), 310–334.

Broome, J. (2004). *Weighing Lives*. Oxford University Press, Oxford.

Cowell, F. and Gardiner, K. (1999). *Welfare Weights*. Report to the UK Office of Fair Trading, UK.

Dasgupta, P. (2007). Commentary: the Stern Review's economics of climate change, *National Institute Economic Review* 199, 4–7.

Department of Finance and Deregulation. (2007). *Best Practice Regulation Handbook*. Commonwealth of Australia, Canberra.

Garnaut, R. (2008). *The Garnaut Climate Change Review*. Cambridge University Press, Cambridge.

Gollier, C. (2002). Discounting and Uncertain Future, *Journal of Public Economics* 85, 149–166.

Hall, R. (1988). Intertemporal substitution in consumption, *The Journal of Political Economy*, 96(2), 339–357.

Harrison, M. (2010). Valuing the future: the social discount rate in cost-benefit analysis. Australian Government Productivity Commission, Visiting Researcher Paper.

H.M. Treasury (2003). *The Green Book: Appraisal and Evaluation in Central Government*. London.

Johansson, P.-O. (1993). *Cost-Benefit Analysis of Environmental Change*. Cambridge University Press, Cambridge.

Knetsch, J.L. (2005). Gains, losses, and the US-EPA *economic analysis guidelines*: a hazardous product? *Environmental & Resource Economics* 32, 91–112.

Krinsky, I. and Robb, A. (1986). On approximating the statistical properties of elasticities, *The Review of Economics and Statistics*, 68(4), 715–719.

Layard, R. (2005). *Happiness: Lessons from a New Science*. Allen Lane, London.

Maddison, A. (2001). *The World Economy: A Millennial Perspective*. Paris, OECD.

Maler, K.-G. (1985). Welfare economics and the environment, in Kneese, A. and Sweeney, J. (eds), *Handbook of Natural Resource and Energy Economics Vol. 1*. Elsevier Science, Amsterdam, pp. 3–60.

Marglin, S. (1963). The social rate of discount and the optimal rate of investment, *Quarterly Journal of Economics*, 77(1), 95–111.

Ng, Y.-k. (2006). Public policy implications of behavioral economics and happiness studies, in Ng, Y.-K. and Lok Sang, H.o. (eds) *Happiness and Public Policy: Theory, Case Studies and Implications*, Basingstoke, Palgrave Macmillan, pp. 237–252.

Nordhaus, W.D. (2007). A review of the Stern Review on the economics of climate change, *Journal of Economic Literature*, XLV, 686–702.

Pannell, D.J. and Schilizzi, S.G.M. (2006). Time and discounting in economic decision making, in Pannell, D.J., Schilizzi, S.G.M. and Cheltenham, G.M. (eds) *Economics and the Future: Time and Discounting in Private and Public Decision Making*, Edward Elgar, Cheltenham, UK, pp. 1–11.

Pearce, D.W. (2006). Framework for assessing the distribution of environmental quality, in Serret, Y. and Johnstone, N. (eds), *The Distributional Effects of Environmental Policy*. Edward Elgar, Cheltenham, UK, pp. 23–78.

Pearce, D.W. and Ulph, D. (1999). A social discount rate for the United Kingdom, in Pearce, D.. (ed). *Economics and Environment: Essays on Ecological Economics and Sustainable Development*. Edward Elgar, Cheltenham, pp. 268–285.

Pearce, D.W., Atkinson, G. and Mourato, S. (2006). *Cost-Benefit Analysis and the Environment: Recent Developments*. OECD, Paris.

Poe, G., Giraud, K. and Loomis, J. (2005). Computational methods for measuring the difference of empirical distributions, *American Journal of Agricultural Economics*, 87(2), 353–365.

Portney, P.R. and Weyant, J.P., eds. (1999). *Discounting and Intergenerational Equity*. Resources for the Future, Washington, DC.

Quiggin, J. (2008a). Stern and his critics on discounting and climate change: an editorial essay, *Climatic Change*, 89, 195–205.

Quiggin, J. (2008b). Equity between overlapping generations, RSMG Working Paper, http://ideas.repec.org/p/rsm/climte/c08_1.html.

Ramsey, F. (1928). A mathematical theory of savings, *Economic Journal*, 38, 543–559.

Randall, A. (2006) Discounting future prospects, and the quest for sustainability, in Pannell, D.J. and Schilizzi, G.M. (eds) *Economics and the Future: Time and Discounting in Private and Public Decision Making*. Edward Elgar, Cheltenham, pp. 97–120.

Rawls, J. (1971). *A Theory of Justice*. Harvard University Press, Cambridge, MA.

Samuelson, P. (1947). *Foundations of Economic Analysis*. Harvard University Press, Cambridge.

Scarborough, H. and Bennett, J. (2008). Estimating intergenerational distribution preferences, *Ecological Economics*, 66, 575–583.

Scarborough, H., Burton, M. and Bennett, J. (2009). Decision-making in a social welfare context, School of Accounting, Economics and Finance Working Paper, Deakin University. http://www.deakin.edu.au/buslaw/aef/workingpapers/papers/2009_2.pdf.

Schelling, T.C. (1995). Intergenerational discounting, *Energy Policy* 23(4/5), 395–401.

Stern, N. (2007). *The Economics of Climate Change: the Stern Review*. Cambridge University Press, Cambridge.

Viscusi, W.K., Huber, J. and Bell, J. (2008). Estimating discount rates for environmental quality from utility-based choice experiments, *Journal of Risk and Uncertainty*, 37, 199–220.

Weitzman, M. (1998). Why the far-distant future should be discounted at its lowest possible rate, *Journal of Environmental Economics and Management*, 36, 201–208.

Weitzman, M. (2007). A review of the Stern review of the economics of climate change, *Journal of Economic Literature*, 45(3), 703–724.

Windle, J. and Rolfe, J. (2004). Assessing values for protection with choice modeling using different payment mechanisms, Paper presented at the AARES conference, Melbourne.