



Research article

Cost-benefit analysis in a climate of change: setting social discount rates in the case of Ireland

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Abstract: The global practice of Cost-Benefit Analysis (CBA), to analyse the welfare impacts of public investments, has undergone profound changes in recent years. The reforms in general practice have primarily been driven by the discussions of the implications of climate change and environmental degradation. Central to the discussion has been the social discount rate, used to value future costs and benefits in the present, and also the dual discount rates for “environmental goods”, as goods that are of no, or of risky substitution. Official rates, in many nations, are calculated using the “Ramsey” formula. The literature has explored the relevant factors in this formula, but with less attention paid to the selection of the rate of future growth in consumption, or to the setting of dual discount rates in national practice guidance. Through considering the case of Ireland, this study demonstrates that the selection of growth rates in consumption, in the context of future uncertainty, requires the use of plausible scenarios, rather than historical trends or forecasts. By employing economic scenarios, alongside established values for the other factors, the main discount rate for Ireland is calculated in a range of 1.7 to 2.8 per cent. Separately, a dual discount rate, for capital that cannot be replaced, is estimated at ≤ 1.3 per cent. The main discount rate is validated by comparison against discount rates found in the literature, applied in other comparable nations, and by the rate estimated from the real yield on government bonds. All four independent lines of evidence support the range estimated. This demonstrates that the Irish government’s estimated discount rate, of 4.0 per cent, is not credible, and needs reduction, alongside introduction of dual discounting.

Keywords: cost-benefit analysis; social discount rate; project evaluation; economic growth; sustainability; transition

JEL Codes: E01, E17, D61, D62, O22, O44, Q01, Q32, Q54

1. Introduction

The urgency and magnitude of the challenges of climate (IPCC, 2018) and ecological breakdown (IPBES, 2019), have profound implications for how we understand and analyse the world, how we conceive and develop policy and how we support policymaking in general. As a result, the practices in project evaluation internationally, have been evolving considerably, driven in large part by the economics of climate change, and the inclusion of the “environment” in economics (OECD, 2018). Major changes have been occurring in how Cost-Benefit Analysis (CBA) is considered by national governments, and the guidance they issue for implementation. The transition in how welfare is conceived and evaluated internationally offers a template for updating the practice of CBA. This “transition” encompasses the parallel technological, social and ecological transition, as described in the prominent Quinet review in France (Quinet, 2013).

A key topic in CBA is the social discount rate (SDR), used to value future costs and benefits in the present. In recent years, estimates of SDR have been considered for a variety of nations, and Choo and Chuang (2016) provided a review of approaches to for estimation. Empirical papers on setting an SDR include studies of Iran (Daneshmand et al., 2018), Russia (Kossova and Sheluntcova, 2016), the USA (Moore et al., 2013), Turkey (Halicioglu and Karatas, 2013), Germany (Schad and John, 2012), Italy (Percoco, 2008), Canada (Boardman et al., 2010), Latin American countries (Lopez, 2008) and India (Kula, 2004). Much of this literature seeks to refine estimations of the factors in the Ramsey model (Ramsey, 1928), and to use a variety of econometric methods to derive estimates for each. Some studies have also sought to provide different discount rates across economic sectors (Kossova and Sheluntcova, 2016), while Kyllonen and Basso (2017) discuss applying different rates to environmental resources, a priority issue in CBA according to the OECD (2018). Relatively little attention is given to the choice of the rates of per capita growth in consumption in the Ramsey equation. This study considers the case of Ireland, and the choice of rates for each of the factors in the standard Ramsey formula. It places particular attention on identifying an appropriate rate for growth in consumption per capita, and considers the implications of “dual discounting”, for priority sustainability issues.

In Ireland, CBA applies to all current and capital public expenditure above €20 million. The only exception permitted is where Cost-Effectiveness Analysis is used in its stead, a rare occurrence. Consequently, CBA has a crucial function in prioritising public investment in Ireland. The government’s Public Spending Code (PSC), which provides guidance on how CBA is to be implemented, has had the stated aim of being revised and updated regularly to “*remain in line with evolving best practice, both in Ireland and internationally*” (DPER, 2012). In keeping with this, Ireland’s key ministry, the Department of Public Expenditure and Reform (DPER), initiated a review in 2017. This review was published by the Irish Government Economic and Evaluation Service (IGEES, 2018), and led to changes in the spending code guidance of Ireland (DPER, 2019). Key changes included the social discount rate (SDR) and the shadow price of carbon emissions. The SDR was lowered from five per cent to four, and declining discount rates were also adopted.

At the same time, a comprehensive technical review of the practice of CBA in Ireland was completed (O’Mahony, 2018). This review recommended a parcel of related measures, termed a “*CBA sustainability package*”, that is required to update CBA in Ireland to approach best practices internationally. The review recommendations included: an extension to the time horizon, with application of techniques that improve the handling of uncertainty, see also O’Mahony (2021), and a lower discount rate, with application of the declining discounting and dual discounting methods. This

paper focusses specifically on the topic of the SDR, how it is estimated and implemented, and deriving rates for Ireland based on the standard Ramsey approach.

The SDR is a key factor in CBA, at higher rates, even very large long-term costs and benefits are “dramatically devalued” (CBO, 2009). Consequently, the discount rate has major implications for the outcomes of the analysis. The OECD state that contributions within the ambit of environmental CBA—particularly in climate economics—have broken new ground and helped shake the conceptual foundations of discounting in general. This is in part through novel technical insights, but also through renewed debates about ethical underpinnings (OECD, 2018). Hulme (2009) suggests that the social discount rate (SDR) is *the issue* when it comes to mitigation and climate change impacts.

The Asian Development Bank note that setting the SDR too high could preclude many socially desirable public projects from being undertaken (ADB, 2009). The corollary of this is that it could also facilitate undesirable projects to proceed. The SDR has major implications for “mitigation” projects to reduce emissions, and “adaptation” to the impacts of climate change. In both cases, up-front capital investment costs may be large, while the flows of costs and benefits stretch into the long, and very-long term. A CBA that applies either a short time horizon, or high discount rate, can skew the result away from projects that are beneficial for the public good, and towards those that are environmentally damaging and carbon intensive (O’Mahony, 2021).

The “Ramsey formula”, used by government analysts to set the social discount rate, involves analyst choices, to select appropriate values for each factor of three factors: time preference; elasticity of utility and expected growth in consumption. The first two factors combine empirical and ethical issues, the last factor, expected growth, is seen as empirical, and therefore less contentious. However, this paper demonstrates that the analyst’s choice of the expected growth rate, whether it is informed by historical trend, forecast or by plausible scenarios, is critical to the final result. This paper places increased attention on this sometimes ignored factor. The case of Ireland, as a nation that has moved in recent decades from a comparatively poorer, to a wealthy economy, is particularly pertinent to examine this factor.

After the introduction, the paper provides a review of the background to discounting in section 2, including approaches to estimation, the need for declining discounting as the term structure, and for dual discounting to account for different types of capital. This section is completed by reviewing the official rates currently applied in economically advanced nations. Section 3 discusses each of the components of the standard Ramsey “Social Rate of Time Preference”, and progresses to calculate and validate an appropriate rate for Ireland. This section also calculates a “dual discount” rate for application to “non-substitutable capital”, as a priority issue in CBA (OECD, 2018). Section 4 discusses findings and section 5 concludes.

2. Setting and implementing social discount rates

2.1. Background

Economists have employed several different approaches to setting the SDR, in the presence of real world market distortions, that mean the market interest rate is not appropriate (Beckerman and Hepburn, 2007), yet, there has been no consensus on which rate is the most suitable. Some of the differences reflect diverging views of how public investment affects consumption, private investment, and the cost of borrowing. However, for projects with very long-term impacts, that last for more than

one generation, or even centuries into the future—in the case climate change and biodiversity loss—many have argued that the choice of the SDR should not only consider *economic efficiency*, but also *intergenerational equity* (Stern, 2007). In the context of incorporating mitigation and climate change in economic analysis, this move away from just economic efficiency, to incorporate the long-term, and ethical concerns, has become a defining condition of analysis (Fleurbaey et al., 2014). Climate change economics has driven the re-consideration of the foundations of discounting and CBA, as welfare and ethical challenges (OECD, 2018). This development in the literature has also driven changes in the practice of CBA in project evaluation, due to the need to consider the value of mitigation and climate change impacts. This process of evolution, in the theory and practice of CBA, is illustrated by changes to CBA in France, to accommodate the “ecological transition” (Quinet, 2013), throughout the public system of evaluating investment.

The importance of social discount rate in CBA calculations cannot be overstated. As a multiplier of the flows of all costs and benefits, across the time horizon of the appraisal—and any residual value estimated at the terminus—it is crucial to the eventual results. The SDR must be appropriate to the economic circumstances of the country in question, but also to the type of cost or benefit impact. This is particularly pertinent for the impacts of economic activity, which have global and long-term implications. It includes GHG emissions, climate change, and loss of biodiversity, amongst core planetary boundaries identified by Steffen et al. (2015).

For social discount rates, three key issues could be highlighted: i) how the SDR is estimated; ii) how it is implemented in practice; and, iii) the type of capital to which it is applied. The *first* issue of estimation refers to the theoretical basis of discounting, and the choice of a technique used to set the rate in practice. The *second* issue refers to how the rate is applied. Different forms, whether exponential or declining (hyperbolic), also have significant implications for estimation of future costs and benefits, particularly in the long-term. While an exponential rate rapidly depletes future values, a declining rate softens how long-term future costs and benefits are discounted, placing a higher ethical value on the long-term welfare across generations. Long-term priorities that impact welfare include systemic issues such as greenhouse gas emissions, and related climate change, and impacts on ecosystems and biodiversity¹. O’Mahony (2021) discusses long-term issues including systemic and global impacts of climate change, and losses of natural resources and ecosystem services, but also project-specific long-term impacts, such as air and water emissions from landfill, and the public health impacts of transport air pollution. The *third* issue refers to the different types of capital the discount rate applies to in practice. This may include financial capital, physical capital, natural capital or social capital. Different types of capital may require consideration of different discount rates, to adequately reflect the role and value of each type of capital to welfare.

¹A growing body of influential research has identified nine processes or systems that regulate the stability and resilience of the Earth system upon which societies depend (Steffen et al., 2015). Two of the core boundaries, climate change and biosphere integrity (biodiversity loss and species extinction) have been transgressed. Of the other seven, biogeochemical flows and land-system change have transgressed planetary boundaries, ocean acidification is worsening, freshwater use is within boundary, and global-level boundaries for two processes cannot yet be quantified: aerosol loading and novel entities (such as organic pollutants and micro-plastics). Only one boundary shows evidence that it is safely within the boundary; stratospheric ozone depletion.

2.2. *The approaches to estimation*

There is widespread consensus that the social discount rate is usually lower than the private financial rates used by individual companies or households, as the latter are unable to diversify risk as effectively as society as a whole (European Commission, 2016). Employing the Social Opportunity of Capital (SOC) approach, tends to indicate towards high single digit rates, although these have tended to decline in recent decades (ADB, 2009). Kula (2008) documented how the UK was the first to set a discount rate in 1967 at 6%. This varied over the decades as economic conditions changed, until it settled at 3.5% in 2003, the rate currently applied.

Most European-wide institutions and some European countries apply the Social Rate of Time Preference (SRTP) rate, typically lower than the SOC, and in low single figures (Spackman, 2017). For regulatory appraisal, where the impact is on consumers rather than business investment, the US specifies a rate of 3%, based on the real rate of return on long-term government debt (Spackman, 2017), which is in effect similar, to an SRTP approach. The SOC approach, while empirically it is observational, has disadvantages in the context of a social rate. It may be biased towards a higher SDR as it does not reflect the cost of externalities, nor any risk premium, such as those reflecting the existential risks of climate change, and it can also be influenced by market volatility and asset bubbles (Sartori et al., 2014). Two further approaches include the weighted average of the SOC and SRTP, and the Shadow Price of Capital (SPC). In practice, neither of these approaches tends to be favoured. The weighted average ignores the possibility of reinvestment, and it is practically difficult to derive the weightings. The SPC while theoretically the most attractive, can be difficult in practical application (ADB, 2009).

2.3. *The social rate of time preference*

The Social Rate of Time Preference (SRTP) is the rate at which society is willing to postpone a unit of current consumption in exchange for more future consumption. Underpinning this approach is the theory that government should consider the welfare of both current and future generations, and derive an appropriate balance. The two common approaches to calculating the SRTP, are i) the return on holding low risk securities such as government bonds, an observational method, or ii) estimating the rate using the “*Ramsey growth model*”. This approach is prescriptive-normative as opposed to market observations, which are seen as empirical.

Estimating the SRTP by the Ramsey economic growth model (Ramsey, 1928) involves the following formula:

$$r = p + e * g \quad (1)$$

where (p) is the rate of “pure” time preference, often the most contentious component, this is the rate at which individuals discount the future, with impatience for consumption now, and therefore encompasses ethical issues in the value placed on current and future generations. The elasticity of the marginal utility of consumption (e), sometimes listed as μ , is the percentage change in individuals’ marginal utility in relation to each percentage change in consumption. It also encompasses ethical issues in the effect of inequality on utility. The last factor, (g), is the expected growth rate of per capita consumption into the future. Beckermann and Hepburn (2007) regard p and e as the two “ethical factors”, and g receives less attention in the literature, as it is perceived as empirically observed. However, as it is a multiplier in the

formula, growth in consumption is of major significance, and is the subject of comprehensive discussion in this paper. Extra attention is paid to the difference between using historical economic trends, short-term forecasts and long-term scenarios, with major implications for the choice of an appropriate rate for g . The theoretical, ethical and empirical basis, of each of p , e and g , are discussed further in sections 3.1, 3.2 and 3.3. These are related aspects, which provide the appropriate background for choosing rates, when analysts are estimating the discount rate by Ramsey's SRTP.

Later, Pearce and Ulph (1995) further decomposed p as:

$$r = (\delta - L) + e * g \quad (2)$$

In this approach δ is the "true" utility discount rate; and L is the rate of change in life chance. Decomposing p considers individuals utility preference, such as impatience or myopia, and the changing life chances of a population. As discussed in the review of Chua and Choong (2018), formula (2) is often favoured. However, as the objective of this study is to compare against the estimation of the Irish government (IGEES, 2018), similar Boardman et al. (2010) for Canada, the original Ramsey approach in formula (1) is applied in this study, allowing direct comparison.

2.4. Form of application, exponential or declining "hyperbolic"

Once an appropriate social discount rate has been estimated, it is also important how it is applied in practice, whether as a constant exponential rate or declining into the future. While CBA has roots in welfare economics, the outcome of discounting is morally unacceptable to some, because of how severely the SDR can discount future costs and benefits. It has led to the prominent ethical concerns in CBA literature about the "tyranny of discounting". Large costs and benefits accruing in the future can become insignificant in present value (PV), because the shadow price associated with them becomes vanishing small (OECD, 2018). To counter the effect of exponential discounting, declining, or "hyperbolic" discount rates are now frequently offered as a more acceptable approach.

The literature suggests consensus for using declining discount rates over time (IPCC, 2014), and Weitzman (2015) clarifies this further in that the declining discount rate (DDR) argument has become sufficiently mainstream that climate-change discounting is generally viewed as incomplete without it. The use of declining discount rates is now commonplace in many OECD countries: including the United Kingdom, France, Norway and Denmark, and it has strong theoretical and empirical support. How the declining rate is applied in practice is key. Declining discount rates (DDR) must be scheduled appropriately by its "term structure". In 2003, the Treasury Green Book recommended that a 3.5% declining rate should be used for projects with long term impacts, over thirty years. This rate falls to 3.0%, 2.5%, 2.0%, 1.5% and 1.0%, in years 31, 76, 126, 201 and 300 respectively. However, what is crucial is the rate of decline. Kula (2008) argued that this decline is insufficient to actually affect the results of appraisal to a notable degree -they do not decline rapidly enough.

The rationales for time-varying discount rates, range from those founded on economic theory, to others based on principles of intergenerational equity. It becomes abundantly clear from these strands of literature, that while economic efficiency remains important, the technical and ethical considerations of sustainability—long-term impacts and intergenerational equity—are now crucial to CBA and discounting. Martin Weitzman's work showed that where future discount rates are uncertain, then the expected net present value should be used, implying a decreasing term structure, with the discount rate approaching the smallest possible rate (Weitzman, 1998).

2.5. The need for dual discounting

2.5.1. Theoretical discussion and international practices

In recent years, the issue of dual discounting has resurfaced in CBA literature (OECD, 2018). Dual discounting is the practice of applying different discount rates to different classes of “commodities”, sometimes referred to as “goods” or “capital”. A clear analytical discussion of dual discounting is provided by Weikard and Zhu (2005), that considers two classes of goods: consumption goods and environmental goods. The Netherlands have devised a set of different discount rates for different goods including environmental goods. While the default rate is 3%, a higher rate is applied to public infrastructure of 4.5%. Different rates are applied to nature at 2% (the reduced effective rate), 3% for substitutable nature, and the same rate for carbon emissions and health. The latest UK Green Book iteration (Treasury, 2018) applies a lower discount rate to human health, at 1.5%. This illustrates that the willingness to implement dual discounting has grown in practice. Kula (1996) gave an earlier account of how dual discounting was being applied since the 1970’s in the UK. When the overall SDR in the UK was 5%, forestry was given a lower rate of 3%. The long-term environmental issue of the legacy of nuclear waste, where decommissioning could take 100 years, led to nuclear receiving a 2% rate. As this long-term issue motivated a lower rate, due to the consequences and risks for future generations, the externality of greenhouse gas emissions has parallels, to justify a different discount rate.

The OECD (2018) term assuming full substitutability of all forms of natural capital in CBA as “weak sustainability”. The “*Hartwick Rule*” (Hartwick, 1977) proposes that future consumption can be sustained, when exhaustible resources are extracted, if other investments offset the value of resource depletion. It is now accepted in sustainability science that there are very different types of natural capital, some of which cannot be replaced, or entail significant risks (European Environment Agency, 2015). Even if we take only a human-centred view on the value of the environment, any approach that applies an assumption of full substitutability of natural capital has become exceedingly problematic from a scientific perspective. A burgeoning literature places empirical evidence at odds with the theoretical assumption of “perfectly substitutable capital”—that if natural capital declines, it can be replaced with financial or physical capital. The UNDP-UNEP Millennium Ecosystem Assessment identified 15 of 24 ecosystem services that function as humanity’s life-support system that are now in serious decline (MEA, 2005). Steffen et al. (2015) identified nine “planetary boundaries”, four of which have crossed the boundary of the “safe operating space” that is characteristic of the epoch in which human civilisation has emerged. In the face of the advances in sustainability science, conceiving the “economy” as separate from the environment, is becoming increasingly problematic. Consequently, where environmental goods are relatively scarce compared with other consumption goods, and, more importantly, if environmental goods have limited substitutability, they should command a lower discount rate.

Within this debate, rather than assume that capital is substitutable, Herman Daly proposed that capital is complementary, therefore the utility of one form of capital, will be in large part, determined by the availability of other forms, since each form is dependent on the other (Daly, 1995). Kyllonen and Basso (2017) suggest that there is a much greater willingness among economists to use resource-specific discount rates. Baumgartner et al. (2015) emphasise that most ecosystem services are in decline globally, and yet are essential for human wellbeing. At the same time, the production of market goods and services, measured by GDP, continues to increase. In an extension of the classical *Ramsey* model, they suggest the need for application of good-specific discount rates for market consumption goods, and for ecosystem

services. Baumgartner et al. (2015) use empirical data for ten ecosystem services, and five countries, as well as the world at large, to produce conservative estimates. These highlighted that ecosystem services, in all countries, should be discounted at rates that are significantly lower than those for market consumption goods.

The economics of climate change has been central to re-igniting such considerations in the field of economic analysis. The *Stern Review on the Economics of Climate Change* (Stern, 2007) spawned important debates in economics in general. The debates centred on the social discount rate that should be applied to evaluation of climate change impacts and mitigation costs. Stern did not use a single discount rate but applied a stochastic approach. Within this, the discount rate varied with the expected outcomes, reflecting the interaction between growth and the elasticity of marginal utility—in line with *Ramsey's growth model*. The average discount rate for climate change damages is approximately 1.4% in the Stern Review. The Review was supported by a variety of leading economists such as Solow, Mirrlees, Sen, Stiglitz, Sachs, Arrow, DeLong and Deaton. It was criticised by a minority of others, such as Tol, Weitzman and Nordhaus, where most of the criticism referred to a perceived low discount rate (OECD, 2018).

Terry Barker (Barker, 2008) provides a useful summation in the wider context of applying CBA to questions related to climate change “...the Stern Review considers cost-benefit analysis as a marginal analysis inappropriately applied to a non-marginal multi-disciplinary systemic problem (p. 50). Both Stern (p. 163) and the IPCC Reports after 1995 take a multi-criteria approach rather than a narrowly monetary one and question cost-benefit analysis”. Stern argued that on the basis of the Ramsey formula the social discount rate by SRTP would be calculated by combining a long-term per capita growth rate (g), of 1.3% with a marginal elasticity of utility (e) of 1, and a social time preference (p) of 0.1, generating the SRTP discount rate of 1.4. It is in the value for p , the time preference, that debate has centred. Proponents of the alternative view argued that the higher returns from financial markets are the basis for applying a higher time preference (p) value. Kyllonen and Basso (2017), discuss the rates of return from financial markets are not appropriate. The choice of the discount rate is an ethical one, and not simply one of *efficiency*, as determined by investment returns. Within Ramsey then, p would not simply be *impatience for consumption*, but *concern for future welfare*, e would not only be the *relative effect of a change in consumption on welfare*, but also *aversion to intertemporal inequality*. Stern draws on a long heritage of prominent economists that support zero, or near zero, as the appropriate time preference p value.

Adopting market rates is also at odds with the conclusions from sustainability science, in the context of substitutability, as previously discussed. In the *Fifth Assessment Report*, the IPCC conclude that in the context of climate change, “a broad consensus is for a zero or near-zero pure rate of time preference for the present” (Kolstad et al., 2014)². Establishing the time preference (p) is essentially an ethical question informed by analysis, as it implicitly determines the value of future generations, and indeed of the environment, in the context of climate change damages. However, as IPCC reports are reviewed and accepted by the world's governments, in addition to global experts, this shows a strong support for establishing a time preference (p) at 0.1—specifically in the case of non-substitutable capital.

²Kolstad et al. (2014) cite a long heritage of thinkers that argue in support of a rate for p of zero, or near-zero (Ramsey, 1928; Pigou, 1932; Harrod, 1949; Parfit, 1986; Cowen, 1992; Schelling, 1995; Broome, 2004; Stern, 2008).

2.5.2. The implications of dual discounting

The effect of changing the discount rate in this manner would coincide with policy priorities that integrate sustainability into development, and would favour the low-carbon transition rather than status quo. Kula and Evans (2011) tested two variant analyses to value avoided carbon emissions (specifically CO₂ absorbed or “sequestered” by tree growth) in a forestry project in Northern Ireland. The standard Green Book rate of 3.5% was applied to all costs and benefits in the first example. In the analysis with dual discounting, a 1.5% discount rate was applied to the CO₂ benefits, the value of the carbon emissions sequestered by tree growth, and 3.5% to all other costs and benefits. The results showed that dual discounting of projects, which yield environmental benefits, would enhance the economic viability of investment. In the single discount approach, over thirty years, the project yields a net cost of –£27,323. In the case where dual discounting is applied, to improve the valuation of the benefits CO₂ absorbed out of the atmosphere, the project yields a net benefit of +£7,141, turning the project from a net negative investment into a net positive one.

Maddison and Day (2015) propose an alternative approach, to use an *ecological discount rate*, as opposed to a consumption-based discount rate detailed above. Maddison and Day note that as incomes increase, environmental goods and services are increasingly depleted and damaged by this growth. The ecological discount rate can be calculated by a variation on the Ramsey type formula. This would specifically include the change in the quantity of the specific environmental good, and in its own elasticity of marginal utility. An important dimension of this approach is to recognise that not only is there a special discount rate for discounting environmental impacts, there is also a special discount rate for discounting consumption. The discount rate for consumption is affected by, amongst other things, the change in the quantity of environmental goods, and consequently this would have implications for the appraisal of all projects in general, not just projects tagged as “environmental”.

Dual discounting could be described as a best practice process, that seeks to represent non-substitutable capital, and the inescapable ethical dimensions, in related decision-making. This is preferable to obscuring them in the analysis, under financial market observations, that often do not reflect the welfare costs of externalities. As the OECD review notes “*While the theory is not new, the applications are becoming more frequent*” (OECD, 2018), with specific reference to guidance in France and the Netherlands on discounting environmental quality changes. It is important to recognise, that the specifics of each environmental resource have empiric and ethical implications for discounting.

2.6. Social discount rates in international comparison

There is no agreement in the literature on what the level of the SDR should be. This is due to different methodological approaches, and varying national economic and political contexts. The differences reflect both varying quantitative inputs, but also different implicit value systems in the choice of the variables. Techniques for calculation of the SDR such as SOC, SRTP and government borrowing costs, guide different countries to specific, nationally-defined rates. However, the rates in the industrialised countries have been converging to lower levels for decades. The following Table 1, presents the official national rates among several advanced economies, adapted from OECD (2018) and O’Mahony (2021). It also includes European Commission guidance for higher income Member States (Sartori et al., 2014), official guidance from Ireland (IGEES, 2018), the mean rate from a survey of 200 experts internationally (Drupp et al., 2018), and also the new results estimated in this study.

This literature clearly demonstrates, that rates have converged at low single digits in economically advanced economies, outside of the rate officially mandated in Ireland at 4 per cent.

Table 1 also notes the issue of risk. Risk is ever-present in CBA, and in Ramsey factors, as risk and uncertainty are intrinsic to the future. For time preference (p), there is risk of death and catastrophe, which suggests favouring consumption in the present, in a higher p value. However, there is also the risk that current consumption, of non-substitutable capital—such as a stable climate and the services provided for by ecosystems—leads to permanent damage, requiring prudence and a lower p value. For growth in consumption (g), the continued growth rates of wealthier economies are more uncertain, and require a focus on low growth scenarios as values for g (OECD, 2018).

“Project risk” involves the over, or, underestimation of costs and benefits in CBA. Some nations such as the Netherlands adopt a risk premium to manage “risky projects”, while others such as the UK consider project risk insignificant, as it is theoretically managed across the portfolio of public projects. The US approach based on government bonds, is different from the SOC observational approach of private returns, which are subject to more risk, and tend to be higher.

A “risk-free” discount rate assumes that interest rates, growth in consumption and project benefits and costs are certain -essentially a risk-free world. This allows extensions to deal with risk afterwards, including applying risk premia to projects, and using declining discounting, as per section 2.4. Within the Ramsey formula, to estimate the discount rate, approaches to risk include: that of Pearce and Ulph (1995) in section 2.3, which includes life expectancy by splitting p , and the use of low economic growth scenarios for g . The necessity to address economic uncertainty, in the estimates of growth in consumption, receives comprehensive treatment in section 3.3.

Table 1. Discounting rate guidance adapted from OECD (2018), including this study.

Nation/Region	Short to medium-term	Long-term
United Kingdom	3.5% all projects and regulatory analysis	Declines to 1% after 300 years
United States	3–7% CBA project and regulatory analysis, depending on source of funding	-Lower rate for intergenerational projects recommended by US Office of Management and Budget -2.5% recommended by USEPA
United States	2% for Cost Effectiveness Analysis	No guidance on long-term
France	2.5% for risky projects	Risk-free rate declines to 1.5% for 75 year horizon
Norway	3% for risky projects and regulatory analysis	Risk-free rate declines to 1% after 100 years
Netherlands	3% for all projects and regulatory analysis	Apply declining discount rates, considering type of capital and risk
European Commission	3% for higher income States	No guidance on long-term
Global	2.27% mean rate	Expert survey of Drupp et al. (2018) notes declining discounting
Ireland (<i>official</i>)	4% all projects and all goods	Declining discounting
Ireland (<i>this study</i>)	1.7 to 2.8% for substitutable goods ≤1.3% for non-substitutable goods	Declining discounting through years 100+, see O’Mahony (2021)

3. Establishing a social discount rate for Ireland using the Ramsey formula

There is debate on establishing appropriate estimates for “pure” time preference p , and the elasticity of marginal utility e . There is also a need for plausible estimates for the growth in consumption g . In order to come to credible conclusions, the following discussion explores appropriate values for each component, with particular emphasis on growth in per capita consumption g .

3.1. Estimating the Ramsey “pure” time preference (p)

The social time preference p is the rate at which society values the present over the future. Most of the literature and empirical studies apply the social time preference, as opposed to an individual time preference. Social discount rates place a higher relative importance on income earned by future generations, and this is the rate that the government would choose in allocating resources across generations. Market discount rates are typically higher than social discount rates, as individuals and enterprises tend to demand a quicker return from their ownership of an asset. A catastrophic risk rate may also be employed. This would reflect low probability catastrophic events that permanently reduce wealth (Gollier, 2011). The HM Treasury Green Book (2003) separated the catastrophic risk rate in addition to a pure time preference rate to derive the discount rate.

It must be noted that there are inescapable ethical issues, particular in the context of the risks of climate change for global welfare. The economic empirical literature generally estimates a value for p of between 1 and 3 per cent (Sartori et al., 2014). However, the Stern Review set a 0.1 per cent rate, due to the assumption about a nil impatience or myopia component. This is in line with Ramsey’s argument, and supported by many other luminaries in economics. It states that from a social perspective, it is ethically indefensible to set this term different from zero (Ramsey, 1928). Spackman (2015), suggests a value of 2% per annum may be too high, while a value of 1% may be widely accepted. The survey of experts in Drupp et al. (2018) found a median value of 0.5, and a mean of 1.1, suggesting merit in analysing p within this lower range. In Drupp et al. (2018) it was also noted that the most frequent response was zero. The IPCC Fifth Assessment Report (Kolstad et al., 2014) offer a long history of literature, since Ramsey (1928), that recommend that pure *time preference* should be zero or near zero. The argument for this is one that emphasises the ethical difficulties in penalising future generations because they are born later. If *the pure time preference* is not set at zero, this would suggest that separate discount rates are therefore necessary for non-substitutable capital, as discussed in section 2.5.

Sartori et al. (2008) propose a pure rate of time preference, for “non-Cohesion Fund”, countries such as Ireland, of between 0.9 and 1. In its recent recalculation of the Irish government rate, the Irish Government Economic & Evaluation Service adopted values of p —between 0 and 2, with focus on values around 1 (IGEES, 2018). The Irish Department of Finance adopted a value of 1.5 for p in its 2007 review, following in the footsteps of The UK Treasury Green Book. However, given the results of Drupp et al. (2018) and Spackman (2015), it is reasonable to assume that 1.0 should be an upper ceiling for p , with ≤ 0.5 as the lower bound. This is dependent on which type of capital it is applied to. In practice, values of 1.0 or lower may be required in keeping with Spackman (2015) and Drupp et al. (2018). This focus towards ≤ 1.0 , for *the pure rate of time preference*, is particularly relevant if a single SDR is employed to all forms capital, noting the long heritage of recommending a rate of zero or close to zero. As noted above, an alternative to this is to differentiate between different forms of capital or “goods”, such as financial and natural capital, through applying the “dual discounting” approach discussed in section 2.5.

3.2. Estimating the Ramsey elasticity of marginal utility (e)

The elasticity of the marginal utility of consumption (e), how much utility changes in response to changes in consumption, is derived from microeconomic theory, and is calculated through a high degree of mathematical abstraction. The issue of equality is prevalent here, because the level of welfare gained or lost from a change in consumption varies across individuals, with those in poverty likely to gain more substantially from a given increase. In this case, aggregating across all individuals then becomes an ethical issue. Drupp et al. (2018) surveyed results for intergenerational discounting and derived a mean value of 1.35%. Spackman (2015) discussed a relative consensus in US literature, for a value of 1.5, to which the UK literature has also converged. In contrast, the HM Treasury Green book (2003) adopted a value of 1. Evans and Sezer (2004) differentiate values as 1.3 for France, 1.4 for Germany, Japan and the USA, 1.5 for the UK and 1.7 for Australia. The European Commission estimated values of between 1.2 and 1.79 for the non-cohesion fund countries (Regio, 2008). Evans (2005) estimated a range for Ireland of 1% to 1.47%. The Irish Department of Finance 2007 review selected 1, in line with the Treasury Green Book, and the most review of IGEES (2018) adopted values of between 1 and 1.5. This range of literature suggests that values of 1.0 to 1.5 should bound the range for e .

3.3. Estimating the ramsey growth in consumption (g)

3.3.1. From short-term forecasts to long-term scenarios

Because of the magnitude of Irish growth in recent decades, “ g ” is the most important factor in estimating the national SDR, if historic rates are used. Three key considerations can be emphasised in determination of a value for g in the Ramsey formula for Ireland. These are: the indicator that is used (a welfare correlated indicator); the timeframe of the estimation (which may skew the rate); and, the approach that is used to set the rate (based on historical observations, future forecasts or scenarios).

Estimating g involves considering a welfare correlated indicator as a proxy for consumption growth, such as real per capita GDP growth, consumption growth or personal income growth. From the perspective of inter-generational equity, it implies that where future generations are expected to be wealthier than today, and consumption rises through time, this would result in an increase in the discount rate to shift priority to the poorer current generation (Sartori et al., 2014). On the other hand, uncertainty in future growth prompts the prudent social planner to place greater emphasis on future generations (Lebegue, 2005), leading to application of declining discount rates.

While previous estimates for Ireland appear to have been based on historical observations, Sartori et al. (2014) offer that empirical estimates of the Ramsey g are usually based on growth models, taking into account both the past long-term development path and expected future growth. The extended time period, and the use of an annual average, is used to smoothen out volatility across time periods from recessions and recoveries. As noted in the literature on CBA, this long-term period may be one hundred years or more for long-term impacts on welfare, and even multi-century in the case of the impacts of climate change, or the lifetime of nuclear waste (O’Mahony, 2021; OECD, 2018; Quinet et al., 2013; Boardman et al., 2010; WHO, 2006). Very long-run growth rates of real per capita consumption have been used to estimate future growth, in order to smooth out possible short-term distortions. The alternative is the rate of growth per capita based on scenarios and forecasts from growth models, fundamentally different to applying the historic rate. Long-term economic scenarios clearly demonstrate

that the future will not be a repeat of past patterns for wealthy economies (Dellink et al., 2017). Climate and ecological breakdown, and related the need for sustainability transition, are defining challenges for 21st century economies, that mean past performance is not a good guide for the future.

The time frame that is chosen to estimate growth into the future is important. If a short timeframe is used for Ireland, rates will be skewed upwards by recent decades of high historic growth, or by recessionary recovery in future growth. Bergin et al. (2016) forecasts average wage growth declining to 2.3% by 2025, and assumes a longer term convergence towards the inflation rate of 1.5 (Bergin et al., 2016)³. A longer-term economic projection for Ireland is available from the European Commission, estimating the potential growth rate in GDP per capita (GDPPC) at 1.6 per cent per annum from 2016 to 2070 (DGECFIN, 2017). This offers a longer term perspective than Bergin et al. (2016), but crucially also coincides with their conclusion that growth in the long-term will converge towards the inflation rate.

The most comprehensive and robust explorations of plausible future growth in GDP per capita globally are widely acknowledged as the Shared Socio-economic Pathways (SSP's) (Leimbach et al., 2017). For the high income countries, across the five scenarios from SSP1 to SSP5, these frame plausible average annual growth of GDPPC from 2010 to 2100, in a range of 0.6 to 1.6 per cent. The scenarios database housed by the *International Institute for Applied Systems Analysis* (IIASA)⁴ details the finer national detail from the OECD scenarios (Dellink et al., 2017). For Ireland, the OECD scenarios of average annual growth in GDPPC are: 0.8, 1.1, 1.2, 1.25 and 1.6 per cent for each of the five scenarios from 2010 to 2100.

3.3.2. Selecting plausible long-term rates for growth in consumption

When considering historic growth, it is important to consider if the recent pattern of the economy is stable in the long-term. This may occur in mature low-growth advanced economies, or in high-growth less developed economies. Ireland does not fit neatly into either category, for the purposes of considering historical growth rates it is on the cusp of the two. It evolved from a high-growth economy to a mature economy over the recent historical period. The historical growth from 1970 to 2016, as selected by IGEES (2018), included an anomalously high growth rate of 2.3%. This occurred as the nation accelerated along the growth curve, in development catch-up to its neighbours. Another acceleration occurred during the years post-financial crisis, in economic recovery. Consequently, the recent historic growth path is not a plausible course for the long-term future.

Defining an appropriate value for growth in consumption should therefore be found, not by applying the historical trend, but by using scenarios of plausible rates from growth models, as per Sartori et al. (2014). Figure 1 details the five scenarios of growth in Ireland's GDPPC, from the economic scenarios of the OECD (Dellink et al., 2017), and from IIASA (Cuaresma, 2017). Illustrated on a common 2020 baseline, the scenarios of each study are grouped by similar colours, to highlight the different overall interpretations. Figure 2 superimposes the chosen rate of the government, at 2.3

³In suggesting the projected growth in average wages, Bergin et al. (2016) clarify that while growth may be higher in the period up to 2025, in the longer term, it will converge towards the projected inflation level of 1.5. "*The inflation rate which is expected to remain relatively low over the period at around 1.5 per cent per annum. The growth in average wages will tend to converge towards the inflation level, but will remain higher for most of the period [up to 2025]*" (Bergin et al., 2016).

⁴ The IIASA public database including GDPPC data by scenario and study is available at: <<https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=welcome>>.

per cent, with their sensitivity tests of 1.6, 2.6 and 3.0 per cent (IGEES, 2018). Figure 2 clearly demonstrates that the governments rates are implausible, and skewed significantly upwards. The lowest rate considered by the IGEES, the sensitivity test at 1.6 taken from DGECFIN (2017), is the only rate which falls within the plausible range. After 2025 the chosen rate of 2.3 per cent has exceeded the forecasts of Bergin et al. (2016) and DGECFIN (2017). By 2030 it has exceeded all of the OECD scenarios, and all but the highest single scenario from IIASA. The chosen rate continues to become more implausible as the period stretches further beyond the next ten years, accelerating away from the plausible range in the decades that follow. The excessively high range of values chosen by IGEES (2018)—essentially formed from assumptions about future growth based on historic patterns—demonstrates an extreme of the optimistic growth bias now widely acknowledged in economic forecast literature (Windsor, 2021; Morikawaa, 2020; Frankel, 2011).

To determine a single plausible rate, the “middle of the road” scenario “SSP2” from the OECD (Dellink et al., 2017) is suitable for this purpose. At 1.2 per cent average annual growth, it is similar to Cuaresma (2017), which averaged at 1.165 per cent from 2020 to 2100. It is important to note, that while this rate is estimated to 2100, selecting a shorter period does not markedly affect the rate of growth in GDPPC. On shorter timescales, this scenario has an average annual growth rate of 1.26 to 2030, and 1.17 to 2050. For sensitivity testing, the long-term potential growth of DG ECFIN (2017), at 1.6 per cent, similar to the highest SSP5 scenario of Dellink et al. (2017), is the plausible upper bound. The plausible lower bound from Dellink et al. (2017) is 0.8 in SSP3.

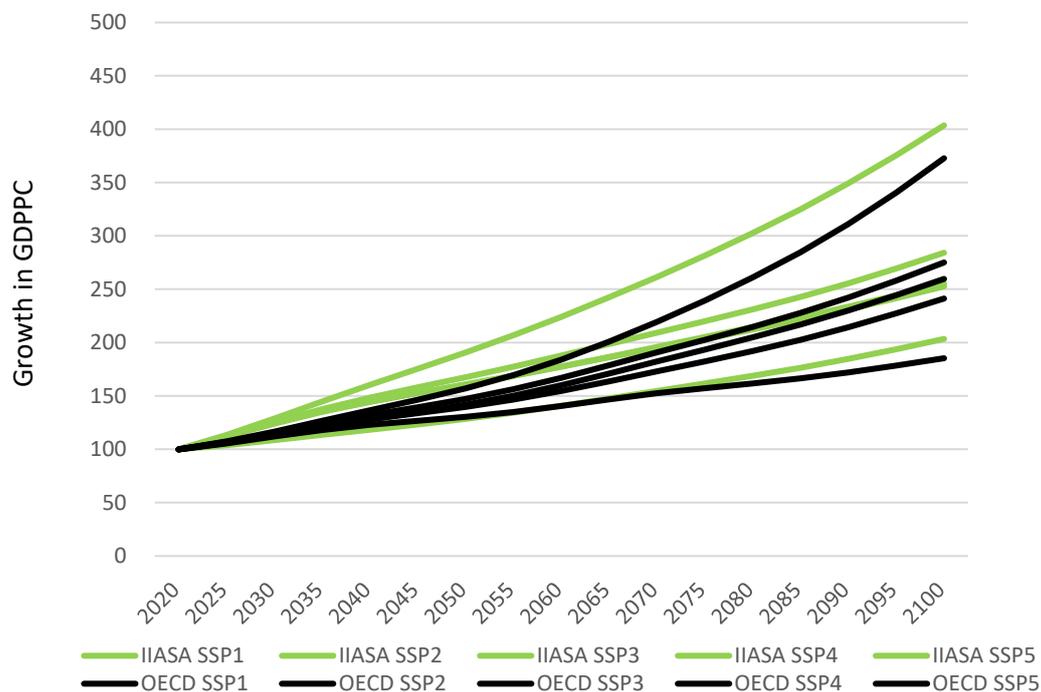


Figure 1. Scenarios of growth in GDPPC for Ireland from 2020 to 2100 from the OECD (Dellink et al., 2017) and IIASA (Cuaresma, 2017).

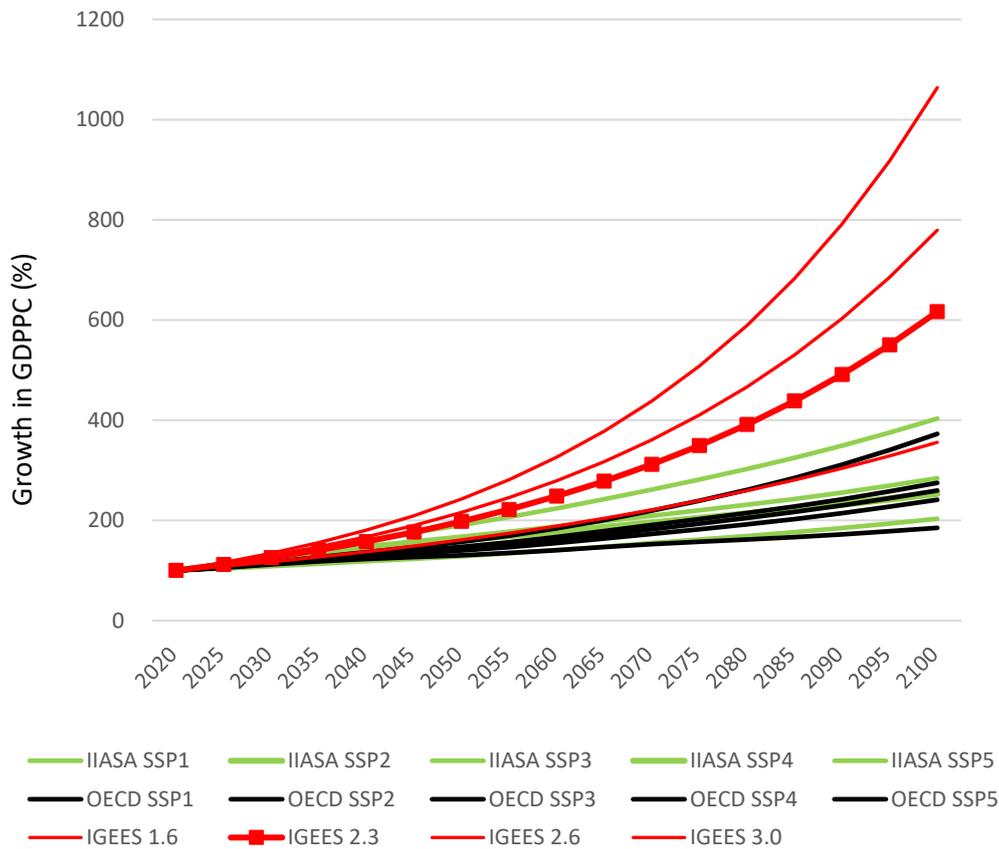


Figure 2. Scenarios of growth in GDPPC from the OECD and IIASA with Irish government rates (IGEES, 2018) super-imposed.

3.4. Calculating and validating a ramsey-based social discount rate for Ireland

The following details the same approach as Boardman et al. (2010), to apply a lower, middle and higher calculation to the Ramsey calculation, as presented in Table 2. It is completed according to the appropriate values for p (time preference), and e (elasticity of marginal utility) described above, with p as 0.5 to 1.0, and e as 1.0 to 1.5. For (g) long-term multi-decadal growth (g), is valued as discussed above, at 1.2, with sensitivity tests at 1.6 and 0.8. Based on these values, the recommended range of a plausible middle SDR for Ireland, is shown to be 1.7 to 2.8. In using the estimation of the SRTP by the Ramsey formula, it is worth noting that this approach involves judgements for parameterisation of factors, and is consequently regarded as arbitrary by some practitioner's (OECD, 2018). Deciding on the rate to be applied can be informed by such analysis, but it is a value-laden task under conditions of risk and uncertainty.

Table 2. Sensitivity test of Ramsey-based social discount rates for Ireland.

<i>Parameters</i>	<i>Consumption growth (g)</i>	<i>Elasticity of Marginal Utility (e)</i>	<i>Pure Time Preference (p)</i>	<i>SDR = r</i>
Lower	0.8	0.5	1	1.3
	0.8	1	1	1.8
	0.8	0.5	1.5	1.7
	0.8	1	1.5	2.2
Middle	1.2	0.5	1	1.7
	1.2	1	1	2.2
	1.2	0.5	1.5	2.3
	1.2	1	1.5	2.8
Higher	1.6	0.5	1	2.1
	1.6	1	1	2.6
	1.6	0.5	1.5	2.9
	1.6	1	1.5	3.4

In this paper, the alternative method to calculate an SRTP, by observable values, is achieved by beginning with the nominal yield on 10-year Irish government bonds, similar to the approach of the US (Council of Economic Advisers, 2017). This is then adjusted for inflation and after-tax return to give the real yield.

Using Central Statistics Office monthly data on bond yields for Ireland, with 320 data points from June 1993 to January 2020 (CSO, 2020), and averaging to smoothen year-to-year fluctuations, the mean of the nominal yield is 4.49 per cent. The real yield is obtained, net of inflation, by adjusting for with long-run national Consumer Price Index data (World Bank, 2021), and net of Irish Capital Gains Tax, varying from 20–33 per cent over this period. This leads to a real yield of 1.99 per cent, as a mean over 27 years of bond data. This rate is at the lower end of the Ramsey-based social discount rate previously calculated, between 1.7 to 2.8, as further evidence that a low rate is necessary.

The survey of Drupp et al. (2018) described a mean SDR from the Ramsey SRTP of 2.27%, with a standard deviation of 1.62 and mode of 2%. In addition, the European Commission have applied a 3% SDR to Ireland as a non-cohesion fund country (Sartori et al., 2014). The historical rates for the SDR used by government institutions in Ireland have varied from 1984 to 2007 at 5 per cent (SOC approach), from 2007 to 2015 at 4 per cent (SRTP approach)⁵, from 2015 to 2018 at 5 (SRTP approach) and currently at 4 per cent from 2019 onwards (SRTP approach). Both of the estimations for Ireland above are clear that 4 per cent is an excessively high rate, as is also borne out by comparison with international literature and practices. Following the triangulation of evidence, it is clear that the SDR for Ireland needs reduction. A higher rate of 4 per cent would require a heroic assumption, in an anomalously high rate of growth in per capita GDP, outside the plausible range. Where dual discounting is not employed, as is currently the case in Ireland, this effectively aggregates all forms of capital into a single discount rate. Consequently, there is an additional argument to support using an SDR from the lower end of the range, at 1.7, until dual discounting is introduced.

⁵The 2007 Department of Finance Review estimated an SRTP of 3.7%, which was rounded up to 4%. This rate adopted 1.5% for the pure rate of time preference (p), 1 for the marginal elasticity of productivity (e), and a per capita consumption growth (g) of 2.2%. This g was based on considering historical growth rates and ESRI forecasts.



Figure 3. 10-year Irish government bond yields, with mean of Real and Nominal yield.

3.5. Calculating a dual-discount rate for non-substitutable capital

In Kolstad et al. (2014), it was described how a long heritage of literature, over almost seventy years, has shown that non-reproducible goods like environmental assets will become relatively more scarce in the future, thereby implying an increasing social value. Ecosystem services and biodiversity are prominent examples of natural capital with limited, or risky substitutability. Drupp (2016) provides a useful discussion on “Limits to substitution between ecosystem services and manufactured goods and implications for social discounting”, and it would be desirable to extend this calculation to other forms of non-substitutable capital. An Irish-specific dual discount rate, for non-substitutable capital, can be estimated according to this rationale. Following the more plausible long-term value for growth in per capita consumption (g) at 1.2 per cent for Ireland (Dellink et al., 2017), with the desired values of time preference (ρ) at 0.1 (Kolstad et al., 2014) and the preferred value of elasticity of marginal utility (ϵ) at 1 (DoF, 2007; Treasury, 2003; Stern, 2007), the dual-discount rate for non-substitutable capital is estimated at ≤ 1.3 . Further research is needed to disaggregate to specific environmental resources. As per Maddison and Day (2015), each environmental good should have its own special ecological discount rate.

4. Discussion

The issue of discounting is a defining one within CBA. Discount rates affect the calculation of all costs and benefits, and consequently the rate, and how it is applied, are key considerations. The issues involved are not only empiric, but value-laden and controversial. A range of arguments and sources of evidence have a long heritage that supports decision-making in this area. In the case of the rate itself, the Social Rate of Time Preference (SRTP) method from the *Ramsey formula* is a preferred approach for many advanced economies. There are more complex approaches to applying the SRTP method, that place emphasis on accounting for risk, uncertainty and inequality aversion (Baumstark and Gollier, 2013). To allow comparison with the official rate used in Ireland, this paper has followed the standard Ramsey-based approach similar to Boardman et al. (2010) for Canada.

This study has reviewed the three factors that lead to Ramsey estimation, and concluded that a key factor is the growth in consumption (GDPPC). This is usually based on long-term economic forecasts or scenarios (Sartori et al., 2014). Very long-term historic rates are sometimes used -if they can be defended as a realistic guide to future growth potential (Freeman et al., 2018). The Irish official rate was estimated at 2.3 per cent for GDPPC, based on the recent historic period from 1970 to 2016 (IGEES, 2018). In comparison, the UK rate was estimated by Freeman et al. (2018), by considering growth from 1830 to 2016, and thereby excluding volatility and bubbles. This recent historical period for Ireland is noted as an anomaly of economic development, where the country was growing rapidly while playing catch-up. As such, it does not provide a plausible guide for estimating expected future growth, and effectively skews the rate upwards. A defensible rate can be found in scenarios of economic growth from the OECD (Dellink et al., 2017), at 1.2 per cent average growth in GDPPC, with lower and upper bounds of 0.8 and 1.6 as sensitivity tests. Based on these three factors, the middle range for an SDR is 1.7 to 2.8. This range is supported by a number of independent lines of evidence, including comparison with international surveys and practices, and estimation of the real yield on government bonds. It leads to the conclusion that the official rate for Ireland, at four per cent, is not appropriate, and can only be arrived at by using a heroic assumption on expected multi-decadal consumption growth.

Dual-discounting for non-substitutable natural and social capital is now being pioneered, as a best practice, by countries such as the Netherlands and the UK. With the emergence of climate and ecological breakdown, as core policy issues relevant to welfare, it is necessary to apply both declining and dual discounting. Where “dual discounting” is applied, then the higher rate of 2.8 could be applied to financial capital, with a lower rate of ≤ 1.3 for non-substitutable capital. While in theory it may be possible to apply a dual discount rate to the cost of greenhouse gas emissions, if this cost has already been discounted, as is standard in the Social Cost of Carbon (SCC), then no discounting should be applied to the cost of emissions in project evaluation. It is for this reason that resource-specific discount rates are desirable. The rate calculated in this study provides an approach to non-substitutable capital, and serves to illustrate that applying a “standard” rate across all types of capital is not satisfactory.

There are important general observations, on the support CBA provides to decision-making processes, and the influence of ethical dimensions, which require surfacing in these discussions. CBA does not provide a comprehensive basis, and can only ever provide partial insights into economic dimensions. Governments increasingly face complex, “wicked” public policy challenges, characterised by *volatility, uncertainty, complexity and ambiguity* or “VUCA” (OECD, 2020). In such a context, the partial and reductive insights of CBA have the potential to mis-guide policy with simplistic conclusions, and the practice of strategic decision-making, requires use of tools such as scenario planning, and multicriteria analysis. It is also recognised that important ethical principles cannot be reduced to monetary valuations, or to cost/benefit ratios (Kolstad et al., 2014), and that other ethical framings outside of the utilitarianism of CBA require inclusion (Beckerman and Hepburn, 2007).

Another ethical issue that requires addressing within CBA in Ireland, is that of transparency. It is now overdue, that the common practice in Ireland of not publishing CBA, moves to a proactive openness to democratic scrutiny, to come in to line with existing legislative requirements (O’Mahony, 2018).

5. Conclusions

The practice of CBA has undergone substantial change in the last two decades, driven by analysis in global climate change economics, but also by the mainstreaming of the environment, sustainability

science and transition, within national project level evaluation. This paper has considered the contemporary changes to practices of setting and applying social discounting, in key theoretical, empiric and practice literature internationally. Three key changes can be gleaned from the literature: i) the move from exponential to declining discounting, ii) the use of dual discount rates for different kinds of capital, and iii) the favouring of lower social discount rates estimated through the Ramsey “Social Rate of Time Preference” approach.

The Ramsey approach is used to calculate a discount rate specific to Ireland. Analyst choice plays a significant role in selecting the rates of each of the factors in the Ramsey formula. The empirical issue of uncertainty, that underlies the analysts choice of expected growth, is demonstrated as being considerable. Rather than historical or forecast rates, it necessitates the use of plausible scenarios in response. Scenarios from the literature are used to determine a plausible range of per capita consumption growth for Ireland. This leads to a range for the SDR of 1.7 to 2.8, and demonstrates that the official rate at 4 per cent used nationally is too high. A variety of independent lines of evidence are used to validate this conclusion. The higher SDR of 4 per cent, implemented by the government, was arrived at through a historic growth rate, that is anomalous internationally, and an implausible guide to the future.

On the term structure, it is now widely accepted that declining discount rates are required to avoid discounting large future costs and benefits to negligible levels, including in Irish guidance (DPER, 2019). However, dual discounting is also necessary to account for different types of capital. It is demonstrated that a dual rate of ≤ 1.3 is required for Ireland, in the interim, until good-specific rates are calculated, as recommended by Maddison and Day (2015).

It is important to recognise that determining an appropriate SDR has normative underpinnings. The IPCC also note that “*Prudent agents should care more about the future if the future is more uncertain, in line with the concept of sustainable development*” (Kolstad et al., 2014). This strongly cautions against a “*presentist*” bias of high discount rates, short time horizons of analysis, and considering the natural capital which underpins our societies and economies as perfectly substitutable. To take such an approach risks favouring carbon-intensive and environmentally damaging development, and undermining the ability to deliver economic efficiency in general, or to hand over welfare capabilities to future generations. Considering the centrality of climate and ecological breakdown, and wider environment and sustainability to welfare, it appears indefensible to avoid dual discounting. Specifically in the Irish case, it also requires a reduction in the official central discount rate, as CBA itself transitions to meet the challenges of the 21st century.

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Conflict of interest

The author declares no conflicts of interest in this paper.

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