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Central Technical Appraisal Parameters

Discount Rate, Time Horizon, Shadow Price of Public Funds
and Shadow Price of Labour

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This paper has been prepared by IGEES staff in the Department of Public Expenditure & Reform. The views presented in this paper do not represent the official views of the Department of Public Expenditure and Reform or the Minister for Public Expenditure and Reform.

Note on Technical Paper and Public Spending Code

The Public Spending Code (PSC) applies to both capital and current expenditure and brings together in one place details of the obligations that those responsible for spending public money are obliged to adhere to as well as guidance material on how to comply with the obligations outlined. In September 2013, Departments and Offices were formally notified by circular that the PSC is in effect.

An element of the PSC is guidance for the completion of economic appraisals which includes central technical parameters that should be used across relevant analysis. The purpose of this paper is to review the central technical parameters that are contained within the Public Spending Code. The project has been completed by the IGEEES Unit in the Department of Public Expenditure and Reform and is an input to the on-going review of the Code being led by the Department's Government Accounting Unit.

This paper is a technical research paper and does not amount to official appraisal guidance. The technical appraisal parameters that are currently stipulated for use are maintained on the Public Spending Code website and the rates specified there should be used. The research contained within this paper will be considered in the on-going overall review of the PSC.

Addendum: Minor corrections were made to Table 7.2 and 7.3 in Appendix Three in July 2019.

Summary

The Public Spending Code is the set of rules and procedures outlining the obligations that those responsible for spending public money are obliged to adhere to. A central part of the Code, is guidance in relation to the economic appraisal and evaluation of public expenditure and policies. The central technical parameters are in place to ensure that there is consistency across the analysis that is being carried out such as Cost Benefit Analysis (CBA). The purpose of this paper is to review the application of the following parameters:

- Discount Rate
- Time Horizon
- Shadow Price of Public Funds
- Shadow Price of Labour

The report makes the following findings based on a review of theoretical literature, international practice and analysis relevant to Ireland:

Discount Rate

Based on a Social Rate of Time Preference methodology, an appropriate value for the Social Discount Rate in Ireland is **4%**. This is a 1 percentage point decrease from the current discount rate and in line with the rate previously in use in Ireland between 2007 and 2015. In addition, based on recent literature and practice the rate can adopt a declining term structure over long time horizons.

Time Horizon

The relevant time horizon for analysis should be set having regard to the **asset, project or intervention's lifetime** taking into account its nature and impacts. Residual values, to capture any impacts/values beyond the lifetime, should also be included.

Shadow Price of Public Funds (SPPF)

An appropriate valuation for the Shadow Price of Public Funds for application remains **130%** and the parameter should continue to apply to public funding within economic appraisals to reflect distortions related to taxation.

Shadow Price of Labour (SPL)

For the Shadow Price of Labour, the range of **80 to 100%** remains appropriate. However, in terms of application, there should be clear emphasis on the need to justify a SPL different from 1 in the context of current labour market conditions.

Next Steps and Future Research

Further detail on the application of these central parameters should be provided in user guides within the Public Spending Code to ensure ease of application in practice.

Further research is recommended to generate further evidence specific to an Irish context across each of the parameters. For example, this would include the specific elements of the discount rate calculation.

The parameters should be reviewed every 3 or 4 years to ensure that they continue to reflect best practice and the most recent data and information.

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1. Introduction and Project Overview

Appropriate appraisal of public expenditure proposals is an important element of best practice expenditure management. For example, in considering the relative merits of different interventions or infrastructure investments there are a number of approaches that can be utilised to consider the costs and benefits. The Public Spending Code (PSC) is the set of rules and procedures outlining the obligations that those responsible for spending public money are obliged to adhere to. The PSC was published in 2012 and consolidated and built upon existing guidance. A key aspect of the Code is the detailed guidance provided in relation to the conduct of appraisal and evaluation.

In this regard, the PSC provides a number of central technical parameters for use in the conduct of Cost Benefit Analysis (CBA) and other analysis. The Code contains guidance and central rates for use in relation to a number of technical parameters including the discount rate, the time horizon, the shadow price of public funds, the shadow price of labour and the shadow price of carbon. The objectives of providing a central list of appraisal parameters are to:

- Promote rigour in the conduct of economic appraisals across the public sector;
- Ensure that there is consistency in the preparation of economic appraisals; and
- Support practitioners in the development of appraisals to inform spending decisions.

The objective of this paper is to review four central technical parameters (discount rate, time horizon, shadow price of public funds and shadow price of labour) and provide analysis in relation to the appropriate application, usage and values. A brief description of each parameters including their purpose and current rate are provided in table 1.1 below. The analysis has been carried out by the IGEES Unit in the Department of Public Expenditure and Reform and is a contribution to the work of the Department's Government Accounting Unit which is leading the overall review of the PSC. In completing the project, the author's engaged with a Steering Group containing representatives from a number of Government Departments and external research bodies. Further details are provided in Appendix One.

In analysing the four technical parameters and providing related recommendations, the analysis follows a set structure. For each parameter a wide evidence base was gathered and analysed. This included consideration of theoretical literature in an Irish and international context, a review of international practice and relevant analysis related to the Irish economy and appraisal. As will be detailed throughout the paper, the evidence in relation to each of the parameters is mixed. In general, there exists no consensus in terms of the application and valuation of the parameters. As such, the findings provided here are based on a pragmatic assessment of the evidence gathered through this research project and within this context.

Table 1.1: Overview of Technical Appraisal Parameters in Public Spending Code, Pre-Update

Parameter	Overview Description	Rate/Value
Discount Rate	Used to convert future costs and benefits into their value today (present value) to allow them to be meaningfully measured and compared for appraisal purposes.	5%
Time Horizon	Used to define the period of time over which a potential project should be assessed (i.e. how many years of benefit and cost flows should be included).	Economically Useful Lifetime
Shadow Price of Public Funds	Used to adjust the costs of publically funded projects due to the distorting effect of the taxation generation to fund it.	130%
Shadow Price of Labour	Used to adjust labour impacts as the social opportunity cost of labour resource may be lower than the market rate due to underemployed resources.	80-100% Where justified

Source: PSC. Note: Values refer to pre-2018 update

2. Social Discount Rate

In thinking about the appraisal of a typical project or programme, it is evident that the relevant flows of both benefits and costs can occur at different times. For instance, in the construction of a large infrastructure project, the majority of the costs may be borne upfront while the benefits from the project span into the future years of the project's lifetime. Thus, if the current values of future costs and benefits are regarded as different from those occurring today, the use of a discount rate permits valuation of the project in present terms. It states the value of monetary flows in different years by linking their value to a single date. The use of discounting is common across economic and financial analysis in both the public and private sector. The purpose of this section is to review the relevant theoretical, national and international evidence in relation Ireland's social discount rate and assess the appropriate value and application of the parameter in an Irish context.

The Social Discount Rate

The Social Discount Rate/Test Discount Rate (SDR) is a rate of discount applied within the public sector to future streams of costs and benefits in order to determine a present value for a given investment project in an economic appraisal. It is extensively used in Cost Benefit Analysis in the public sector where the associated benefits and costs of a proposed project manifest at different points in time. The SDR represents the central rate to be used in the economic appraisal of public sector projects. However, under specific circumstances, such as commercial projects undertaken by commercial semi-state bodies and PPP projects, other discount rates may apply¹. There are a number of important areas for consideration in relation to the SDR which will be examined through this section of the paper including:

- The SDR can be calculated based on a number of different theoretical approaches including society's time preference (SRTP) and the opportunity cost of capital (SOC).
- There are a variety of methodological issues to consider in calculating the rate itself.
- It can be applied under an exponential methodology (same discount rate over time) or a hyperbolic methodology (discount rate varies over time e.g. declining rate over time).

The Application of Discounting

Table 2.1 details an example of how discounting works in practice when being undertaken in a typical exponential fashion (same discount rate over time). In effect, the financial flow in each year is discounted by a discount factor which is determined by the following formula:

$$\text{Discount Factor in Year } n = \frac{1}{(1 + \text{Discount Rate})^n}$$

The discount factor represents the factor applied to a flow at a given time based on the discount rate applied. Once the discount factor for a particular year has been calculated it is then possible to work out the present value of that flow by multiplying the monetary value by the factor. For instance, in the example below, the year 10 discount factor is rounded as 0.61 (formula is $1/(1+5\%)^{10}$) and multiplying the financial flow in that year (€10 million) by the factor yields a present value of €6.14 million. By summing all of the relevant flows over time we can arrive at the total present value of the benefit or cost which in the example in Table 2.1 is €134.62 million. Once flows have been discounted, one can calculate key metrics such as Net Present Value (the net impact of the proposal in discounted monetary terms) and the Benefit Cost Ratio (the ratio of discounted benefits to discounted costs).

¹ DPER 'Project Discount and Inflation Rates' - <http://www.per.gov.ie/en/project-discount-inflation-rates/>

Table 2.1: Discount Rate Example – 5% Discount Rate

Year	0	1	2	3	4	5	6
Flow (€m)	10	10	10	10	10	10	10
Discount Factor	1.00	0.95	0.91	0.86	0.82	0.78	0.75
Present Value (5% DR)	10.00	9.52	9.07	8.64	8.23	7.84	7.46
Year	7	8	9	10	11	12	13
Flow (€m)	10	10	10	10	10	10	10
Discount Factor	0.71	0.68	0.64	0.61	0.58	0.56	0.53
Present Value (5% DR)	7.11	6.77	6.45	6.14	5.85	5.57	5.30
Year	14	15	16	17	18	19	20
Flow (€m)	10	10	10	10	10	10	10
Discount Factor	0.51	0.48	0.46	0.44	0.42	0.40	0.38
Present Value (5% DR)	5.05	4.81	4.58	4.36	4.16	3.96	3.77
Total NPV	134.62						

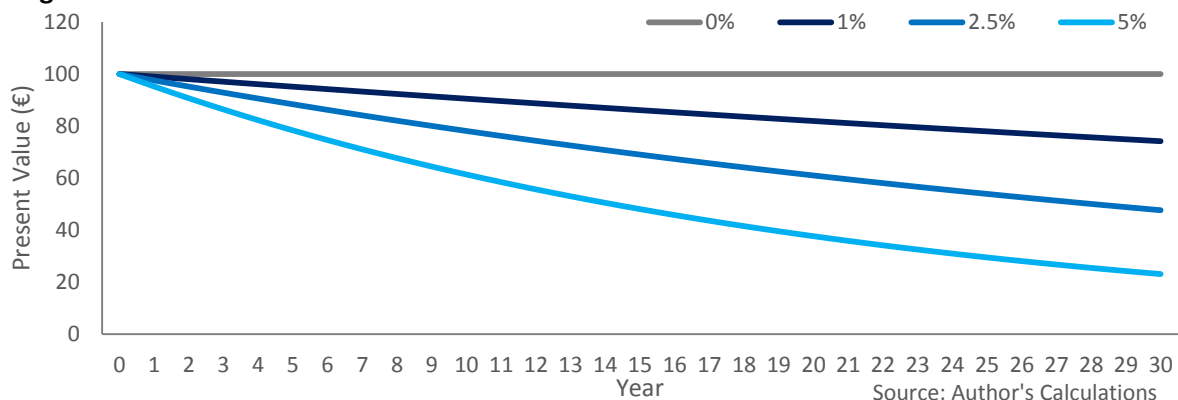
Source: Author Calculations

The choice of discount rate can have an important impact on the final result of appraisals and CBAs. In this way discounting has a varied impact on projects, depending the distribution of costs and benefits. A project where all the costs arise in the first year, and all benefits accrue in the final year will be affected differently than a project where the costs and benefits arise throughout the project. The discount rate can therefore be thought of as giving a value to time. As Box 1 describes, the impact of various discount rate scenarios has implications for the net present value of benefit and cost flows. As such, it is important that the chosen discount rate is pragmatically underpinned as appropriate by theory and evidence.

Box 1: Discount Rates and Impact on Net Present Value

Figure 2.1 demonstrates the differential impact of discount rate scenarios including 0%, 1%, 2.5% and 5% rates. The figure exhibits the value of €100 in each year over a 30 year horizon and presents its present value based on the discount rate scenario. As can be seen, there is a large differential in the present value of €100 in year 30 depending on the discount rate that is selected. For example, under a 1% discount rate scenario, the present value of €100 is €74 while under a 5% scenario it is €23.

Figure 2.1: Discount Rate Scenarios for €100 Over 30 Years



In considering the appropriate SDR for Ireland, this section is structured around the following elements:

- Literature review and discussion of theoretical debates on the discount rate
- Review of international practice
- Analysis of discount rate application in an Irish context.

2.1 Overview of Literature on Social Discounting

The Social Discount Rate is among the most contentious topics in the economics literature. Despite the voluminous quantity of work carried out on the topic, many of the central issues remain subject to at least some disagreement. This disagreement in the theoretical sphere is reflected in the wide range of SDRs both recommended by economists and used in practice by governments and other institutions. Rather than giving a full chronological review of the literature we will provide a brief outline of the origin and development of the SDR, and then provide an overview of the literature as it relates to four questions which are of interest in terms of the practical application of the rate. This will allow us to draw out and discuss relevant insights.

Development of Social Discounting

Understanding of compound interest dates back as far as Babylonia and ancient Egypt (~2500 BCE), who used the concept, and mathematics similar to the modern standard, in thinking about investment². In more recent history the concept developed in three academic spheres: the actuarial sciences, civil engineering and political economics.³ The first tables of interest were printed in the financial centres of Antwerp and Lyons in the sixteenth century by accountants and financial appraisers. The civil engineering practice in nineteenth century United States contributed to the formal mathematics of discounting in appraising the value of railway investment; the concept of Net Present Value for example, was developed by O.B. Goldman of the Department of Mechanical Engineering in the University of Arizona. The most familiar theoretical work on compound growth and discounting was developed within the domain of political economy over the last two centuries. The development of capital theory by economists such as Alfred Marshall in England, Bohm-Bawerk in Austria, Wicksell in Sweden and Fisher in the U.S., from the late eighteenth century up to the early twentieth century, set the stage for much of our current understanding of interest, discounting and the market dynamics of capitalism generally.

The greatest theoretical leap which occurred in the development of Social Discounting was the move from discounting expected future profits to discounting expected future welfare, or utility. Scottish economist John Rae produced the first in depth discussion of the psychological motives underlying intertemporal choice. This seminal work, with theoretical contributions from others eventually led to Samuel (1937), in his Discounted Utility (DU) model. The central assumption of this model was the assumption that all of the complex subjective psychological process governing individual intertemporal consumptive decision making could be condensed into a single parameter – the discount rate. Despite the fact that Samuelson himself expressed deep reservations about the validity of this assumption⁴, DU became the dominant paradigm in both public policy making and academic research⁵, and the model became viewed as an accurate description of individual behaviour.

The modern discussion of discounting⁶, specifically Social Discounting, began in the 1950s, due to a burgeoning interest in the appraisal of large scale social projects, at the time coming primarily from the U.S. Much of the earlier part of this discussion was dominated by disagreements on the appropriate methodological approach to choosing a discount rate – a discussion which still persists to the present, though in a more muted form. The two schools, represented by different noteworthy economists were the proponents of the Social

² See Neugebauer (1951).

³ See Parker (1968).

⁴ In Samuelson's own words "It is completely arbitrary to assume that the individual behaves so as to maximize an integral of the form envisaged in [the DU model]." - See Frederick, Loewenstein and O'Donoghue (2002) for a full review.

⁵ This was likely due to the model's similarity to previous financial discounting which was well established in the discipline, as well as its simplicity, elegance, and ready applicability.

⁶ See Robinson (1990), and Campos, Serebrisky and Suárez-Alemán (2015) for more detailed descriptions.

Opportunity Cost (SOC) approach, and proponents of the Social Rate of Time Preference (SRTP) approach, with significant debate and controversy between the two methods. During the 1950s the literature had tended to preference the Social Opportunity Cost method, particularly in empirical papers, due to its comparative simplicity and ready applicability (one could simply take a market rate of interest and use it in economic models).

In the early 1960s however several critiques of the SOC approach were published, some related to developments in economic growth theory, such as Arrow (1966), which cast doubt on the assumption of public sector displacement of private sector output, central to the SOC rationale. Gradually consensus tilted towards favouring those advocating use of the SRTP method⁷ as a more theoretically coherent approach to social discounting. This development was then challenged in a paper by William Baumol (Baumol 1968), in which he reformulated the essential question of social discounting and argued in favour of the SOC approach. Baumol was met with numerous replies, sparking renewed debate into the 1970s. An effort at reconciliation between the two approaches, known as the 'Weighted Average' approach was put forward by Harberger (1972, 1976). While this approach was met with some success and has been applied by a small number of countries, it was also subject to significant criticism.⁸

Box 2: Main Discount Rate Methodologies

Social Opportunity Cost

Based on the idea that public investments displace private investments. Therefore, according to this approach, the return from the public investment should be at least as big as the one that could be obtained from a private investment. As a result, the SDR is considered equal to the marginal social opportunity cost of funds in the private sector.

Social Rate of Time Preference

Rate at which society is willing to postpone a unit of current consumption in exchange for more future consumption. The logic of this approach is that the government should consider the welfare of both the current and future generations and solve an optimal planning programme based on individual preferences for consumption.

Source: Florio, 2014

In the last couple of decades the most significant growth in the literature has occurred around the issue of the term-structure of the discount rate i.e. whether successive periods ought to be discounted at the same rate, or whether the rate should decrease with time. The primary catalyst for this has been an observation of the power of exponential discounting in virtually eliminating benefit-costs occurring after a given period, coupled with a growing understanding of the acuteness and long-timescales of issues such as climate change, necessitating a need for a change in our analytical approach to long-term investment.⁹ The main theoretical criticism of this approach was the potential for time-inconsistency (that the decision maker would wish to change their behaviour, not based on any new information, but solely on the passage of time), as detailed in Strotz (1955). While this is valid in the case of an individual who is discounting hyperbolically, such concern has been argued to be unwarranted in the case of a decision maker who maximises a time-separable expected utility function where expected utility is discounted at the constant exponential rate.¹⁰

⁷ Such as Sen (1961), Marglin (1963a, 1963b), Tullock (1964), Feldstein (1964), and Sen (1967).

⁸ See Feldstein (1972).

⁹ Given the significant economic restructuring (transformation) required to keep average global temperatures within 'safe' +1.5°C on preindustrial levels threshold. See IPCC (2014).

¹⁰ See Gollier et al. (2008), Hansen (2006), and Heal (2005).

Literature Overview: Relevant Questions for Practical Application of SDR

This section is intended to provide an overview of the literature as it relates to questions which would be of particular interest to the practical application of the SDR. The fundamental questions which one would seek answers from the literature might be:

- i. Why would it make sense to discount future costs and benefits?
- ii. Is it coherent and ethical to discount the future?
- iii. At what rate should we discount?
- iv. Should the discount rate decline over time or remain constant?

i. *Why would it make sense to discount future costs and benefits?*

Financial appraisals, such as those carried out by private firms, employ discounting to account for the opportunity cost of a capital investment (the value of the next best investment). Ideally this would be a comparison to the profitability of the next best investment, but for pragmatic reasons the opportunity cost is often assumed to be the rate of interest.¹¹ Assuming that public sector investment, which because it is funded through the extraction of capital from the economy, displaces private investment that would otherwise have taken place, then in order to ensure that the social project being undertaken is as efficient as the private project it is replacing, it may make sense to apply the same rate of interest to public investment. Economists such as Baumol (1968) and Harrison (2010) recommend this line of reasoning - that the rate of interest is used as an approximation of the *Social Opportunity Cost*. This argument however, has been persuasively critiqued on the basis that government investment does not have the simple 'displacement effect' on private investment as alleged in the SOC framework.¹² Arrow (1966) argues that displacement of private investment in one year, consequently displaces the investment and consumption which would have been generated from the returns from the initial investment. He also notes that the SOC of a private investment would depend heavily on the source of the tax revenue,¹³ and that the returns of public investment tend to accrue to private citizens – in turn financing future private investment. To compute the SOC of a public investment using this line of reasoning therefore, one must account for all the potential streams of consumption/investment displaced, and those which are generated as a result of the public investment.¹⁴ Feldstein (1964) and Sen (1967) argue that this distortionary (displacement) effect, which forms the basis of the SOC argument, should be accounted for specifically in an estimation of the shadow cost of public funds, and discounting should be based solely on society's time preference, as is current practice in Ireland.

The rationale for discounting given by critics of the SOC approach and proponents of the SRTP approach, such as Arrow (1966), instead relies on estimating an optimal rate of savings for an economy, based on explicitly defined social utility functions, underpinned by psychological assumptions regarding the consumption preferences of individuals. In this vein, economists such as Lind (1982) argue that it is valid to set the SDR equal to the SRTP – the rate at which society prefers short-term consumption to long term consumption. This framework is commonly articulated in the 'Ramsey formula'¹⁵ where the SDR is equal to the 'pure rate of time preference' plus a 'smoothing criterion' which smooths the utility from consumption across time periods.¹⁶ In

¹¹ Which under models of perfect competition equals the marginal productivity of capital and the rate of time-preference.

¹² Baumol used a model of a highly idealised economy, into which he introduced distortionary taxes. His conclusion is valid in a 'first best world' – however as Lind (1982) states "Clearly, in the real world, the situation is more complex".

¹³ For example, revenue generated from an income tax would displace consumption disproportionately, whereas revenue generated from corporate tax would displace investment.

¹⁴ To do this one would need to have perfect knowledge of all current and future government policy and macroeconomic conditions.

¹⁵ Ramsey (1928)

¹⁶ Smoothing criterion is made up of the rate of consumption growth multiplied by the marginal elasticity of consumption. In effect if people in the future will consume more, then it is warranted to place greater weight on a unit of consumption today.

this sense, one may choose to discount future costs and benefits in order to account for time preference and the balancing of consumption between future and present, accounting for distortions using the SPPF.

The above two arguments for discounting represent the two primary approaches to discounting. Another argument exists in the negative – i.e. that failing to apply discounting in CBA (or discounting at a zero rate) is problematic and untenable. As Olsen and Bailey (1981) discuss, due to the sheer amount of potential future generations, the possibility of contributing even a negligible improvement to each would greatly outweigh any benefit to the present with a discount rate of zero. Taken to the extreme, the ultimate conclusion of this would be the impoverishment of the present generation and the expense of those in the future, or a ‘dictatorship of the future’. In order to deal with temporality in the CBA framework therefore, general practice and theory supports the use of some level of positive discounting.

ii. *Is it coherent and ethical to discount the future?*

The use of social discounting has long been controversial, both within economics and in related fields. The primary concern ethically is that discounting unjustly promotes the interests of people in the present above those of people in the future. Specific critiques differ depending on the approach to discounting one is employing. Broom (1994) argues that exponential discounting should only be used in order to account for growth in the economy, (relating to both the SOC and SRTP approaches in different ways). Discounting resources which grow over time, such as timber or livestock, makes sense because yield quantity is correlated with time. Applying this rationale to other resources however, or to utility, he argues, is not sound.

Critiques of the SRTP approach usually concern the ‘pure rate of time preference’ (PRTP) component. PRTP implies that, assuming individuals discount their own utility exponentially, that government should do the same. Early Utilitarians, such as David Hume and Jeremy Bentham viewed government primarily as an instrument ‘to counteract the pernicious effects of unrestrained individual initiative’.¹⁷ Similarly, the utilitarian philosopher Sidgwick noted that ‘the interests of posterity must concern a utilitarian as much as those of his contemporaries’. This view was shared by the pioneers of nineteenth and twentieth century economics, who came from this utilitarian tradition.¹⁸ With the growing dominance the Anglo-American economics tradition during the twentieth century however, this philosophical position within economics changed. Anglo-American economics turned away from evaluations of social well-being based on objective criteria, and towards evaluations based on subjective preferences held by individual consumers. In this respect Marglin (1963) rejected earlier scepticism of PRTP as ‘authoritarian’, arguing against paternalistic government policy which seeks to impose on the citizenry what it proposes to be right. Similarly Eckstein (1953) viewed PRTP as the basis of consumer sovereignty and therefore democracy. In more recent decades, particularly with growing concern around intergenerational transfers in the context of climate change, PRTP has again been subject to disagreement. The Stern Review (Stern 2006) virtually abandoned PRTP, setting a rate of 0.1 – applying instead a stochastic approach to discounting.¹⁹ While this was praised by many influential economists, including Solow, Mirrless, Sen, and Stiglitz, it was also subjected to criticism from other noteworthy economists such as Weitzman, Nordhaus and Dasgupta.

While there are important points in the critiques and philosophical implications of discounting, these arguments do not in themselves imply abandoning its use as the correct course of action. CBA is a practice which pursues efficiency above distributional equity, be it static or inter-temporal. While this may be fairly

¹⁷ See Robinson (1990).

¹⁸ Bohm-Bawerk (1888), Marshall (1890), Pigou (1920), Ramsey (1928), Harod (1948), Dobb (1960), Sen (1960, 1961).

¹⁹ Whereby the discount rate varied with the expected outcomes, reflecting the interaction between growth and the elasticity of marginal utility, in line with Frank Ramsey's growth model.

critiqued on a variety grounds, it may be better understood as one of several limitations of the CBA framework, which should be understood by policy practitioners.

iii. *At what rate should we discount?*

Not surprisingly given its inherent connection to the previous two questions, a wide divergence of opinion appears in answer to this question throughout the literature.²⁰ In general, the SOC approach derives a higher value for the SDR than formulations using the SRTP approach, as in theory the SOC comprises of both the displacement effects of public expenditure and time preference, whereas the SRTP comprises only of the latter. There is a vast amount of literature which, offering justifications for one or other approach, apply a methodology and arrive at a figure for a given country or jurisdiction.²¹ While this work is necessary from a pragmatic perspective, the lack of coherency between methodologies, and lack of consistency between the given rates, highlights the differences in the literature and the challenges in identifying an appropriate rate.

In this sense ‘skipping’ the theory and methodological considerations and looking towards large-scale surveys of economic opinion may at least provide a barometer of acceptable discount rates. Drupp, Freeman, Groom, Nesje (2015) carried out a survey of two hundred experts in the field of discounting. Specific to their study was the decomposition of the SDR into its Ramsey components, on which they requested economists to submit values (the summation of which provide the SDR). Their findings gave a mean SDR of 2.27% with a standard deviation of 1.62 and mean, and mode of 2%. The lowest submissions they received were 0% and ranged up to 10%; by their own statement, most of the answers they received were between 0-4%. However, taking the individual mean responses for the components of the SRTP formula, the results imply a SRTP rate of around 3.5%. A similar, though much larger study was carried out by Weitzman (2001) of 2,160 economists – the distinction here being that participants were not regarded as ‘expert’ in the field. This survey returned a higher average rate of 3.96%, however the modal value (the most frequent submission) was the same between the two studies, at 2%. As Weitzman said in that paper, reiterating something which could have been said at any point over the last sixty years, “There does not now exist within the economics profession, nor has there ever existed, anything remotely resembling a consensus, even-or, perhaps one should say, especially-among the ‘experts’ on this subject”.

Table 2.2: Studies on General Valuation of Discount Rates

Economist	Proposed Rate
Metastudy: Weitzman (2001)	3.96%
Metastudy: Drupp, Freeman, Groom, Nesje (2015)	2.27%
Stern (2006)	1.6%
Nordhaus (2008)	5%
Weitzman (2007)	6% (in near term)
Gollier (2012)	3.6% (in near term)

Source: As stated

iv. Should the discount rate decline over time or remain constant?

Over the last two decades a significant literature has developed around the term-structure of the discount rate. This has been motivated primarily by a feeling among both economists and non-economists that the use of the classical Net Present Value (NPV) rule to assess the economic efficiency of policies with costs and benefits accruing in the long term is particularly problematic²². In response, a variety of arguments have

²⁰ For practical purposes this section will be confined to only to the mainstream economics literature.

²¹ Evans and Sezer (2004, 2005), Moore et al (2004), Morgenroth (2011), Percoco (2007)).

²²The general concern is surmised in Groome et al. (2005) stating that exponential discounting implies a dictatorship of the present over the future- i.e. present welfare is given great consideration whereas future welfare is disregarded.

emerged which provide a theoretical basis for use of a declining discount rate (DDR). These arguments have been based on four main points:

- Evidence on human's innate intertemporal decision making structure.
- Concern about future rates of consumption and environmental spending, given externalities.
- Reconciling intra and intergenerational benefits.
- The incorporation of uncertainty into discounting models.

Assuming one agrees with the inclusion of the PRTP element in the SDR (to reflect the rate of discount held by society), so too should the term-structure by which society discounts²³. Several studies have looked at the inherent preferences of individuals with regard to intertemporal consumption decision making²⁴. These suggest that people make intertemporal choices according to a hyperbolic function – a form of DDR. Choosing between various combinations of small rewards sooner, and larger further away, hyperbolic curves tended to fit study data better than the traditional exponential curve i.e. participants place greater weight on consumption trade-offs occurring in the near term than those further away. Pearce et al. (2003), among others, following Marglin's (1963) commitment to the rule of consumer sovereignty, argued that this provides justification for the use of hyperbolic discounting for DDRs. However, this form of discounting is characterised by time-inconsistency; hyperbolic models have been used to explain addiction, under-saving, and other temporal difficulties humans face. Incorporation of hyperbolic discounting into analytical modelling, based on explicitly irrational behaviour therefore may be more difficult to justify theoretically²⁵.

It is well understood that environmental externalities in consumption or production can cause the social and private rates of return on capital to diverge²⁶. This observation has been used to provide the theoretical justifications for employment of a DDR. Assuming that society values environmental resources, and that consumption is negatively correlated with environmental resources, then society faces a trade-off in investment between consumption and environmental investment. Weitzman (1994) imagines that environmental damage must be kept at some maximum level; this will lead to a gradual but continuous increase in environmental investment at the cost of consumption. In this case he illustrates that the socially efficient discount rate will be declining over time due to the continuous increase in environmental investment.²⁷ Fisher and Krutilla (1975) develop and model for natural environmental resource allocation, in which willingness to invest in environmental preservation is a function of the rate of growth²⁸. Environmental preservation therefore is treated as a luxury good, which a society gradually consumes more of as income increases.²⁹ As growth is expected to remain at some positive level, investment in the environment will be expected to increase, leading to a declining discount rate (for environmental goods)³⁰.

DDRs have been presented as a solution to problems of sustainability and intergenerational equity. Chichilnisky's (1996, 1997) axioms of sustainable development require that consumption paths be determined

²³ Conventional discounting also relies on other assumptions which are not borne out by empirical studies of human preference – e.g. discount rate should be the same for all types of goods, level of flows, periods of time etc.

²⁴ See Thaler (1981), Cropper et al. (1994), and Harris and Laibson (2001).

²⁵ See Feldstein (1964).

²⁶ Meaning the private benefit to production/consumption is higher than the social benefit, as the social rate of return is sensitive to the effects of pollution.

²⁷ Interestingly he assumes that environmental investment is external to the production process, underestimating the benefits of investment in green technology.

²⁸ Meaning a wealthier society will be more willing to forgo consumption in order to protect the environment.

²⁹ A framework also used by Horowitz (2002)

³⁰ Subsequently referred to as dual discounting – i.e. discounting environmental and non-environmental goods at different rates.

both by preferences of the present, but also those of the very long run.³¹ She presents these axioms in the following utility discount function criterion:

$$U = \alpha \int_0^{\infty} u(c(t))\Delta(t)dt + (1 - \alpha) \lim_{t \rightarrow \infty} u(c(t))$$

where utility is maximised under the integral path (short term, denoted by the first part of the expression), and secondly by the asymptotic path (the limit which determines the long term). This is incompatible with exponential discounting, which maximises the utility of the present at the expense of the future, and is therefore solvable only with a DDR (Heal, 2003). As Dasgupta (2001) notes however, this approach implies a switching date which would be subject to time inconsistency; the aggregate wellbeing would always be improved by choosing to postpone the switching date.

A further case for DDRs comes from the observation of the impact of uncertainty around any of the elements of the discount rate (most commonly future levels of growth), or uncertainty over the discount rate itself. Given the varying degrees of uncertainty that exist, it is argued the most appropriate response is to incorporate this into our models. Weitzman (2001) argues that discount rates should decline according to the probability distribution which defines our uncertainty around them.³² Taking an illustrative example from Hepburn (2007):

Table 2.3: Illustrative Example of Declining Discount Rate and Uncertainty

Time (years from Present)	1	10	50	100	200	400
Discount factor for 2% rate	0.98	0.82	0.37	0.14	0.02	0.00
Discount factor for 6% rate	0.94	0.56	0.05	0.00	0.00	0.00
Certainty-equivalent discount factor	0.96	0.69	0.21	0.07	0.01	0.00
Certainty-equivalent (average) discount rate	4.0%	3.8%	3.1%	2.7%	2.4%	2.2%

Source: Hepburn, 2007

Here two potential discount rates (2% and 6%) are presented with an equal probability. The two rates have different effects on the starting value of 1 over the timescale; by taking the average of these effects, using the certainty equivalent discount factor³³, we can work backwards and develop the average discount rate, which declines over time. As illustrated in Weitzman (1998, 2001) if the assumptions of uncertainty, and persistence (that discount rates are autocorrelated) hold, then a DDR is required to achieve intergenerational efficiency. The form and rate of decline will be determined by the source of uncertainty in the economy. Newell and Pizer (2003) for example find evidence for a DDR by forecasting future rates using a reduced-form time series process based on US interest rate data.

When considering uncertainty about future levels of growth, the argument for high levels of discounting based on future expected consumption is weakened. The degree to which people are willing to accept risk must also be considered. Kimball (1990) introduced a 'prudence effect', relevant to situations where future income is uncertainty; this, he illustrated, leads to precautionary saving in a representative subject. Applying this insight to an underlying utility function, Gollier (2001, 2002a, 2002b) provides a theoretically robust justification for DDRs in the case of uncertainty. Given that future consumption growth is uncertain he adds this prudence effect on to the familiar Ramsey equation:

$$r = \rho + \mu g - \frac{1}{2} \mu P \text{var} g$$

³¹ The two axioms require that neither the future, nor the present should solely determine society's consumption path.

³² Based on a meta-survey of economists he found that responses most closely suited a Gamma distribution. He therefore employed 'Gamma Discounting' finding a mean SDR of 4%, declining to around 0% in the far distant future.

³³ Given by $s_c(t) = (1 - D_c(t))^{1/t} - 1$

where P is the measure of prudence effect. Assuming no risk of recession, and that people have decreasing relative risk aversion, the optimal social discount rate is declining over time. Despite the elegance of the approach, the difficulty from a policy perspective lies in the fact that many of the underlying parameters in the model are unknown. Secondly the assumption of no risk of recession is difficult to justify, without which the model loses its theoretical practicability.

2.2 Social Discount Rate in Ireland

The following section sets out details of how Ireland’s discount rate is currently formulated and how this has developed over time. The purpose of the section is to place the analysis of the discount rate within an appropriate historical context.

Table 2.4: Ireland’s Rate of Discount

Time	Social Discount Rate
1984-2007	5%
2007-2015	4%
2015-present	5%

The current social discount rate is set at 5%. This estimation of the SDR was based on analysis of relevant evidence including a piece of research carried out by Edgar Morgenroth (Morgenroth, 2011). Morgenroth’s methodological approach is based on the Social Rate of Time Preference. Therefore, using the Ramsey formulation, the SRTP is broken down into the pure rate of time preference, plus the product of the projected real consumption growth and the marginal utility of consumption. Ascribing values to each of these components he develops an estimated range for the SDR. Noting the contention around valuing the pure rate of time preference, a range of between 1% and 3% is adopted. Using data from over the period 1970-2010, per capita average consumption growth is determined to have grown by 4.1% annually. Finally, using a measure estimated by Evans (2005), the elasticity of marginal utility of consumption is given as between 1 and 1.47. These estimates yield a SDR between 5.1% and 9%. The lower bound of this range was adopted in practice.

In the 2005 update of *Guidelines for the Appraisal and Management of Capital Expenditure* it was stipulated the SDR should be derived from “the official discount rate as stipulated by NDFA which corresponds the cost of Government borrowing” (D/Finance, 2005). This guidance implies basing the SDR on the Irish government bond rate. In the update of the discount rate in 2007, the methodology was changed from SOC to SRTP. In calculating the rate at the time, the analysis focused on values of 1.5% for the pure rate of time preference and a value of 1 for the marginal elasticity of productivity in line with the values used in the UK’s Green Book. The assessed level of per capita consumption growth was 2.2% based on analysis of previous rates of growth in personal consumption per capita and ESRI forecasts of growth. This analysis estimated an SDR of 3.7%, which was rounded up to 4%.

2.3 International Practice for Social Discounting

The following section outlines international practice related to discounting and the formulation of the discount rate. The objective of the section is to understand, within the context of the diverse theoretical debates, how countries practically approach this issue and how Ireland’s current practice sits within this. The section will set out in detail how a number of countries approach the issue within appraisal guidelines before summarising some of the main cross-country findings. For each country the analysis will attempt to explore, from published CBA guidance material, how the discount rate is formulated, the chosen theoretical underpinning and the approach to both risk and longer time horizons. The approach taken in the following areas will be outlined; Australia, Canada, European Commission, France, Netherlands, New Zealand, Norway, UK, USA.

Australia

The Australian CBA guidance states that the use of the cost of capital or produced rates of discount are preferable to concepts related to time preference rates (Commonwealth of Australia (Department of Finance and Administration), 2006). Furthermore, the guidance states that a project specific discount rate is appropriate in many cases such as when the risk is borne by specific lenders or when the project could be undertaken by the private sector. The Handbook does not prescribe a benchmark real SOC discount rate as it is under continuous review. The Office of Best Practice Regulation has set out that it requires the use of an annual real discount rate of 7% with sensitivity analysis conducted at a lower bound of 3% and a higher bound of 10% for any appraisal of regulatory proposals (OBPR, 2016).

In practice, it appears that there are different rates used between different states in Australia with New South Wales, Western Australia and Victoria employing an opportunity cost of capital approach in line with the general Commonwealth guidance and Queensland operating a social rate of time preference approach (Argyrous, G. 2013). Furthermore, Dobes et al list the variety of approaches that are taken with the primary approach advocated centrally by actors such as Infrastructure Australia, the Australian Transport Council, and Austroads in line with the ABPR approach of using a central 7% rate and sensitivity at around 3-4% and 10% (Dobes et al, 2016). The range of approaches implemented on a state by state basis, as previously touched upon, is stated through that report. For instance, while the report also lists New South Wales as using a SOC approach as its central method, it details the use of the SRTP approach in that state as a sensitivity test. (ibid).

In summary, practice varies across Australia with respect to the calculation and implementation of the discount rate but in general practice appears to favour a theoretical underpinning in the area of the social opportunity cost of capital and rates in the region of 7% (with sensitivity analysis)

Canada

The CBA guidance in Canada outlines the relative merits of both the social rate of time preference and the opportunity cost of capital (equivalent to SOC) approaches to formulating the discount rate. It also outlines the potential to include measures of risk in the discount rate and the use of declining discount rates for intergenerational issues. The guidance states that the discount rate is calculated on the basis of the opportunity cost of capital. The rate is calculated without a declining rate or adjustment for risk. The precise method for calculating the opportunity cost of capital is a weighted average of the costs of funds from three different sources of funding: the rate of return on postponed investment, the rate of interest (net of tax) on domestic savings, and the marginal cost of additional foreign capital inflows.

The stated estimate of the discount rate in Canada is 8% based on this method. The guidance notes that it is within the range of previous estimates of 7-10%. The guidance goes on to state that other organisations sometimes use other rates reflecting circumstances where consumer consumption is involved and there are no or minimum resources involving opportunity costs. Some contributions to the literature within Canada have challenged the rate and it is stated that an estimate for the discount rate in Canada using the SRTP approach would be around 3.5% (Boardman et al, 2009). The guidance states there are several reasons why hyperbolic discounting is not recommended for use including that there is no general rationale for their use unless it is the case that the opportunity cost of funds is abnormally high or low from one period to another. In terms of including risk, the guidance states that this is better dealt with through Monte Carlo risk analysis rather than adjusted discount rates as uncertainty is mainly related to the input variables themselves.

European Commission

In relation to the appropriate discounting methodology, the European Commission guidance states the following: 'According to Annex III to the Implementing Regulation on application form and CBA methodology, for the programming period 2014-2020 the European Commission recommends that for the social discount rate **5%** is used for major projects in Cohesion countries and **3%** for the other Member States. Member States may establish a benchmark for the SDR which is different from 5% or 3%, on the condition that: i) justification is provided for this reference on the basis of an economic growth forecast and other parameters; ii) their consistent application is ensured across similar projects in the same country, region or sector. The Commission encourages MSs to provide their own benchmarks for the SDR in their guidance documents, possibly at the start of the operational programmes and then to apply it consistently in project appraisal at national level'. (EU Commission, 2015). As such, the EU Commission stipulates the use of a benchmark discount rate of 5% for cohesion countries and 3% for Member States while Member States can also establish their own relevant benchmark rate. The guidance does not set out a specified preference for one methodology over another (e.g. SRTP and SOC) and Member States are encouraged to define their own benchmark. However, it does note that the SRTP method is 'widely used in developed countries, especially European ones' and that most economists agree that the approach is 'grounded on a robust theoretical basis' (ibid).

France

The CBA Guidance in France recommends a risk free interest rate of 2.5% which then decreases to 1.5% after 2070 (the period beyond which the guidance dictates as being the residual value). In addition, the guidance stipulates a risk premium of 2% increasing to 3% after 2070. In effect, this implies an overall rate of 4.5% over the lifetime horizon. However, the guidance does state that these values are in place during a transitional period and that it is possible that the individual elements of the overall framework (discount rate and risk premium varying between time periods) will vary in the future. While not stated explicitly within the current CBA guidance, the methodology for calculating the discount rate in France appears to be in line with the Social Rate of Time Preference approach. The 2005 report which set the previous rate adopted a 4% discount rate for cash flows over a 30 year period and a 2% rate for time horizons longer than 30 years based on the Ramsey rule (Gollier, C. 2011). The rate had previously been set at 8%. In summary, appraisal practice in France appears to rely on a discount rate calculated on Social Rate of Time Preference principles, including a risk premium and elements of a declining discount rate.

Netherlands

The central CBA guidance in the Netherlands (published in 2013) states that the real risk free discount rate is calculated as being 2.5% while a general risk premium of 3% is also used (although for irreversible effects the discount rate is reduced by 1.5%) (CPB Netherlands, 2015). As such, the Netherlands employed a real discount rate of 5.5%, which can be reduced by up to 1.5% depending on project specific macroeconomic risk factor. In 2015, an update to the discount rate was provided by the Discount Rate Working Group. The analysis states that the methodology is in line with previous work and that the rate is based on market information. The overall rate was revised from 5.5% to **3%**. It states that the updated calculated rate is based on the required returns on a broad portfolio of investments in the economy, and as such is in line with the SOC theoretical underpinning. It is also stated that this rate is in line with a discount rate based on an SRTP approach. It is stated that the risk premium is 3% and, given the decline in the risk-free long term interest rate to 0, the overall rate is 3% (Netherlands Discount Rate Working Group, 2015).

The report states that, while noting the scientific debate in relation to climate change, there is no rationale for implementing a declining rate (or hyperbolic method) in Netherlands and the 3% should be applied exponentially in CBAs. It states that this is the case as there is no certainty that risk should have a declining structure (it may be constant), the risk free rate is currently very low and lower than what would be

appropriate for long maturities, it is easier to apply a single rate structure and the issues pertinent to climate change can be dealt with within CBA in a different way (ibid).

The Netherlands also utilises differential discounting with different rates for specific policy areas where this is deemed to be justified. Table 2.5 sets out the various rates that are in place across sectors. For instance, a higher discount rate for physical investments/infrastructure is stipulated as there are high fixed costs making the net benefits of the project riskier in economic terms as a result of any fluctuations in usage or demand. Meanwhile, the education sector is deemed to necessitate a higher discount rate (based on the return of one year of additional education) as the returns on education are stated as being considerably higher than the standard discount rate (ibid). Finally, the discount rate report states that the relative price of various goods and services across sectors is an important element of the overall CBA. There is an implicit assumption that prices are constant. Given the fact that different price trends may emerge adjustment is made for certain discount rates and further research on other areas is recommended (ibid). For instance a 1% increase is applied to environmental impacts prices rather than a decrease in the discount rate. Further information is provided in the note to table 2.5 below.

Table 2.5: Discount Rates in Netherlands

Category	Discount Rate
Default Rate	3%
Public Physical Investments/Infrastructure	4.5%
Nature (standard)	3%*
Nature (if substitutable)	3%
CO ₂	3%
Health (costs)	3%
Health (benefits)	3%
Education	5%

Source: Netherlands Discount Rate Working Group 2015. Note, *: Relative price changes can imply a lower effective rate. E.g. Standard environmental impacts have a reduced effective rate of 2% due to the assumed future price increase of costs/benefits (1% per annum).

New Zealand

The discount rate currently in place for use in CBA in New Zealand is based on the social opportunity cost. Analysis by the NZ Treasury details that the SOC approach to discounting has been used in New Zealand since at least 1971 and that the actual rate is calculated using a version of the tax-adjusted capital asset pricing model (CAPM) (NZ Treasury, 2008). Previous NZ Treasury research states that the SRTP method is considered to be the appropriate approach and that the SOC approach should be used where estimates of the STRP approach are unavailable or unreliable (Young, L. 2002). New Zealand also employs differential discount rates depending on the project/sector. Finally, the methodology does not include an adjustment for risk as the Government can 'subsequently levy taxpayers to meet any shortfall on a project' (NZ Treasury, 2008). The current rates are listed in Table 2.6 below.

Table 2.6: Discount Rates in New Zealand

Category	Rate
Default Rate	6%
Office and Accommodation Buildings	4%
Infrastructure and Special Purpose Buildings*	6%
Telecommunications, Media and Technology, IT, R&D	7%

Source: NZ Treasury Website³⁴. Note: *: Water, Energy, Hospitals, Hospital Energy Plans, Road and Other Transport projects

³⁴ Accessed at <http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates> on 1/11/17

The latest CBA guidance in New Zealand (NZ Treasury, 2015) highlights a preferred discounting methodology based on the long-run return on investments made by share-market companies. The stated rationale for using such a methodology is that the Government could alternatively invest the costs of the project/programme in the share market and as such the discount rate should reflect this potential alternative use of funding. However, it does not appear that this methodology is currently in use and the previously detailed social opportunity cost of capital appears to be the method used.

Norway

In Norway, the latest official guidance in relation to Cost Benefit Analysis was published in 2012. The method of discounting set out in the guidance is for a discount rate based on the opportunity cost of capital (SOC) which includes an adjustment for risk and a declines over time. The standard risk free discount rate is stated as being 2.5% over a 40 year time horizon. The level is chosen as being ‘on par with the unconditional expected return on government bonds in the Government Pension Fund Global’. The guidance estimates a risk premium of 1.5% over a 40 year time horizon to put the risk-adjusted discount rate at 4%. (Hagen et al, 2012). The guidance states that the use of a declining discount rate is justified due to increasing uncertainty over time and as ‘it is reasonable to assume that one will be unable to secure a long-term rate in the market, and the discount rate should accordingly be determined on the basis of a declining certainty-equivalent rate as the interest rate risk is supposed to increase with the time horizon’. (Hagen et al, 2012). The risk adjusted rate declines from 4% to 3% between years 40 and 75 and then 2% after year 75 as detailed in table 2.7.

Table 2.7: Discount Rates in Norway

	Year 0-40	Years 40-75	From Year 75
Risk Free Rate	2.5%	2%	2%
Risk Premium	1.5%	1%	0%
Risk Adjusted Rate	4%	3%	2%

Source: Hagen et al, 2012

United Kingdom

HM Treasury specifies a discount rate as part of its Green Book Guidance based on the social time preference rate methodology and the Ramsey Equation. In calculating the rate, the Treasury assign a value of 1.5% per year for ρ (comprises of catastrophe risk and pure time preference). They also assign a value of 1 for the elasticity of marginal utility of consumption and a value of 2% per year for annual per capita consumption growth. Using these inputs, the Treasury guidance sets a discount rate of 3.5 per cent. In addition, the Treasury also stipulate the use of a declining discount rate for time periods in excess of 30 years. They state that ‘the main rationale for declining long-term discount rates results from uncertainty about the future. This uncertainty can be shown to cause declining discount rates over time’ (HM Treasury, 2018).

In addition, further specific guidance provided by the Treasury suggests that a lower declining discount rate should be used for sensitivity analysis, in conjunction with the central declining rate, where the effects under examination are long term and involve substantial wealth transfers between generations (ibid). Finally, the Green Book also sets out that a lower discount rate is to be used for risk to health or life effects as the wealth effect of the SRTP formula is excluded and that the discount rate used for international aid may differ based on conditions within the relevant recipient country (ibid). The declining discount rate in the Treasury’s guidance is listed below.

Table 2.8: Green Book Long Term Discount Rates

Years	0-30	31-75	76-125
Standard Rate	3.50%	3.00%	2.50%
Reduced Rate (STP = 0)	3.00%	2.57%	2.14%

Source: HM Treasury 2018

USA

The approach to discounting and the actual recommended rate varies across a number of agencies in the United States (Bazon, C. and Smetters, K. 1999; Karoly, L. 2017) and this section details the approaches taken by key agencies. The Office for Management and Budget (OMB) issued a revision to circular A-94 in 1992 which listed the revised rules in relation to the 'Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs'. The guidelines apply to the appraisal of projects and programmes undertaken at a federal level. The guidance states that the real discount rate to be applied is 7%. Furthermore, the circular states that the discount rate 'approximates the marginal pre-tax rate of return on an average investment in the private sector in recent years', indicating an approach in line with the SOC (OMB, 1992). The rate had previously been set at 10%.

In 2003, the OMB issued a further circular in relation to regulatory analysis which reaffirmed the use of the 7% rate set in 1992 as a reference rate as the average rate of return on private investment remained at around 7%. The 2003 circular introduced a second rate for use in circumstance where the regulation primarily and directly affects private consumption. The second rate, set at 3%, is calculated based on the social rate of time preference basis by using the real rate of return on long term government debt as a proxy. As such, federal projects use a discount rate of both 3% and 7% based on two different approaches to discounting. The discount rate prescribed by the Congressional Budget Office was set in 1990 as part of the Federal Credit Reform Act of 1990. In the act, it is stated that 'in estimating net present values, the discount rate shall be the average interest rate on marketable Treasury securities of similar maturity to the cash flows of the direct loan or loan guarantee for which the estimate is being made' (CBO, 1990). This approach is in line with the SRTP approach (Bazon, C. and Smetters, K. 1999). The actual rate is set at 2% with sensitivity analysis of +/- 2%.

Finally, the General Accounting Office (GAO) also lists relevant guidance in relation to discounting. The discount rate recommended in the GAO guidance is for an approach based on the 'interest rate for marketable Treasury debt with maturity comparable to the program being evaluated' (GAO, 1991) with a strong emphasis put on sensitivity analysis to account for the variety of factors and the theoretical debates. This approach can again be largely equated with the SRTP method. The guidance states that analysis of intergenerational effects present a particular challenge and suggests that sensitivity analysis be carried out with very low discount rates where risk changes are not minor (ibid).

In summary, it is clear that there is a variety of practice in place with regards to discounting at a federal level in the United States with both SOC and SRTP methods used.

Table 2.9: Summary of International Practice on Social Discount Rate

Country	Method	Exponential or Hyperbolic	Risk Premium	Rate
Ireland	Social Rate of Time Preference	Exponential Rate - Constant (Hyperbolic in certain circumstances)	No	5%
Australia	Opportunity Cost of Capital (Preferred but practice varies by State)	Exponential Rate - Constant	No	No Central Rate (Generally 7%, tests at 3% and 10%)
Canada	Opportunity Cost of Capital	Exponential Rate - Constant	No	8%
European Commission	N/A	N/A	N/A	5% (Cohesion Countries) 3% (Other Member States)
France	Social Rate of Time Preference	Hyperbolic Rate - Declining (Reduced rate after 70 years)	Includes Risk Premium (2% for < 70 years, 3% for > 70 years)	4.5% (< 70 years: 2.5% DR + 2% Risk) (> 70 years: 1.5% DR + 3% Risk)
Netherlands	Opportunity Cost of Capital	Exponential Rate - Constant	Includes Risk Premium 3% of rate related to risk.	3% (Differential rates in areas, 2-5%)
New Zealand	Opportunity Cost of Capital	Exponential Rate - Constant	No	6% (Differential rates in areas, 4-7%)
Norway	Opportunity Cost of Capital	Hyperbolic Rate - Declining (Reduced rate after 40 and 75 years)	Includes Risk Premium (1.5% 0-40 years, 1% 40-75, 0% 75+)	4% (4% 0-40 years, 3% 40-75, 2% 75+)
UK	Social Rate of Time Preference	Hyperbolic Rate - Declining (Schedule of rates to 125 years)	No	3.5% (decreases 0.5% after 30, 75 and 125 years)
US	A) Opportunity Cost of Capital (Rate of return - average private sector investment) B) Social Rate of Time Preference (Rate of return - long-term Govt. debt)	Exponential Rate - Constant (Varied practice – intergenerational sensitivity analysis in GAO guidance)	No	SOC - 7% (OMB) SRTP - 3% (OMB Test) 2% (CBO) (GAO also in line with SRTP)

Source: Author’s review of previously referenced national appraisal guidance

Table 2.10 describes the analysis of national guidelines undertaken as part of this analysis. In addition, it is possible to highlight the broad approaches taken in other countries from previous meta-analyses. Table 2.10 sets out the details of the theoretical approaches taken in a number of other countries as set out in analysis by the European Commission. As is detailed, there are number of other countries in Europe that utilise the SRTP approach while the SOC method is in place in India. In addition, the analysis outlined a number of countries who take alternate approaches such as weighted average approach between SRTP and SOC (China) and use of the Government’s borrowing rate (Czech Republic and Hungary).

Table 2.10: Social Discount Rate Approaches in Other Countries (as of 2014)

Approach	Country
Social Rate of Time Preference	Germany
	Italy
	Portugal
	Slovakia
	Spain
	Sweden
Opportunity Cost of Capital	India
Weighted Average Approach	China
Government’s Borrowing Rate	Czech Republic
	Hungary

Source: European Commission, 2014

In summary, it is evident from this review of international practice that there is significant variation in terms of how countries calculate and implement discount rates across economic appraisal. This reflects the overall debates previously outlined in the literature review. As there is no theoretical consensus in terms of how to apply discounting to public policy and public economics, countries have taken a variety of approaches to the issue. In general the following key messages are evident;

- There appears to be **varying practice across countries in relation to the calculation of the SDR with some countries adopting a Social Opportunity Cost methodology and other relying on a Social Rate of Time Preference method**. It is clear that the SRTP method is favoured by many European countries however there is no definitive guide towards best practice based on the review of existing international practice.
- In terms of the use of declining discount rates, it appears that **the majority of countries utilise an exponential (or constant) rate rather than a hyperbolic (or declining rate)**. Hyperbolic discounting is used in the UK, France and Norway. It is possible that the use of hyperbolic discounting reflects recent considerations of the literature as only some of those utilising an exponential rate explicitly state reasons for not using declining rates.
- Finally, **the majority of countries do not make an explicit and separate risk adjustment within the discount rate**. France, Netherlands and Norway do make such an adjustment but the practice is not evident in other countries.

2.4 Analysis of the Social Discount Rate in an Irish Context

Having constructed an evidence base around theoretical debates and relevant international practice, the following section will set out an analysis of the appropriate application of the SDR for Ireland. In doing so, the section will consider the appropriate calculation and application of the rate.

As detailed through both the literature review and the review of international practice, the calculation of an SDR is typically undertaken through an SRTP or SOC methodology. Based on the existing evidence base, include

the review of theoretical literature and international practice, **no compelling evidence exists to change the methodology for calculating the SDR in Ireland from the existing SRTP approach.** This approach has been used in Ireland for a number of years, is utilised across a number of European states and appears to be supported generally by more recent developments in the international literature. On this basis, the analysis presented here will focus on the calculation of the SDR using the SRTP methodology.

Calculation of SDR for Ireland using SRTP Methodology

The following section details the analysis behind the calculation of the SDR in Ireland. In calculating the SDR using the SRTP methodology, it is necessary to detail the components of the Ramsey rule which is typically used within the literature. The Ramsey rule can be expressed as follows (Ramsey, F.P. 1928):

$$\text{Ramsey Rule: } r = \rho + \mu \cdot g$$

In essence it is necessary to consider two primary components: the rate at which people and society discount future consumption versus current consumption and the expected level of future growth in consumption (in tandem with the elasticity of the marginal utility of consumption). In the Ramsey rule stated above, ρ refers to the time preference element, μ refers to the elasticity of the marginal utility of consumption and g refers to the annual growth in per capita consumption. The following analysis will describe each of these components in more detail and will assess potential values in an Irish context.

Estimates of ρ

As detailed, the parameter ρ in the Ramsey rule equates to the discount people and society put on future consumption as opposed to current consumption. It captures the general element of time preference detailed throughout the paper. In calculating the value of ρ , the Treasury's Green Book outlines that it can be split into two constituent components (HM Treasury, 2018):

- Catastrophe Risk (L); and
- Pure time preference (δ).

Catastrophe risk refers to the likelihood that there will be a seismic event in the future which entails the elimination of returns from particular public investments or policies. There are a variety of examples such as war, natural disasters, technological advancement etc. By definition, this element of the parameter is difficult to quantify and presents a number of issues. The second element refers to the preference for consumption now versus consumption in the future. It attempts, as previously detailed, to capture the time preference which exists within society. There are a variety of studies which analyse the appropriate value of both catastrophe risk³⁵ and pure time preference³⁶ as highlighted in HM Treasury's Green Book. As detailed, positions in relation to this element of the SDR have been the subject of extensive disagreement throughout the theoretical literature given its linkage to philosophical and societal issues. There are a number of sources of evidence in relation to appropriate values including theoretical analysis, empirical work and international survey evidence of views in relation to this element of the SDR.

While there is significant variation across the literature in terms of the value of pure time preference assigned within analyses of the SDR from the review of literature undertaken for this project it appear that values between 1 and 3 are largely utilised with a number of sources pointing towards values around 1:

- Spackman, while detailing the differential between those who believe that time preference should be zero and those who believe it should have a positive number, states that there is little empirical

³⁵ Newbery (1992) estimates L as 1.0, Kula (1987) as 1.2, Pearce and Ulph (1995) as 1.2, OXERA (2002) as 1.1 and 1 in the near future.

³⁶ Scott (1977, 1989) estimates δ as 0.5. HM Treasury (2003) states that other literature suggests it lies between 0.0 and 0.5.

evidence on the value and that no study appears to have estimated people's views precisely (Spackman, 2015). He goes on to state that a value of 2% per annum may be too high while a value of 1% may be widely accepted (ibid).

- In the work undertaken by Evans and Sezer to estimate a discount rate for six EU Member States, the analysis states that through taking into account the disparate views in relation to the appropriate value of ρ , 'an approximate value range of 0%-2% may be considered relevant. The safest option would then be to select a central rate of 1% as being appropriate, at least for most developed countries'. (Evans and Sezer, 2005).
- In 2015, Drupp et al undertook a survey of 200 experts to gain insights into the appropriate calculation of the SDR. In relation to the time preference element of the calculation, the survey finds a median value of 0.5 and a mean or average value of 1.1 suggesting some merit in analysing figures within this range (Drupp et al, 2015). It should be noted that the modal value of responses, or the most frequent response, was zero however Drupp et al state that they cannot confirm the IPCC statement of there being a broad consensus for zero or near zero pure rate of time preference (ibid).
- Florio and Sartori state that the economic literature generally puts the estimate of the value at between 1 and 3. They highlight work by Newbery (1992), Arrow (1995) and Evans (2007) using a value of 1 for ρ and also work by Nordhaus (1993) which uses a value of 3 (Florio and Sartori, 2013).

Exemplifying the arguments within the literature there are however a number of analysts who cite a value for ρ of 0, or close to 0, as being appropriate. These arguments are typically in line with the overall critique of social discounting previously detailed in relation to ethical debates around intergenerational considerations. In his review of climate change Stern set the pure time preference element of the SDR as 0.1 and states that even this may be high given implications when interpreted purely in a catastrophic risk context (Stern, 2006). However, as previously stated there is significant debate within this space, and there are a number of critiques of arguments for very low values of ρ (e.g. Nordhaus, 2007).

In terms of research on the value of pure time preference within an Irish context there is not a large amount of detailed analysis. Florio and Sartori state that the value of ρ can be proxied by accepting the argument that the time preference element is zero and then using the annual crude death rate of the population as a proxy for the catastrophe risk element. Using this approach they estimate a value of 0.63 for Ireland in 2011³⁷ (Florio and Sartori, 2013). In analysing the appropriate value for Ireland SDR in 2011, Morgenroth utilised a value range for ρ of between 1 and 3, stating that this is often used (Morgenroth, 2011). In its 2008 guidance, the EU Commission included indicative estimates of the SDR for seven non-Cohesion Fund countries and for four Cohesion Fund countries. This analysis suggested a value for the pure time preference rate of between 0.9 and 1.1 for non-CF countries and between 1 and 1.4 for CF countries (EU Commission, 2008).

Based on the available evidence, **it is reasonable to examine a value of between 0 and 2% in the Irish context with a focus on values around 1%**. Based on this analysis, and in the absence of further Irish research, the subsequent calculation will focus on these values to reflect the issues within the literature and as there is no compelling evidence that a reasonable estimate is outside this range.

Estimates of μ

The component μ refers to the elasticity of the marginal utility of consumption. This is a measure of how much marginal utility changes in response to a change in consumption. As an individual's or country's income

³⁷ Author's own analysis estimates a 0.64 value for 2016 in Ireland based on CSO data and an average value of 0.76 between 1989 and 2016.

increases, it may be that this results in a different change for welfare than the actual increase in income. In simple terms μ measures the percentage rate at which the marginal utility falls for every percentage increase in consumption (Pearce and Ulph, 1999). The concept is derived from microeconomic theory, and is therefore the product of a high degree of mathematical abstraction; for example, even arriving at 'a euro's worth of utility' in order to assess the rate of exchange between welfare and growth is challenging. Secondly, the figure is likely to vary from person to person; 'a euro's worth of utility' is likely to be higher for someone with less money than someone with more. The goal therefore is to estimate an aggregate value.

Furthermore, observing and calculating values for μ is subject to a lot of controversy with some authors viewing it as unobservable. For those that do estimate the value, it is typically seen as either 'reflecting the views of individuals about how they wish to transfer consumption across time' or 'society's judgement about how we should transfer consumption across people at different times' (ibid). A number of methodologies for the estimation of the parameter have been applied; these generally rely on one of three approaches – direct survey methods, indirect behavioural evidence and revealed social values.

Surveys³⁸ can be employed to give insight on an appropriate value by investigating popular attitudes. However these are costly, must include a representative sample and have a wide degree of variance when carried out on different populations. As such, alternative methods of investigation have been used through analysing lifetime consumption patterns in populations. As detailed across the literature estimates of μ can be assessed by 'using surveys or it can be inferred from observation on indirect individual behaviours. People's savings, for example, can reflect their views about how much consumption they wish to transfer over time' (Florio, M. and Sartori, E. 2013). This can lead to a number of estimates for the value of the parameter. Another approach to estimating the value is to consider society's judgement about how consumption should be transferred across people at different times and is typically captured by considering national contribution of aid to developing countries or the progressivity of national personal income tax rates³⁹ (ibid). Based on a review of available evidence internationally it appears that the majority of analysis utilises a value of μ of between 1 and 2 with a particular focus on values of around 1.5:

- **Spackman** states that there has existed within the American literature a **relative consensus around the value for the marginal utility in the context of the SRTP SDR of about 1.5** and that literature in the UK has seen a convergence towards a similar figure (Spackman, 2015).
- **Groom and Maddison** utilise four different empirical methods to assess the marginal utility in the context of the UK. Their meta-analysis suggests a **value of 1.5** as being defensible within the UK and they also state that 1 (the value used within the Green Book) is within the confidence interval of the estimate (Groom and Maddison, 2018).
- **Evans** states that a number of papers across the 1990s based on micro models of lifetime consumption behaviour obtain a value of μ close to 1⁴⁰ and that more recent studies (in the mid-2000s) suggest values which are closer to 1.5 than 1⁴¹. He states that based on a consideration of a number of approaches a value for the elasticity close to 1 seems appropriate for the analysis of the EU (Evans, 2006).

³⁸ Such as those carried out by Amiel, Creedy and Hurn (1999) and Barsky et al (1995)

³⁹ Utilising a model including the assumption that the income tax structure is based on the principle of equal absolute sacrifice satisfaction and iso-elastic utility functions.

⁴⁰ Blundell et al. (1994), Attanasio and Browning (1995) and Besley and Meghir (1998)

⁴¹ Evans and Sezer (2002), Evans (2004a and 2004b), Kula (2004), Evans, Kula and Sezer (2005) and Percoco (2006)

- In work determining the SDR for six major economies in 2004, **Evans and Sezer** use values for the elasticity of **1.3** for France, **1.4** for Germany, Japan and the USA, **1.5** for the UK and **1.7** for Australia (Evans, 2004). In further work in 2005,
- In estimating the SDR for 20 EU countries, **Florio and Sartori** use a range of values for the elasticity from 1.09 to 2.31. They find an **average value of 1.5** across the countries with a slightly higher rate in non-cohesion fund countries (1.51) than cohesion fund countries (1.49) (Florio and Sartori, 2013).
- In a survey of economists views, **Drupp et al** find that the **mean value for the elasticity of marginal utility is 1.35 and the median and modal value is 1** (Drupp et al, 2015).
- In analysing the appropriate discount rate for Italy, **Percoco** utilises a number of different techniques to assess the appropriate value for the elasticity of the marginal utility of consumption. The research highlights and utilises **a range between 1.289 and 1.347** for Italy (Percoco, 2008).
- Earlier work by **Little and Mirrlees** in 1974, which is highlighted by Spackman, posited that most people would probably put μ **in the range of 1 to 3** (Spackman, 2004).
- Finally, two studies that are often cited as examples of estimates of the elasticity based on survey methods are Barsky et al (1995) and Amiel et al (1999). The first study surveyed middle-aged adults in the US and found a value of **approximately 4** and the second surveyed US students and found a value **range of 0.2-0.8** (Evans, 2005). A number of sources have stated that these results may reflect risk aversion and inequality aversion across the lifecycle.

In terms of analysis of the elasticity for Ireland, **Morgenroth** uses a value of **between 1 and 1.47** when estimating and SDR for Ireland based on previous work undertaken by **Evans** (Morgenroth, 2011). This work by Evans considers the appropriate value for the elasticity across 20 OECD countries and highlights a value of 1 for Ireland at low income levels and 1.47 at high income levels (Evans, 2006). **Florio and Sartori** highlight a particularly high value of the elasticity in their analysis of Ireland's SDR with a value of **2.31** (Florio and Sartori, 2013). The EU Commission's indicative estimates of the SDR in EU Member States in 2008 used a value of between 1.20 and 1.79 for seven non-cohesion fund countries and between 1.12 and 1.68 for four cohesion fund countries (EU Commission, 2008). In more recent analysis of SDRs across Europe, Florio and Sartori use a value range of between 1.09 and 2.31 and highlight an average of 1.5 across 20 EU countries (Florio and Sartori, 2013).

Based on the general evidence in the literature outlined here, and the relative convergence around a rate between **1 and 1.5**, it would appear **reasonable to assess a value of μ within this range** for practical purposes. This approach is in line with that suggested by Morgenroth (2011) based on Evans (2005). However, it is acknowledged that the estimation and observation of this element of the SRTP methodology is subject to relatively more critique within the literature as outlined.

Estimates of g

In estimating a discount rate using the SRTP methodology, an important component is g, the rate of per-capita consumption growth. The component captures expectations around future wealth and income and is typically measured by per-capita consumption but can also be captured by utilising other variables such as income⁴². In general the term implies, that by including expectations over future consumption growth, that future wealth levels should be reflected in the overall time preference for consumption. For instance, if future generations are expected to be wealthier than the current generation the discount rate would reflect this to an extent to account for this and the current generations relatively poorer context.

⁴² E.g. Spackman (2007) and Kula (2012) as noted by the European Commission (2013)

Typically, in analysing the value of this component, analysts look at long-run previous growth rates to take account of economic fluctuations and business cycles. For example, many analysts look at the average growth rate of consumption per capita over previous decades to assess a suitable value for g . However, using past performance to calculate the value of g may also present some difficulties as it does not consider future expectations of growth levels. As highlighted elsewhere an optimal approach may be to estimate a long-term development path for an economy (Florio, M. and Sartori, E. 2013). In practical terms, it is though worth noting that the vast majority of studies do base their valuation of this component on previous growth levels. In analysing this area in an Irish context, it is important to acknowledge the potential limitations of this. As detailed, most analyses take a long term view of growth due to economic cycles and this is particularly important for Irish analysis in the context of the economic crisis and subsequent recovery in recent years. The range of values used across estimates of the SDR obviously reflect the economic conditions of the country being analysed and therefore there is significant variation around this component of the SDR:

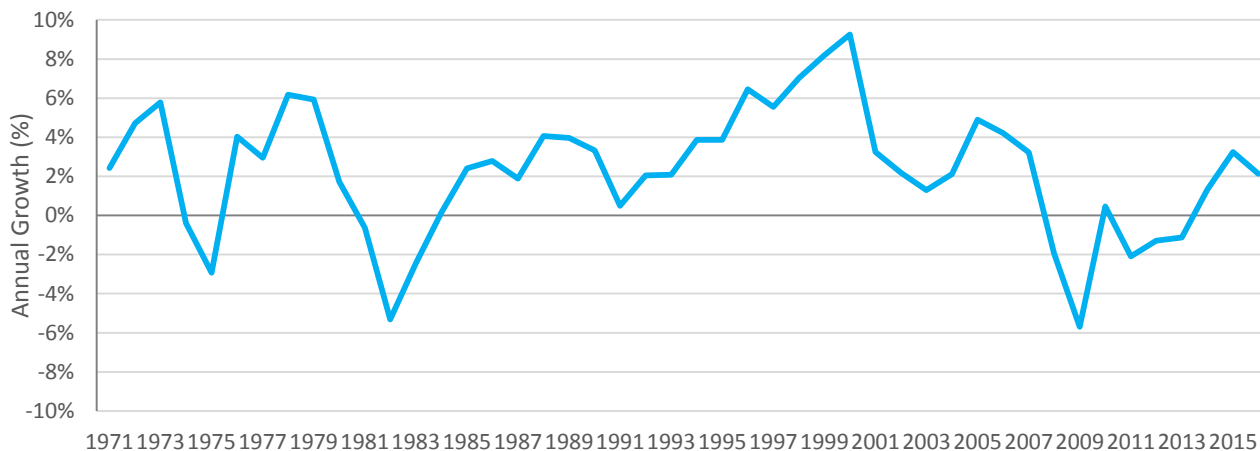
- **Maddison** looked at the long-run level of growth across the OECD and found that the **UK**, for example, had an **average growth rate of 2.1% between 1950 and 1998** (Maddison, 2001). That result was combined with analysis by HM Treasury to estimate value of 2 in the UK's case (HM Treasury, 2003).
- **Evans and Sezer**, in looking at the social discount rate across a number of countries set out the growth rate of consumption **between 1970 and 2001 to estimate the value of g and find a range of values between 1.9% and 2.5% for 6 countries** with a value of 1.9% for Australia and France, 2.1% for the UK, 2.2% for Germany and the USA and 2.5% for Japan (Evans and Sezer, 2004).
- In their analysis of EU countries, **Evans and Sezer** estimate a level of growth between **1% and 3%** for pre-2004 EU members with the majority being between **2% and 2.7%** (Evans and Sezer, 2005). In further work by **Evans** looking at the appropriate SDR for the EU, a growth rate for per capita household consumption in **Euro-zone countries between 1970 and 2004 of 2.09%** is estimated and for per capita GDP growth a value of **2.06%** is cited (Evans, 2006).
- **Florio and Sartori** estimate a range of values for g based on GPD per capita across 20 EU countries between 2000 and 2018 from **0.1% to 4.43%**. Then **average value is 1.42%** with a higher value for cohesion fund countries of 1.96 and a lower value for non-cohesion fund countries of 0.98 (Florio and Sartori, 2013).
- **Drupp et al** found a mean value of **1.7% for real growth per capita** in their survey of experts. The median value obtained from the survey was 1.6% and the modal value, or response most often provided, was 2% (Drupp et al, 2015).

Previous analyses of the SDR in an Irish context have utilised a variety of values for g . In his analysis of the appropriate rate for Ireland in 2011, **Morgenroth** estimated an average growth rate of real per capita consumption of **4.1%** based on the period between 1970 and 2010 (Morgenroth, 2011). **Florio and Sartori** estimate a value of **1.55%** for Ireland based on per capita GDP growth between 2000 and 2018 (Florio and Sartori, 2013). **Gollier and Mahul** find a mean value of **3.56%** for the growth rate of Ireland's per capita GDP (Gollier and Mahul, 2017). **Evans and Sezer** estimate a growth rate of **3%** between 1970 and 2001 in Ireland based on real per capita household consumption (Evans and Sezer, 2005).

In terms of assessing an acceptable valuation of g in an Irish context, the following sets out some analysis related to trends in past performance related to per-capita consumption growth. As previously described, this is the primary mechanism used in practice to define values for g . Figure 2.2 sets out the year on year growth rate of per capita consumption between 1970 and 2016. The analysis is based on personal consumption of goods and services from the CSO's national accounts. It should be noted that there is a break in the series in

1995⁴³. To calculate the per capita level of consumption the CSO's annual population estimates are used and the percentage annual change is then calculated.

Figure 2.2: Real Per Capita Consumption Growth in Ireland, 1970-2016



Source: Author Analysis of CSO Data. Note: Break in series in 1995 due to FISIM

As can be seen from Figure 2.2, the annual change in per capita consumption in Ireland has been volatile over time reflecting, and describing, the wider economic cycles within the economy. The series is marked by a number of years of high growth (e.g. early/late 1970s, late 1990s) and a number of years of contraction (e.g. mid 70s, early 1980s and around 2008/2009). As such, we can observe the cyclical nature of consumption growth in Ireland. This highlights the importance of analysing consumption growth in the long-run in Ireland. Based on the analysis of 1970-2016, the average growth rate of per capita consumption is calculated as **2.3%** over the time period. If one were to just analyse the period between 1970 and 2000 (i.e. before the recent economic expansion and contraction), the average growth rate in Ireland is around 3%. Finally, the average across the more recent time period between 1995 and 2016 is estimated at 2.6%.

While the analysis of past per capita consumption growth provides some evidence in relation to potentially appropriate values for g in an Irish context, it is also necessary to consider any projections of future performance. The ESRI's most recent analysis of the future of the Irish economy, outlines the results from their new structural econometric model COSMO (Core Structural Model) and estimates under their baseline projections that personal consumption will grow at an average rate of 3% per annum between 2016 and 2020 and at a rate of 2.6% per annum between 2021 and 2025 (ESRI, 2016). The analysis goes on to assess potential outcomes under a number of scenarios including Brexit. In addition, the EU Commission's Ageing Report for 2017 highlights projections for the Irish economy between 2016 and 2070. For the growth rate of potential GDP per capita, the report highlights a rate of 1.6% per annum (EU Commission, 2017).

Based on the available evidence, it is deemed appropriate to assess a range of scenarios for the value of g ranging from **1.6% to 3%**. Given the focus in the literature on using long run estimates of per capita consumption growth the SDR values obtained from the analysis of **2.3%** as the value of ρ will be focused on.

⁴³ Pre-1995 national account data does not include FISIM (Financial Intermediation Services Indirectly Measured). The effect on personal consumption appears to be small with a 0.6% difference between the 1995 value in the 1970-1995 series and the same value in the 1995-2016 series. Further information on FISIM is available on the CSPO website: <http://www.cso.ie/en/media/csoie/methods/nationalaccountsoutputandvalueaddedbyactivity/FISIMinformationnotice.pdf>

Pragmatic Calculation of Social Discount Rate for Ireland

As detailed throughout the preceding evidence, we believe that analysis based on the following values is appropriate within an Irish context:

- ρ – Between 0 and 2, with focus on values around 1
- μ – Between 1 and 1.5
- g – Focus on value of 2.3% (scenarios of 1.6%, 2.3%, 2.6% and 3%)

Appendix 1 details the results of the full analysis and shows how the range of potential values changes based on the chosen specification. Table 2.11 summarises this analysis detailing the values of the SDR under the central scenario for g of 2.3%. As discussed throughout this section, the estimation of an appropriate discount rate involves pragmatic choices with regards to specific parameters within an appropriate range. The precise estimation of parameters has long been, and will continue to be, subject to debate. Based on the research presented here, a broad range of discount rates has been set out in Table 2.14. As detailed, when the value of g is 2.3% the broad identified range of SDRs is between 2.3% to 5.5%.

As identified in the research, we believe that values of ρ around 1 are more appropriate than higher valuations. In addition, the research has identified uncertainty around the valuation of μ . **As such, we believe that an appropriate and pragmatic Social Discount Rate for Ireland would be 4% as lying between the estimates of 3.3% and 4.5%.** It should also be noted that if one were to replicate the approach taken by the UK⁴⁴ in relation to the calculation and just revise the valuation of g for Ireland, the SDR would be 3.8% as listed below.

Table 2.11: Potential Valuation of the SDR for Ireland (when g is equal to 2.3)

ρ Value	μ Value	SDR
0	1	2.3%
0.5	1	2.8%
1	1	3.3%
1.5	1	3.8%
2	1	4.3%
0	1.5	3.5%
0.5	1.5	4%
1	1.5	4.5%
1.5	1.5	5.0%
2	1.5	5.5%

Source: Author Analysis

Box 3: Calculated Social Discount Rate for Ireland

Based on collated evidence from theoretical literature, international practice and consideration of data relevant to Ireland, it is recommended that the Social Discount Rate for Ireland is calculated utilising the Social Rate of Time Preference methodology and that an appropriate and pragmatic value for use is 4%.

2.5 Analysis of Social Discount Rate Term Structure

As detailed in both the overview of theoretical literature and the review of international practice, the term structure of the discount rate (i.e. whether it is constant or varies over time) is an important consideration

⁴⁴ ρ equal to 1.5 and μ equal to 1 (HM Treasury, 2018)

within the overall discounting framework, particularly with regard to the consideration of long time horizons. In general the move to the use of declining rates over the long term is supported by academic literature and in some elements of international practice. Current advisory practice within the Public Spending Code permits hyperbolic discounting where a project has an extended time horizon. However, the guidance does not provide a schedule of rates to be used but rather asks Departments and Agencies to consult with DPER in advance. The purpose of this section is to analyse the application of declining discount rates and in particular what schedule may be appropriate for use in future iterations of the Code.

In addition to recent moves towards the implementation of declining discount rates internationally, it should be noted that there are a number of limitations and criticisms of declining discount rates as previously outlined. A report on discount rates by OXERA (2002) highlights a number of these issues including time inconsistency, the time at which decline occurs and the state preferences (OXERA, 2002). Research and debate around the calculation and application of DDRs is ongoing and there is no consensus around the most appropriate methodology for estimation of the SDR schedule. As discussed in section 2.1, the use of declining discount rates has been justified on several grounds, namely:

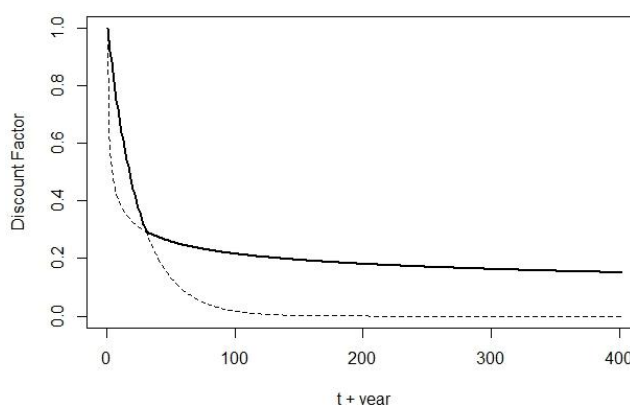
1. Based on observations of human time preference
2. The effect of uncertainty around the appropriate rate, or specific elements of the Ramsey formula
3. Concern about future rates of consumption and environmental spending, given externalities
4. Reconciling intra and intergenerational benefits

This section analyses three main approaches in the context of assessing the potential application of a DDR in Ireland and it then presents resultant findings in relation to the form and application of a DDR.

Individual Time Preference

As discussed previously, several economists have justified the use of social discounting in general, on the grounds that collective social valuing should simply be an aggregation of individual values.⁴⁵ Following this logic it has been argued that not only the rate at which individuals discount should be adapted, but also the form of the discount (be it exponential or hyperbolic). Proponents of this approach have pointed towards studies which have indicated that individual time preferences follow a hyperbolic formula more closely than the traditional exponential formula. This approach follows from the suggestion of Morgenroth (2011) of applying a pragmatic version of this methodology in an Irish context. As Morgenroth points out, while hyperbolic curves apply more weight to long-term costs and benefits, they place significantly less weight on the immediate term. This could be quite problematic as it would significantly disrupt the traditional framework for discounting for the vast majority of investments which are appraised in the near to medium term.

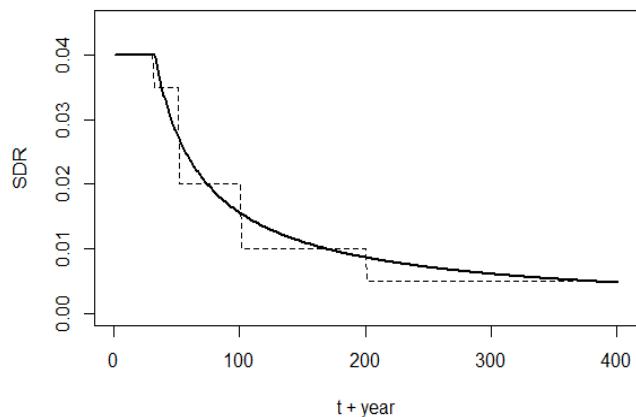
Figure 2.3: Exponential and Hyperbolic Discount Factors



⁴⁵ A position derived from a scepticism of normative valuing of humans needs and desires – instead relying on the will and preferences of individuals which, it was argued, could be glimpsed via market interactions. Examples earlier mentioned include Eckstein (1953) and Marglin (1963).

The practical solution which is suggested is a hybrid approach: use of an exponential curve in the near term (30 years), switching to a hyperbolic curve thereafter.⁴⁶ As shown in Figure 2.3, the discount factor would decrease in line with a traditional exponential curve up to year thirty, at which point the hyperbolic curve intersects. We would then switch to the weight as given along that curve. As can be seen, this would lead to significantly higher weighting of long term cost-benefits, flattening out at around 20% of the actual value, as opposed to ~0% as would be the case under exponential discounting. In terms of translating this discount factor effect into equivalent exponential values for practical discounting, as shown in Figure 2.4, the step sequence would range from 4% in the first 30 years, dropping to a SDR of 0.5% after 200 years.

Figure 2.4: Exponential and Hyperbolic Discount Rate



While this approach is a practical solution, there are weaknesses which ought to be considered. Most broadly, it is subject to the same utilitarian critique as the ‘pure time preference’ approach to discounting, namely the distinction between individual and collective, or social discounting. While an individual subject to morbidity and mortality may prefer the short term, human society which has no pre-defined life span can continue practically indefinitely. Secondly the hyperbolic function of behaviour implies dynamic inconsistency; that the preferences of the subject will change due only to the passing of time. Thirdly, for practical reasons the parameters of the hyperbolic curve in this analysis are programmed in order to intersect with the 4% exponential curve at $t = 30$. Basing the methodology around use of the hyperbolic function as a more accurate depiction of individual time-preference therefore is somewhat arbitrary.

Uncertainty

The remaining two DDR methodologies we consider here are derived from the effect of uncertainty in determining the term structure of the SDR. As discussed in the literature review, this solution is derived from observation of the arithmetic consequences of uncertainty on discounting, pointed out by Weitzman (2001). The source of uncertainty which he used in that analysis was based on a survey of economist opinion for the appropriate discount rate. As discussed, other sources of uncertainty have been identified which can provide justification for DDRs. The two sources of uncertainty which we have applied to analysis are uncertainty around the selection of the Ramsey parameters, as discussed in detail in section 2.4, and uncertainty around the rate of time preference, as reflected in long-term bond yields, as set out in Newell and Pizer (2001).

Uncertainty as derived from Long-term Bond Yield Rates

Newell and Pizer (2003) developed a declining discount rate schedule by approximating future uncertainty as revealed through changes in the rates of long term bond yields in the US. The work analysed fluctuations in the rates of long-term bond yields, which was argued, could be used to approximate society’s time preference through uncertainty. This uncertainty was then modelled and used to simulate a large number of potential future discount factors. The analysis showed that long term uncertainty around interest rates implies a declining discount rate over time. Freeman, Groom and Spackman (2018) in producing analysis for the latest update of the Green Book, state that recent research carried out in the UK and elsewhere have tended to

⁴⁶ Exponential function: $1 - r^t$ and Hyperbolic function: $1 + \alpha t^{-\gamma/\alpha}$ where $r = 0.04$, $\gamma = 1$, and $\alpha = 3.89$

provide further empirical justification for the work done by Newell and Pizer. The research studies to which they refer have shown that the results are robust to alternative methodologies, and alternative assumptions for historical US data.

Figure 2.5a Newell and Pizer (2003) Declining Social Discount Rate

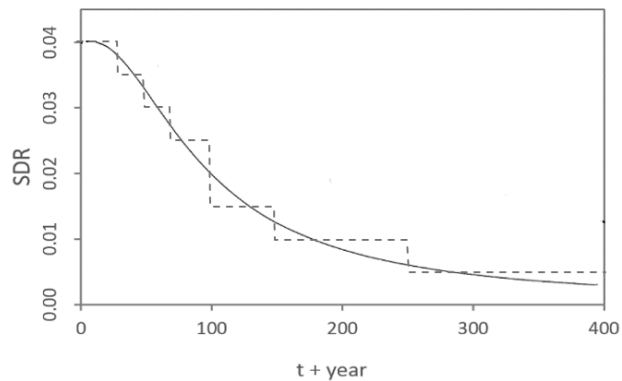
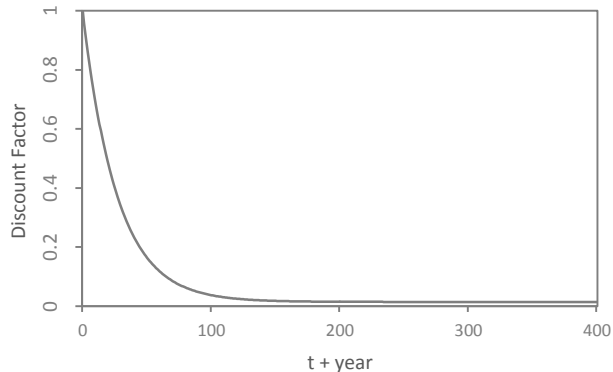


Figure 2.5b Newell and Pizer (2003) Estimated Discount Factor



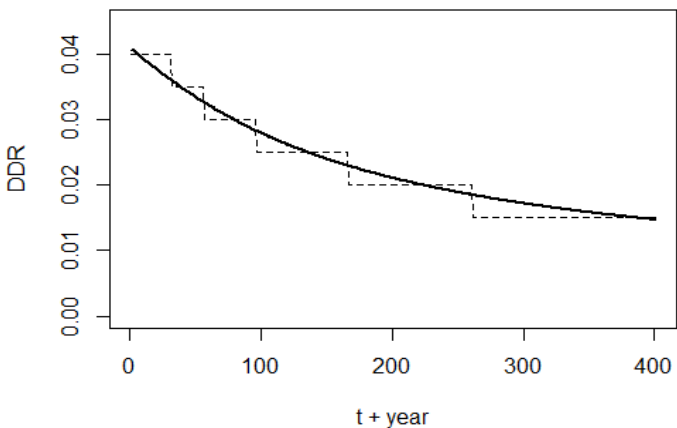
Within their analysis, Newell and Pizer estimate different models of the future discount rate, using long run interest rate data, based on a constant 4% discount rate, a mean reverting model and a random walk model. The paper states that the random walk model is the more compelling methodology.⁴⁷ Figure 2.5 displays the DDR and an approximated step factor in exponential terms, based on that methodology. As shown, the discount rate broadly declines from 4% in year 0 to 1% after year 200 and 0.5% after year 300. In addition, the graph displays an indicative step function for consistency of presentation.

Uncertainty around Ramsey Parameters

While the previous example derived a DDR from uncertainty in future bond yield rates, which was taken as a proxy for uncertainty in general time preference, the earlier discussion around the appropriate rate of discount makes clear that there is significant uncertainty around each of the parameters comprising the discount rate. Using this insight we applied a range of possible values to each of the parameters instead of a single estimation and estimated a variety of possible rates. Then taking the averaging of the resulting discount factors from these SDRs we derived an estimate of a declining rate of discount.

Recalling the Ramsey formula as the discount rate (r) being equal to the pure rate of time preference (ρ) plus the expected rate of future consumption growth (g) times the elasticity of marginal income (μ): $r = \rho + \mu * g$, the ranges for each of the values used in the estimation are given below: 15 potential growth scenarios were considered, ranging from a long-term growth rate of 1.6% to a rate of 3%. The potential values of pure time preference considered were five values, ranging from zero (no pure time preference), to 2%. Finally values between 0.2 and 2.5 were considered for the elasticity of marginal income. While this parameter had the least empirical evidence

Figure 2.6: Parameter Uncertainty Declining Discount Rate



⁴⁷ The paper states this as ‘the mean [interest] rate over the distant past is far less informative than the recent past when we forecast at any horizon in the future’ and tests for the appropriateness of the approach.

around its value and therefore the largest amount of uncertainty from our perspective, the range used is bound by the extremes of the existing empirical estimations, as discussed in section 2.4. In total 1,800 potential discount rates were estimated. The discount factors at each of the 401 time periods was calculated, and the averages used to calculate the rate of decline as given in Figure 2.6.

The result of this estimation is a DDR ranging from 4% in t=0 to around to 2.5% after 100 years. While this is more conservative in comparison to the results of the previous two methodologies, it has the attraction of being based in the ranges identified in the previous analysis of the discount rate, and is therefore methodologically coherent. The main flaw of this approach however is in the selection of the ranges for estimation; as discussed in the estimation of the discount rate arriving at specific and definite parameter values is not possible – therefore identifying ranges with absolute certainty is not possible. The ranges however serve as a reasonable estimate, based on reasonable assumptions.

Application to Ireland

Like the Social Discount Rate, the parameters which determine the schedule of a DDR will depend on the methodology employed in its estimation. While the strengths and weaknesses of methodological approaches are the main concern in arriving at a given rate from an objective as possible standpoint, comparison between the actual outputted discount factors of the different methodologies will to some degree inform selection, particularly given primary motivations for employing DDRs.⁴⁸ The choice is thus informed between consideration of both the methodological strength of a particular approach as well as giving due consideration to the potential impacts of the selection. The introduction of declining discount rates in the UK was largely based on the work done on the uncertainty of time preference reflected in long-term bond yields (i.e. Newell and Pizer) and the uncertainty about the discount rate (i.e. Weitzman); France has introduced their declining term structure based on another methodology based on the work of C. Gollier which employs uncertainty around growth. As discussed, there are caveats to each of these approaches.

The below table provides an indicative schedule of a DDR expressed in exponential terms.

Table 2.12: Potential Long Run Discount Rates and Indicative Step Schedules

Approach							
Years	0-30	31-50	51-70	71-100	101-150	150-250	251-400
Newell and Pizer	4%	3.5%	3%	2.5%	1.5%	1%	0.5%
Years	0-30	31-60	61-100		101-175	176-275	276+
Parameter Uncertainty	4%	3.5%	3%		2.5%	2%	1.5%
Years	0-30	31-50	51-100		101-200	201+	
Individual Time Preference	4%	3.5%	2%		1%	0.5%	

With regards to the three approaches discussed in this section, we find that the most theoretically coherent choice is the Parameter Uncertainty model, given its intuitive basis in uncertainty with regard to estimation of the SDR generally. However, it is acknowledged and noted that there is no one approach used within the literature. While the Newell and Pizer approach is attractive given its grounding in empirically demonstrability, the specific links between bond yield uncertainty in the USA and general social time preference in Ireland are more difficult to discern. Finally while basis in Individual Time Preference is a stark and straight-forward solution, however the selection of specific parameters governing the hyperbolic element of the curve, and the relatively arbitrary switching point at t = 30 (which has a major impact on the long-term discount factors derived) seems less robust.

⁴⁸ A general, and not unfounded disquiet regarding the potent long-term impacts of exponential discounting.

With regard to the differences between the approaches in terms of potential impact, Appendix 3 sets out an analysis of the impact of different discount rate methodologies and how they compare with international practice. As outlined in Table 2.12 and demonstrated in Appendix 3, the Individual Time Preference and Newell and Pizer approaches place considerably greater emphasis on future cost-benefit flows. While this is coherent with the reasoning in that DDRs are employed to ameliorate the severity of exponential discounting, there must still be a balance struck between consideration of consumption growth and time preference. In that sense, while the Parameter Uncertainty approach is less weighted towards the future, it is more in line with current international practice in other countries such as Norway and the UK.

We find therefore, based on our analysis and research, both of the theoretical underpinnings and the potential future impacts, that a discount rate schedule in line with that of the Parameter Uncertainty methodology would be most appropriate for adoption in the Public Spending Code. This recommendation is based on present assumptions and currently available information, and thus should be subject to change as understanding of parameter values, and the role of appraisal and discounting in dealing with long-term challenges is further developed. Furthermore, it is acknowledged that there is no one methodology that is relied on for estimation of DDRs within the literature and as such this is a pragmatic selection.

Box 3: Schedule for Social Discount Rate for Ireland

Based on analysis of potential methodologies, the research finds that an appropriate schedule of discount rates to be applied to projects which have an extended time horizon is as follows:

0-30 Years – 4%. 31-60 Years – 3.5%, 61-100 Years – 3%, 101-175 – 2.5%, 175-275 – 2%, 275+ - 1.5%

2.6 Other Considerations relevant to the Social Discount Rate

Risk and Discounting

As detailed across the review of international practice some jurisdictions make a specific adjustment to the discount rate based on the consideration of risk while other utilise a discount rate without an additional risk factor. There are a number of different elements of risk that are potentially relevant to the consideration of the discount rate. These include macroeconomic risks that reflect uncertainty in consumption growth, project risks (which may be correlated with macro risks) risks related to obsolescence and project failure (not relevant for discount rate if not systematic) and catastrophic risks related to society (Freeman, Groom and Spackman, 2018). Currently, within the Public Spending Code, the importance of adequately analysing risk is emphasised. In particular the Code recommends that risk assessment be a central part of a CBA and that this is done through the use of sensitivity analysis where key assumptions and data are tested and the impact of changes measured (DPER, 2013). The Code also currently states that ‘the discount rate should not be used as a method to account for risk. This should be addressed separately in a sensitivity and scenario analyses’.

While the appropriate and coherent analysis of risk is fundamentally important within the practice of CBA, it is not clear from within the literature and international practice that this is most appropriately dealt with within the discount rate itself. The rate, when calculated based on an SRTP methodology and including consideration of long term declines in the rate, already implicitly includes some elements of risk in so far as the rate of time preference and the uncertainty around the future (which is an underlying rationale for declining discount rates) are included. Within the context of the review of literature and practice, the consideration of risk should remain a central part of appraisal practice within the Public Spending Code but there does not appear to be a clear rationale for the addition of a risk factor to the underlying discount rate

given that the rate incorporates some of the risks highlighted and is then supplemented by project specific consideration of risk through sensitivity analysis. Given this is an area of on-going debate and research, this issue could be reviewed again in the future to reflect any further developments in practice and/or theory.

Differential Discounting

As referenced in the international practice section, some countries, such as the Netherlands and New Zealand employ differential discounting across different sectors (i.e. discounting projects at different rates, depending on their sectors). The rationale put forward for doing so is often that the *nature* of projects differ and that this should be reflected in the discount rate. For instance, the discount rate in the Netherlands is higher (4.5% as opposed to 3%) for public physical investment/infrastructure as the costs are largely fixed up front and thus the net benefit is more sensitive to changes in usage. Other arguments, such as Brouwer Werner et al (2005) have proposed discounting private or social goods at a lower level in order to reflect future increases in the value of certain goods.

However, as outlined, the theoretical basis behind the social discount rate is that it is a broad measure of society's overall preferences for consumption, including considerations of future growth. As such, there does not appear to be a clear rationale or methodology for differentiating discount rates across different sectors. In cases where benefits may be expected to have a higher value into the future, this could be dealt with on the benefit side, through value adjustment. In addition, the PSC currently states that 'it is important that a centrally set test discount rate is applied across economic appraisals and other forms of NPV analysis to ensure uniformity of approach and consistency in calculating present values across the public sector. This also facilitates the comparison of projects within and across sectors'. As such, a central standard discount rate can be seen as providing for a level of central consistency across appraisal practice and sectors.

In summary, there does not appear to currently be a clear rationale for the application of differentiated discount rates across sectors given the theoretical basis for the discount rate and the practical impact of providing consistency. Further consideration could be given to this in the future as international practice develops.

2.7 Conclusion on Social Discounting

In summary, it is evident that there is a large amount of variation in both the academic literature and international practice with regards to the discount rate applicable for any one country. The following summarises the key findings from this section:

- There is significant debate within the literature on the theoretical underpinning and calculation of the social discount rate and the analysis here demonstrates that it is necessary to come to a pragmatic view within an appropriate range based on available evidence.
- Based on a review of available evidence, 4% would be a pragmatic discount rate to be applied across economic appraisal. This rate does not include an adjustment for risk and is for use across sectors.
- In addition, the evidence suggests that it is appropriate for the discount rate to decline over longer time periods to reflect future uncertainty. Where the analysis necessitates a longer time period, the analysis carried out here suggests that an appropriate schedule would be a rate that declines from 4% to 2.5% after 100 years.

3. Time Horizon

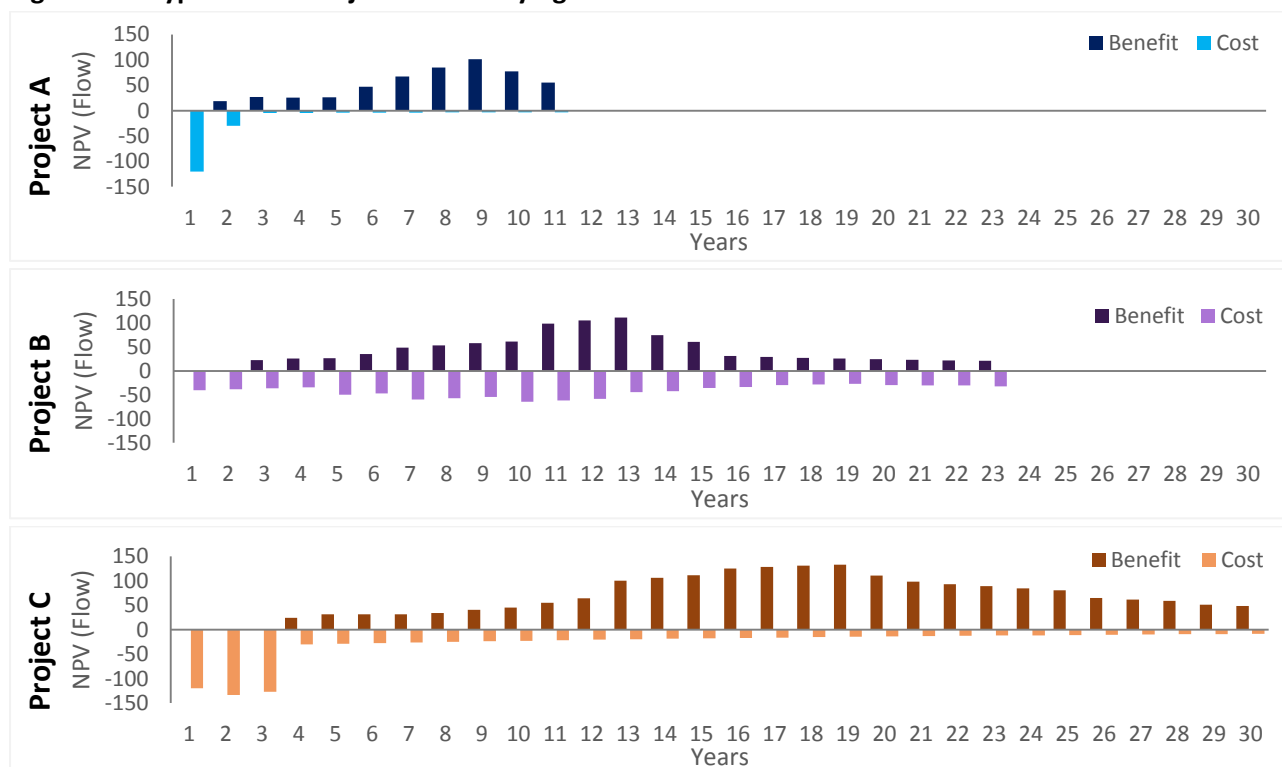
The time horizon over which an appraisal is carried out is an important element of the overall framework for analysis. The following section sets out relevant analysis in the context of assessing appropriate guidelines for time horizons within appraisal in Ireland. The section briefly sets out an overview of the concept, details of current practice within Ireland, summary details of international practice and a concluding analysis of the appropriate definition within Irish appraisal.

3.1 Overview of Conceptual Basis and Time Horizon

In carrying out economic appraisal, the methodology relies on assessing the costs and benefits of the particular intervention or project over a period of time. The period of time over which the assessment takes place can be termed the appraisal time horizon. In carrying out the appraisal, the analyst analyses flows of costs and benefits over this set period and uses discounting to compare the flows. The length of the appraisal time horizon is thus the practice of linking the appraisal methodology in terms of time span to the fundamental nature of the project or proposal.

It is evident that the time horizon for different types of projects will differ given their varying nature. For instance, the construction of a major piece of infrastructure (such as road or rail) differs significantly from an IT investment or a research and development project. Figure 3.1 highlights the flow of net impacts over the course of three hypothetical projects. As is illustrated, the net flow of benefits and costs can vary across projects and proposals with some projects implying longer time horizons and necessarily different timings in relation to the flow of significant costs and/or benefits.

Figure 3.1: Hypothetical Projects with Varying Time Horizons



As discussed elsewhere, the selection of a time horizon may introduce biases into the analysis as unreasonably long time periods could unreasonably project benefits into the future while a time horizon which is too short could reduce the future benefit/cost stream and thus impact on the final analysis (Fuguitt and Wilcox, 1999).

This highlights the importance of assessing a realistic and appropriate time horizon within CBA. In considering the time horizon, it is necessary to think about a number of elements including the lifetime and the impact period of the asset, proposal or intervention.

Approaches to Time Horizon

In setting out the broad approach to appraisal time horizons, there appears to be a number of definitions and approaches across the literature and practice from within which it is possible to observe a number of points. Firstly, a number of theoretical approaches to CBA list the time horizon as being infinite stating that all benefit and cost flows of a chosen project or intervention should be assessed. Under this approach, the focus is on flows of costs and benefits and identifying all of these over time. Secondly, there is also a view that the appraisal time frame should reflect the lifetime of the asset or project. In practice, this approach is tied to the assessment of infrastructure projects or programmes where the time horizon is seen as the operation period.

In looking at the general framework for Cost Benefit Analysis and the environment, the OECD highlight practice in CBA and in specific procedures for measuring environmental impacts such as Environmental Impact Analysis and Life Cycle Analysis (OECD, 2006). In relation to time horizons, the analysis highlights that the physical or economic lifetime of investments has traditionally been used within CBA to assess infrastructure projects but that the transition of CBAs to assessing policies presents issues for that element of the framework (ibid). Two methods for setting appraisal time horizons are discussed including the point beyond which forecast uncertainty presents a constraint and the point beyond which discounting makes further flows insignificant.

In describing the time horizon for CBA, Florio and Vignetti state that the time horizon refers to the number of years for which the inflows and outflows are provided and that although the investment horizon is in principle unlimited, in project analysis it is necessary to consider a specific point in time where virtually all assets and liabilities are liquidated simultaneously and one can determine whether the project was a success or not (Florio and Vignetti, 2013). They go on to state that this entails choosing a particular time horizon which should be appropriate to the project's economically useful life and long enough to encompass its likely mid to long term impact (ibid).

It is worth noting a number of points in relation to the approach to setting a time horizon. Firstly, for the majority of interventions, its lifetime will correspond to the period over which it has an impact. The majority of the impact should be as a result of the project or asset being in service or operational. As such, the lifetime of the asset or intervention should equate to consideration of the impacts of the project in the majority of cases. This will be further detailed in the following analysis in relation to the concept of residual values where any value or impacts beyond this time period are captured.

For the majority of infrastructure projects, the relevant flows of benefits and costs are linked to the economic lifetime of the asset. For instance, for a given infrastructure project impacts such as service benefits will cease once the infrastructure is no longer in service. However, there are exceptions to this rule which are cited including that of a nuclear power plant. While the plant may have a certain economic lifetime during which it generates benefits following its construction cost, there may be future flows beyond the economic lifetime of the asset related to decommissioning costs (See example in Oxera, 2002).

Secondly, in terms of the interaction between the practice of discounting and the time horizon, one must also be cognisant of the practical implications for the relevant time horizon for analysis. As was demonstrated in the previous section, different discount rates and term structures imply different present values for future flows. Under the practice of discounting, it is the case that there will be a future date beyond which impacts will have a negligible impact on the analysis. This point in time will vary by discount rate and term structure.

Furthermore, it is necessary to consider the challenges associated with longer term analysis. The further into the future that is being projected to analyse a project, the higher the potential level of uncertainty around forecasts of flows such as demand. The ability to accurately forecast into the future over long time periods is a general limitation within any CBA framework. Thus, in cases where the project does involve a long time horizon due care and sensitivity analysis is recommended to account for the methodological challenges.

Residual Value

Where there are remaining impacts or value beyond the appraisal time horizon, the term residual value is typically used and it is included in the CBA analysis. This is also sometimes referred to as the terminal value or horizon value. While the main analysis focuses on a detailed period, in practice there may be a value or further impact to be included in the consideration beyond this. In practice, there are generally two methods for assessing the residual value depending on the nature of the project (Jones et al, 2014):

- The remaining value of existing assets at the end of the appraisal time horizon if they were sold; and
- The discounted net flow of benefits/costs after the appraisal time horizon.

On the first point, the value can be calculated as the value of the remaining assets at the end of the project/assets economic lifetime. For example, in the construction of a piece of infrastructure, the remaining physical asset may have a value at the end of its lifetime which should be included within the analysis. There are a variety of mechanisms that are typically used to calculate the value this way. For instance, the average physical lifetime value of stock of fixed capital (such as building, machinery and equipment) is sometimes used (Jones et al, 2014). Also, a further method is the 'estimated amount that an entity would currently obtain from disposal of the asset, after deducting the estimated costs of disposal, if the asset were already of the age and in the condition expected at the end of its useful life' (ibid). In summary, this approach seeks to obtain an asset value for the remaining asset at the end of a project or asset's lifetime.

In relation to the second element, elements of the literature state that in general, the discounted value of every net future revenue after the time horizon should be included in the residual value (Florio and Vignetti, 2003). Thus, if there are flows of benefits and costs beyond the appraisal time horizon (economically useful lifetime) then these should be modelled and discounted and included as the residual value. It is typically stated that this method should be used in theory to reflect the full impact of the proposal beyond the asset lifetime (Jones et al, 2014). This is pertinent in the context of the previously discussed example of a non-typical project that has a flow occurring outside the economic lifetime of the asset (e.g. nuclear power plant). In that scenario, the residual value should reflect the discounted net present value of the future flows beyond the time horizon.

Summary

Thus, in considering the time horizon pertinent for analysis in CBA it is important to be cognisant of issues around the intervention, project or asset's lifetime, the extent and time dimension of impacts and also the classification of impacts into those that occur during the central appraisal analysis and those that occur beyond this period (e.g. residual value).

3.2 Time Horizon in Ireland

The following section sets out details of how Ireland's discount rate is currently formulated and how this has developed over time. The purpose of the section is to place the analysis of the discount rate within an appropriate historical context. For the appropriate time horizon for appraisal, the Public Spending Code currently sets out the following: **'The appraisal timeframe should be the economically useful life of the project. Infrastructure projects such as road and rail should be appraised over a twenty year period whereas productive sector projects should be appraised over shorter time period'** (DPER, 2012).

In terms of relevant sectoral guidance, there are two main notable sources. The Department of Transport, Tourism and Sport’s Common Appraisal Framework sets out detailed methodology for the conduct of appraisal for projects in the transport sector. In relation to the time period for analysis the framework states that, ‘the appraisal timeframe should be the economically useful lifetime of the project’ and that ‘transport projects such as road and rail should be appraised over a thirty year period’ (DTTas, 2016). This is in line with the typical economic lifetime assigned to transport infrastructure internationally. The Department of Business, Enterprise and Innovation has its own Economic Appraisal Model for the appraisal of enterprise grants. The last update to that model states that the model calculates the net benefits of projects across a seven year time horizon (Murphy et al. 2003)⁴⁹. The CBA guidance provided by the CSF Evaluation Unit in 1999, advised that ‘the appraisal timeframe should be the estimated economically useful life of the project. Productive sector projects should generally be appraised over a 10-year period. Infrastructure projects should generally be appraised over a 20-year period. Residual values and/or decommissioning costs at the end of the project’s useful life should be included in the analysis’ (CSF Evaluation Unit, 1999). The further appraisal guidance issued by the Department in Finance is less prescriptive in terms of the time horizon and states that costs and benefits of each option should be identified over the lifecycle of the project (D/Finance, 2005).

3.3 Time Horizon and International Practice

The following section outlines international practice from a number of countries that list relevant guidance related to time horizons typically used in economic appraisals.

The guidance for regulatory impact in **Canada** focuses on the impact time period stating that ‘the discounted present value of net benefits is the algebraic sum of the present values of the expected incremental net benefits of the policy option over and above the baseline scenario during the policy’s anticipated impact time period’. (Treasury Board of Canada, 2007). It should be noted that the Canadian guidance refers primarily to regulatory proposals and as such the guidance may be closer linked to concepts around these appraisals rather than a focus on infrastructure investments which is largely seen in other guidance noted below.

The **European Commission’s** appraisal guidance states that for the financial appraisal of projects that; ‘cash flow forecasts should cover a period appropriate to the project’s economically useful life and its likely long term impacts. The number of years for which forecasts are provided should correspond to the project’s time horizon (or reference period). The choice of time horizon affects the appraisal results. In practice, it is therefore helpful to refer to a standard benchmark, differentiated by sector and based on internationally accepted practice.

Table 3.1: European Commission Reference Benchmark Periods

Category	Reference Period (Years)
Railways and Water Supply/Sanitation	30
Roads and Waste Management	25-30
Ports and Airports	25
Urban Transport	25-30
Energy and Research and Innovation	15-25
Broadband	15-20
Business Infrastructure and Other Sectors	10-15

Source: European Commission, 2014

The Commission proposed reference periods are shown in Table 3.1. These values should be considered as including the implementation period. In the case of unusually long construction periods, longer values can be

⁴⁹ The Enterprise Appraisal Model is currently in the process of being reviewed.

adopted' (European Commission, 2014). The guidance sets out benchmark reference periods for use across a number of sectors. As can be seen different time periods apply to different types of projects ranging from 30 year time horizons for railways and water supply to 10-15 years for business infrastructure. In relation to residual values the Commission's guidance states that this must be included and that it should reflect 'the capacity of the remaining service potential of fixed assets whose economic life is not yet completely exhausted' although it is further stated that this will equate to zero (or negligible) where the time horizon is equal to the lifetime of the asset selected (European Commission, 2014).

With respect to time horizons, the **French CBA guidance** states that 'it is appropriate, in many sectors, to extend the horizon of analysis, often limited to a few decades, in order to make it coincide with, or at least approach, the lifetime of the investments in question, which may sometimes exceed a century'. (France Stratégie, 2013). The guidance goes on to state that appraisal calculations 'will be carried out by explicitly considering changes in traffic and unit values until 2070. After that, calculations will take a residual value into account, corresponding to the discount over 70 years (until 2140), when benefits will stabilise traffic and unit values, except for carbon, for which we will continue to calculate changes in the unit price according to established rules, and considering spending on maintenance and replacement that will occur because of the technical lifepath of the projects' (France Stratégie, 2013). Thus, in the case of France all projects appear to be evaluated over a long time horizon out to 2140 when analysis of the residual is included. It appears that this method includes consideration of the argument that major infrastructure projects, such as transport investments, have lifetimes in the 'order of several decades, or even centuries in certain sectors' (ibid).

The appraisal guidance set out **in the Netherlands** by the CPB includes some detail in relation to the time horizon to be used in analysis. In general, the guidance states the CBAs work with an infinite time horizon in principle necessitating a complete timeline of all costs and benefits for the future (CPB, 2013). In effect, the guidance states that the time horizon should be the period of years between the introduction of the policy or project (and thus the beginning of its impact) to the year when the impact becomes structural in nature (ibid).

The **New Zealand** CBA guidance states that in terms of the evaluation period, 'costs and benefits should be estimated for each period in the life of the project. Sometimes it is convenient to evaluate the project over less than its whole life, e.g., 10 years, but this might result in the underestimation of benefits. Whole of life evaluations are therefore preferable' (NZ Treasury, 2015). As such, the guidance states that the evaluation period utilised should be 'whole of life', tying it to the nature of the project in terms of its useful lifetime.

The CBA guidance in **Norway** makes a distinction between the project lifespan, the analysis period and residual value. The analysis period is listed as being the period for which the effects of a project are analysed in detail. When the lifespan of the project extends beyond the analysis period then a residual value is used to capture future flows. The residual value is defined as the economic net present value a project is expected to generate after the expiry of the analysis period, estimated on a rule-of-thumb basis (Norwegian Expert Committee, 2012). The guidance clearly states that the lifespan may be defined as the period during which the measure under analysis will actually be in use or of service to society. The lifespan used must reflect the period during which the measures under analysis will actually be in use or be of service to society. The lifespan therefore needs to be discussed for each project, or in sectoral guidelines within sectors where a large number of similar projects are implemented. It is appropriate for the approach within each sector to be as uniform as possible to ensure comparability between projects. The main principle should be to bring the analysis period as close to the lifespan as practicable. The guidance lists the example of roads and states that it would seem more appropriate 'to apply 40 years as the analysis period for road projects than the 25 years applied until now'.

Specifically in relation to the time horizon of projects the **UK** Green Book states that ‘costs and benefits should be calculated over the lifetime of an intervention. As a guideline, a time horizon of 10 years is a suitable working assumption for many interventions. In some cases up to 60 years may be suitable, for example for buildings and infrastructure. In all cases, the maintenance and renewal costs associated with the servicing of these assets should be included. An asset’s residual value or liability at the end of the appraisal period should also be included. A longer appraisal period may be suitable where intervention is likely to have significant social costs or benefits beyond 60 years. This should be agreed with the approving authority. Possible examples include immunisation programmes, the safe treatment and storage of nuclear waste or interventions that reduce climate change risks’ (HM Treasury, 2018). Furthermore, the guidance provides a declining schedule for the discount rate up to 125 years (ibid).

3.4 Analysis of Appraisal Time Horizon for Ireland

This section has set out the evidence in relation to the theoretical and practical aspects of appraisal time horizons. In considering the appropriate guidance to provide in an Irish context it is important to consider a number of elements. Firstly, in outlining different approaches to the definition of an impact period it is noted that there are some elements of consistency between them. For example, in the majority of cases the lifetime of the intervention or project will correspond to a period over which the impacts will be largely considered. The inclusion of a residual value beyond this includes any further value or flows. Secondly, there are limitations to the time horizon that could be considered as practical within a CBA framework. As previously outlined, these limitations include the uncertainty around long term forecasting, and the impact of discounting. In general, it is relatively clear that within the practical implementation of CBA the time horizon should be linked to the nature of the project or intervention and as such should consider the lifetime and impacts. In relation to the appropriate time horizon for appraisal the following is recommended:

Time Horizon for Analysis

- The time horizon used within appraisal analysis should be in line with the lifetime of the asset or intervention.
- The rationale for the stated time horizon should be set out in line with the nature of the project or intervention and its impacts and justified within the business case or analysis as this will typically vary on a case by case basis.

Residual Value

- Where appropriate, the analysis should include consideration of a residual value for the project which can capture any value or impacts which exist beyond the lifetime of the asset or intervention.
- The methodology behind, and rationale for, the calculation of residual values should be clearly stated within the economic appraisal.

Sectoral Values

- Where appropriate, sectoral appraisal guidance (where agreed between line Departments and DPER) should outline appropriate time horizons for projects within that sector to ensure consistency.
- As a general guide, major infrastructure projects (such as road and rail investments) should typically be appraised over a 30 year time horizon⁵⁰, other types of infrastructure projects over a 20 year period, while projects in the enterprise/productive sector over a shorter period of around 7-10 years⁵¹.

⁵⁰ In line with current guidance in the DTTaS Common Appraisal Framework

⁵¹ In line with current guidance in DBEI Economic Appraisal Model which is currently being reviewed

4. Shadow Price of Public Funds

The Shadow Price of Public Funds (SPPF) is a technical parameter applied to consequent changes in exchequer flows in the appraisal of publically funded projects/programmes, intended to reflect the economic distortions which arise as a result of the behavioural responses to tax revenue generation. It is argued that general taxation distorts net economic output by influencing labour and production decisions;⁵² the purpose of the shadow price of public funds is to attempt to estimate the extent of that distortion and incorporate it as part of the cost of a publically financed project.

The Public Spending Code, as currently drafted, states that; *'taxation is an important source of revenue for Governments. However, taxation also leads to distortions by altering the incentives faced by consumers, workers and companies, and serving to reduce the overall efficiency of activity throughout an economy. In order to take account of the distortionary impact of taxation, a shadow price must be applied reflecting the fact that taxation is a key source of funding for expenditure on projects and programmes. In other words, because Governments fund projects by raising taxes, the negative impact on the economy of this tax raising activity must be reflected in the cost appraisal of a project. Typically, the costs of a project are of course offset on the benefit side of the appraisal by valuations of impacts e.g. environmental, time savings, increased output, positive externalities etc'* (DPER, 2012).

In his work on the SPPF, Honohan (1987) begins from the assumption that most taxes are raised, not with the aim of correcting for externalities, but for revenue generation; these taxes have the effect of distorting the price system, leading to a deadweight loss in the economy. In order to justify the financing of a public project therefore, it must be shown that its benefits outweigh not just the financial costs, but also the deadweight cost of taxation. Honohan states that the SPPF is a 'factor (in this context greater than unity) by which grant and tax funds are multiplied in order to make them commensurate with private flows in the calculation. The purpose of the factor is to take account of the distortions that would be created (at the margin) by the extra taxation that would have to be imposed elsewhere in the economy in order to make good any loss of revenue arising from the project being evaluated' (Honohan, 1998). Thus, in summary and simple terms, the SPPF is a factor used in appraisal, which increases the cost of a particular project/programme to account for the economic distortion implied by revenue generation through taxation.

4.1 Overview of Literature on Shadow Price of Public Funds

The efficiency costs of taxation have been a topic of investigation within economics for over a century. The seminal theoretical insights date back to Dupuit (1844) and Jenkin (1870), however rapid development of the analytical side began in the late 1960s and early 1970s. The current literature is expansive, and varies along several dimensions such as (i) the underlying theoretical framework used in the research, (ii) the approach to empirical estimation, (iii) the tax instrument(s) under consideration, and (iv) the type/dynamic of cost under consideration. Much of the literature focuses on the *marginal cost of taxation* (the cost of raising an additional unit of revenue), whereas a smaller section focuses on the *average cost of taxation* (the welfare cost of yielding current revenues, given existing tax structures). The two, which are closely related, are frequently referred to as the *marginal excess burden of taxation* and *average or total excess burden of taxation respectively*⁵³, or more generally as the Shadow Price of Public Funds.

⁵² Though both the extent, and direction of the distortion varies depending on the source of taxation. While the vast majority of distortions are negative, some, such as Pigovian taxes (taxes on activities and goods with negative externalities) can both generate income and positively 'distort' the economy.

⁵³ The concept is also loosely referred to as the Marginal and Total Cost of Funds (MCF/TCF), Marginal Social Cost of Taxation, and Marginal and Total Welfare Cost (MWC/TWC), though with distinctions between definitions.

Pre-1960s

As noted, Jules Dupuit (1844) was the first to make the seminal theoretical insight concerning the possibility of welfare costs of taxation, through affecting the response behaviour of consumers after a change in the price signal. The French engineer considered a thought experiment in which a toll is introduced on a bridge; he detailed a hypothetical case where the revenue generated from the toll is less than the unseen loss of consumer satisfaction resulting from the toll. In further work he made pioneering observations such as that the consequent degree of lost welfare is generally a function of the square of the rate of tax (now considered a basic rule of thumb), and should the rate go beyond that point it would result in a reduction in revenue collected (preceding the now famous Laffer curve). Some decades later, unaware of Dupuit's work, the same insight was developed in the UK by fellow engineer, Fleeming Jenkin. Like Dupuit he illustrated consumer and producer welfare graphically with a supply and demand diagram, later popularised by Alfred Marshall. This method of illustration, and fundamental intuition remains essentially unchanged in modern economics, where welfare changes are represented in what are now called 'Harberger triangles'.

This theoretical basis was developed and canonised by subsequent microeconomists such as Leon Walras, Alfred Marshall, and Harold Hotelling, who debated theoretical flaws in the model such as the effect of introducing multiple goods or introducing wealth inequality. The next major development in the microeconomic theory, which circumvented the problems of the multiple good scenario and the wealth inequality effects, came from John Hicks. Hicks introduced the concepts of 'compensating variation' and 'equivalence variation', where demand curves of bundles of goods are constructed so as to maintain utility at a constant level. These have since been frequently used for measurement of deadweight loss due to their property that welfare is uniquely defined even if several prices change simultaneously, and because endogenous changes in the marginal utility of income do not affect measurements, since by definition utility levels are held constant. For example Boiteux (1951) generalised Hicksian measures of deadweight loss to situations of price distortion, where prices are a function of quantity sold. Debreau (1954) applied Hicksian demand to his new conception of deadweight loss, as the portion of resources which could be dispensed with without affecting net utility. By this time it was argued that theory had become well enough developed to consider real world estimation of the excess burden of tax. This however was complicated by set-backs as a result of developments in parallel economic fields; the development of general equilibrium theory made clear the problematic nature of analysing a given market in isolation, due to the inherent interconnectedness in the economy. Secondly, the simplifying assumption of homogenous consumers with identical preferences, necessary for Hicksian demand curves, was revealed as tenuous, given difficulties arising in defining clear social decision rules from heterogeneous consumers. These theoretical problems however would soon be addressed by expansion of strict assumptions and incorporation of GE theory.

1960s onwards

With the theory well defined, by the 1960s the problem had become finding the appropriate methodology of measuring economic distortion. The first empirical attempt was made by Harberger (1964) which he later expanded in a series of papers. Developing a simple general-equilibrium framework with clearing markets, he illustrated the negative welfare effect of taxation, even in a situation where taxpayers receive a lump-sum repayment of their tax payments. He estimated the distortionary effect of US labour tax at the time as equal to 0.4% of GNP, or \$1bn. A key result of this work was in challenging the (then commonplace) assumption that direct taxes (income tax) are preferable to indirect taxes on a net welfare basis. He set out a theoretical framework in which he imagined a government with the choice of raising revenue through either excise (indirect) tax or through a direct labour tax. Considering first the effect of raising the price of a book through an excise tax, employing his 'Harberger triangles' based on 'Harberger demand curves', he illustrated that the

welfare loss is not simply equal to the reduction in the consumption of that good. As with any price increase, it will have a substitution effect, where consumers increase consumption of another good with higher natural cost in response, thus leading to welfare loss. When one introduces a similar tax on that second good however, it will reduce the effect of the previous distortion, leading to a net benefit through equalising distortions between available goods. A similar logic applies to the use of a direct labour tax which is considered as an equal-rate tax on all goods except leisure. While this does not have the effect of distorting the consumer's choice between goods, it distorts the choice between consumption of goods and leisure, which had been unconsidered in previous analysis. In this sense he argued, an indirect tax may be on par with a direct tax in terms of its capacity to distort individual consumption choice. The welfare cost of direct taxation he denotes as: $\frac{1}{2}er^2\omega L$ where r and ωL represent the rate of income tax and net earnings respectively, and where e represents the elasticity of the supply of labour.

The framework developed by Harberger was subsequently widely employed, and further developed by economists including Auerbach (1985), Ballard et al. (1985), Browning (1987), Hausman (1981, 1985), Stuart (1984), and in the Irish context, Honohan and Irvine (1987). Ballard et al. (1985) for example, employed a multisector, dynamic general equilibrium model to calculate the marginal welfare effects of individual income taxes, corporate taxes, payroll taxes, sales and excise taxes and other smaller instruments. Through this they estimated a marginal cost of taxation from a 1% rise in revenue in the range of 17-56%. Browning (1987) employed a partial equilibrium model resulting in an estimated range between 10-300%. Stuart (1984) used a full general equilibrium model to estimate marginal welfare effects of a change in the income tax rate (then set at 42.7%). He found an estimate of about one and a half times Browning's 1976 result of 20.7%. Honohan and Irvine (1987) used a partial general equilibrium to estimate the level of deadweight loss resulting from taxation, citing a lack of estimation of other parameters which would permit the use of a full scale general equilibrium approach. They estimated an efficiency loss of around 75% due to the tax regime at the time, which differs significantly from the present context. More recently this approach was used by Auriol and Warlters (2012) to estimate the marginal cost of funds for African countries on five tax bases: domestic output, exports, imports, capital and labour in the formal sector. Their estimations range between 10% and 60% which vary between the sectors considered.

Analysis by the European Commission has looked at calculating the Marginal Cost of Public Funds across the EU and in particular focused on labour taxes and green taxes (Barrios, S. Pycroft, J. and Saveryn, B. 2013). The research employs a computable General Equilibrium Model to assess the distorting effect. The general finding of the paper is that the MCPF of green taxes is lower than labour taxes although the effect is weaker once spill over effects are included. The average MCPF (a related measure to SPPF) across the EU is 1.90 for labour taxes and 1.08 for green taxes.

The most recent major contribution to the literature was a highly influential paper published by Martin Feldstein (1999). This paper built on previous theoretical insight,⁵⁴ showed that the excess burden of income taxation may be calculated by estimating the 'taxable income elasticity', i.e. the responsiveness of the level of

⁵⁴ Hakosen (1998) derives an expression for the costs of public funds for direct labour tax and indirect consumption taxation using the shadow price approach as detailed by Drèze and Stern (1987). He finds that the shadow price of labour income tax is $\frac{1}{1+\varepsilon_L}$ where ε_L represents the uncompensated elasticity of labour supply with respect to the income tax rate. Using the same approach to derive the cost of indirect consumption tax, he obtains $\frac{1}{1+\eta_C}$ where η_C represents the compensated elasticity of demand. Both definitions of the social cost of taxation therefore are functions of the relative elasticities; the degree to which individuals are likely to respond to a tax is positively related to the distortionary impact of that tax.

taxable income to a change in the tax rate. In part due to the attractive properties of this approach (the relative availability of tax data, and that it is not necessary to account for the various channels through which tax may affect behaviour i.e. hours/effort/training) it has become the central focus on the literature relating to measurement of labour tax distortion. Feldstein finds that the previous framework underestimated the distortions generated by income tax as it failed to account for heterogeneous elasticities tax avoidance along the income spectrum, i.e. the fact that individuals on high incomes are more likely to respond to changes in the tax rate than those on low to mid-level incomes. When taking this consideration into account, he argues, the distortions as estimated by Harberger (1964) may actually be as much as ten times as large. This change in the literature marks a trend away from a general equilibrium approach to estimation and towards econometric estimation of elasticities generally. A wide range of studies have since been carried out using this approach; Dahlby and Ferde (2012) for example, estimate the marginal cost of funds for corporate tax, personal income tax and sales taxes in Canada, separated by province. They find significant variation in estimates, both between tax instruments and between provinces. The highest rate calculated was 306% in the case of corporate tax and the lowest 100%, or no distortion for sales taxes. Most recently a similar methodology was applied in an Irish context in estimating the elasticity of taxable income, as will be discussed in the following section.

The final section of this review briefly notes some of the smaller strands in the literature which may be of interest. A third strain of empirical estimation in the literature has been through the development of microsimulation models, used to generate behavioural models at different income levels within a population. Klevin and Kreiner (2006) for example, examined the extensive participation responses of labourers (i.e. labour force participation as opposed to hours worked) which were found to be more impactful on the marginal cost of funds. While most studies attempt to estimate only the conceptual deadweight loss of taxation (the productivity that failed to occur) some also attempt to include the administrative costs of tax collection (bureaucrats, legal experts, judiciary, etc.). Some works attempt to estimate this side of the costs inherent in taxation, and include them along with distortionary costs. The majority of frameworks assume the social costs of taxation to be due to the legal behavioural responses of individuals or firms. Some authors however, such as Slemrod (1994) consider the possibility of illegal tax evasion, which would affect taxable income non-linearly. Finally, while all of the above consider only the costs of taxation studies such as Thoresen, Jia, Lambert (2016) attempt to consider the general positive effect of taxation, analysing the redistributive effects on overall welfare.

While there is an established literature on the theoretical basis for the SPPF and on calculation methods, it is also relatively clear that much of the literature is fragmented given the variety of measurement approaches and definitions for the SPPF (Dahlby, 2008). Furthermore, there are critiques which have been made in terms of the use of the SPPF. For instance, Jacobs argues that the SPPF should equal one (i.e. not be applied) as the concept suffers from a number of defects⁵⁵. A recent discussion paper published by the Netherlands Bureau for Economic Policy Analysis was entitled 'Should CBA's include a Correction for the Marginal Excess Burden of Taxation?' (CPB, 2018). The paper states that there are few systematic overviews of the arguments behind the SPPF. The paper argues that the best approach for CBA is to assume that the SPPF is broadly

⁵⁵ E.g. the marginal cost of funds for lump-sum taxes is not equal to one, whereas there is no theoretical presumption that it should differ from one, given that lump-sum taxes are non-distortionary; the marginal cost of public funds for distortionary taxes is generally unrelated to the marginal excess burden of taxation, although this relationship is often suggested; and standard measures for the marginal cost of public funds for both lump-sum and distortionary taxes are disturbingly sensitive to the choice of the untaxed good in the economy (Jacobs, 2010).

counterbalanced by the benefits of redistribution from taxes. It also argues that a policy measure can be financed by an alternative source of financing to general tax revenue (e.g. toll revenue).

In summary, there is a relatively well established theoretical basis for the inclusion a shadow price of public funds in the appraisal of public projects, given the distortions implied by tax revenue - although it should be acknowledged that the literature is somewhat fragmented. Developments in the literature have mainly focused on empirical estimation of appropriate rates. The following section will detail analysis and research that has been conducted in an Irish and international context.

4.2 Previous Guidance on the Shadow Price of Public Funds in Ireland

The following section sets out developments in terms of the use and application of the shadow price of public funds in Ireland. The current Public Spending Code mandates a SPPF of 130%. The PSC states that ‘the value of the shadow price of public funds is set at 130% to take account of the deadweight effects of taxation. Therefore, relevant exchequer cash flows should be adjusted by a factor 1.3’. This value updated previous central and sectoral guidance which specified values in the range 125% to 150%’ (DPER, 2015).

Previous analysis of the SPPF in an Irish context is provided by work undertaken by Honohan. An estimate of between 1.75 to 2.44 was provided by Honohan and Irvine as the appropriate rate for Ireland in the mid-1980s (Honohan and Irvine 1987, 1990). In further work in the late 1990s, Honohan again analysed the appropriate rate and stated that ‘it would be necessary to revise the marginal cost of social funds estimate to, perhaps as low as 1.5’ to reflect the fall in top marginal tax rates and the rule of thumb that the deadweight costs of taxation are roughly proportional to the square of the tax rate (Honohan, 1998). In the 2003 update of the enterprise appraisal model, the SPPF was revised downwards from 150% to 125%. The rationale provided behind this decision was that the higher rate of income tax had fallen from 48% to 42% and the standard rate had fallen from 27% to 20% in conjunction with increased taxation thresholds at both levels between 1995 and 2001 (Murphy et al, 2003). Before the revised parameter value of 130% in 2015, practice centred on a range between the 1999 estimate of 150% and the 2003 estimate of 125%. In summary, the SPPF utilised in an Irish context has decreased significantly since the original work undertaken in the 1980s. The rate fell again marginally between 1999 and 2003 with re-estimation moving the rate from 150% to 125% however in practice these two estimates were used as a range. The PSC currently puts the rate at 130%, slightly above the 125% estimated in 2003 but below the 150% estimate in 1999.

Table 4.1: Research/Guidance on the Shadow Price of Public Funds in Ireland

Period	Source	SPPF
1987, 1990	Honohan and Irvine (1987, 1990)	175%-244%
1999	CSF Evaluation Unit: Proposed Working Rules, Honohan (1998)	150%
2003	Murphy et al (2003)	125%
Current	DPER – Public Spending Code	130%

4.3 Shadow Price of Public Funds and International Practice

The following section sets out an overview of the use of a Shadow Price of Public Funds parameter in other countries. The purpose of the section is to situate current practice in Irish appraisal within a wider international context. The approach taken across a number of countries will be outlined.

Australia

The Department of Finance and Administration published its ‘Handbook of Cost-Benefit Analysis’ in 2006. In relation to the SPPF, the guidance states that ‘the marginal excess burden of a tax is the additional value forgone when a tax rate is increased to fund certain government spending’ and that estimates for Australia are around 25 percent of revenue raised implying a shadow price of 125 percent. (Department of Finance and

Administration (Australia), 2006). The guidance further clarifies that 'cases where costs are fully recovered (such as where there is a user charge) or the resources are already committed (which is effectively so for cost-effectiveness analysis and lease-purchase analysis)' are excluded from analysis (ibid). In relation to the application of the rate, the Australian guidance states that it has not been common practice in the past to make explicit allowance for the SPPF in CBA studies, and that some implicit allowance may have been made (e.g. higher discount rates or rejecting marginally positive projects) (ibid). Finally, the guidance states that the adjustment for the SPPF (or excess tax burden) should be undertaken as part of sensitivity analysis. In summary, the Australian CBA guidance points towards an SPPF of 125% but does not appear to provide a defined central value for use across SBA analysis and also recommends that the factor is applied as part of sensitivity analysis.

European Commission

The European Commission's 'Guide to Cost-Benefit Analysis of Investment Projects' states that: '*one Euro of uncommitted income in the public sector budget may be worth more than in private hands because of the distortionary effects of taxation. Under non-optimal taxes, Marginal Cost of Public Funds (MCPF) values higher or lower than unity should be used to adjust the flows of public funds to and from the project. If there are no national guidelines on this issue, MCPF=1 is the default rule suggested in this guide*' (European Commission, 2014). Thus, the guidance states that national values for the SPPF should be utilised within Member States. Where there is no central guidance, the Commission's guidance suggests a value of 1 (i.e. no SPPF adjustment).

France

The appraisal framework outlined in France includes the application of an opportunity cost of public funds which the guidance states is part of a set of parameters which are designed to take into account the imperfections in the tax structure and the shortfall of public resources. The guidance specifically states that the opportunity cost of public funds parameter 'measures the inefficiency of the structure of the tax system' (France Appraisal Guidance, 2013). The recommended application is to 'multiply public spending on construction and maintenance and public budget revenues by the opportunity cost of public funds. The recommended value is 1.2' (ibid). To reflect the limited nature of public funding and the need for prioritisation the French guidance also includes a further factor to reflect the scarcity of public funds. This factor is applied as tax revenue does not provide sufficient resources for public spending on all projects that merit it. The recommended application is to multiply public spending on construction by the shadow price of scarce public funds. It would be appropriate to recalculate this figure frequently to reflect current conditions, but it can be set by default to 0.05 (0.07 in the case of a flat discount rate of 4.5%) (ibid). In summary, the French guidance appears to set a SPPF of 1.2 across CBA analysis. However, this is increased to 1.25 to reflect the scarcity of public funding.

Netherlands

The CPB Netherlands Bureau for Economic Policy Analysis and the PBL Netherlands Environmental Assessment Agency published their 'General Guidance for Cost-Benefit Analysis' in 2013. In relation to the SPPF, the guidance in the Netherlands terms this as the marginal cost of public funds and describes this as 'the ratio between the marginal value of the utility of income in the private sector and the value of an additional euro in tax revenue. The MCF measures the welfare loss to the economy of increasing tax revenues. Government uses tax revenues to finance its expenditure and these taxes have a disruptive effect on the economy, leading to a loss of welfare. This means the MCF is greater than one' (CPB/PBL, 2013). The guidance highlights some of the debates within the literature on the use and value of the SPPF and also states that in the case of the Netherlands, most CBAs do not take account of the SPPF in practice. Given the uncertainty across the literature in the use and value of the parameter, the appraisal guidance recommends that an SPPF of one is used until further research is undertaken into the relevance and application of the parameter in CBA.

New Zealand

The New Zealand Treasury's 'Guide to Social Cost Benefit Analysis' provides guidance in relation to the application of the Deadweight Cost of Taxation (equivalent to SPPF). The guidance states that: 'most of the costs of a project typically arise from the consumption of resources, such as labour, materials etc. But additional costs arise where the funds for the project come from taxation. Taxes encourage people to move away from things that are taxed and toward things that are not taxed or more lightly taxed. Their consumption choices are distorted away from what they would prefer in the absence of taxes. The change in the mix of consumption has an adverse welfare effect which is additional to the loss of welfare resulting directly from the loss of money that is taken away in the form of tax. This welfare loss is referred to as the deadweight cost of taxation (or sometimes as a deadweight loss, or 'excess burden')' (New Zealand Treasury, 2015). The guidance states that 'CBAs should include a deadweight cost of taxation, equal to 20% of project costs that are funded from general taxation' (i.e. 120% or 1.2) and also states that this rate is chosen in the absence of an alternative evidenced based value (ibid).

Norway

In 2012, the Cost Benefit Analysis Framework was reviewed by an expert committee. The resultant report highlights CBA practice within Norway and recommends a number of changes. In terms of SPPF, the report states that: 'many public measures concern public services that may often be difficult to fund in the market. In such cases, these measures need to be funded through taxes or user payments. Taxes will generally result in consumers and producers facing different prices. Such tax wedges will distort production and consumption decisions, thus imposing an efficiency loss on the economy. For all projects to be funded via public budgets, one should therefore calculate a tax funding cost, which is the marginal cost of collecting one additional krone in tax'. (NEC, 2012). Finally, the guidance states that 'the NOU 1997:27 Green Paper refers to calculations that estimate this cost to be about 20 percent on average' (ibid).

UK

HM Treasury's Green Book for Appraisal and Evaluation does not recommend explicitly using shadow prices and states that market prices should be used with a number of caveats (HM Treasury, 2003; Florio and Vignetti, 2009). As such, no shadow price of public funds is set out within the guidance and it is not mandated for use across appraisals and CBAs. While there is no central Departmental-wide application of the SPPF in the UK. It is noted that a number of agencies have explicitly recognised the concept including the Department for Transport and its Scottish equivalent (Spackman, 2011). It is recognised that organisations may handle the SPPF implicitly by requiring CBA benefit to cost ratios to be higher (ibid). For example, the Scottish Transport Appraisal Guidance states that BCRs should take account of the distortionary impacts of general taxation on the economy and this may imply a 30% uplift thus indicating that a BCR less than 1.3 would not be value for money (Transport Scotland, 2014). The guidance states further that as the SPPF is not included in the Green Book, then a BCR greater than 1 might be considered as worthwhile pursuing (ibid). Furthermore, specific business cases in the UK may apply the concept of SPPF⁵⁶. In summary, while the central appraisal guidance in the UK does not include reference to SPPF, it appears that the value is recognised and applied in some sectors.

USA

The federal guidance in relation to appraisal in the USA is largely set out in the Office of Management and Budget's (OMB) 'Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs'. The guidance states that as *'taxes generally distort relative prices, they impose a burden in excess of the*

⁵⁶ For example, the Department for Work and Pensions has published a Social Cost Benefit Analysis Framework (Fujiwara, 2010) which includes an SPPF of 120% within an estimated range of 117%-127% for use in sensitivity analysis.

revenues they raise' and that a reasonable estimate of the SPPF is 25 cents per dollar of revenue based on studies (OMB, 1992). The guidance thus states that costs in the form of public expenditures (from projects which are not justified on cost-saving grounds) should be multiplied by 1.25. This applies to projects with the exception of those where information clearly suggests that the excess burden is higher or lower (e.g. zero excess burden for project funded by user charges).

Table 4.2: Shadow Price of Public Funds in International CBA Guidance

Country	Parameter Term	Rate	Detail
Ireland	Shadow Price of Public Funds	130%	
Australia	Marginal Excess Burden of Tax	125%	No prescribed central value but lists research pointing towards 125%. Also, states that SPPF should be included as part of sensitivity analysis.
Canada	N/A	N/A	Appraisal guidance does not appear to include SPPF.
European Commission	Marginal Cost of Public Funds	Use National Rates; or 100%	Guidance states that Member States should utilise SPPF parameters set nationally and in the absence of same, CBAs should apply 1.
France	Opportunity Cost of Public Funds	120% 125% with scarcity of public funds	Guidance states that a factor of 1.2 should be applied for SPPF but also an additional factor of 0.05 to reflect the scarcity of public funds.
Netherlands	Marginal Cost of Public Funds	100% until further research is done	Recommends an SPPF of one (i.e. non application) until further research is undertaken due to the uncertainty in the application and value.
New Zealand	Deadweight Cost of Taxation	120%	States that 20% should be added to costs and that figure is utilised in the absence of more evidenced based estimate.
Norway	Tax Funding Cost	120%	Guidance states that SPPF should be applied and that calculations have estimated the cost to be 20% on average.
UK	Social Cost of Public Finance	N/A	Central appraisal guidance does not include SPPF but some use or recognition of parameter in certain sectors/practice.
USA	Marginal Excess Burden of Tax	125%	States that 125% should be used as within appropriate range and that higher or lower estimates may be used based on evidence.

Source: As stated throughout section

4.4 Analysis of Shadow Price of Public Funds in Ireland

As indicated in Section 4.2 above, significant theoretical analysis of the SPPF in relation to the Irish tax system was undertaken throughout the 1980s and 1990s. While empirical estimation in the Irish context has not previously been an area of research, a recent piece of work has been undertaken by the Department of Finance, the Revenue Commissioners and the ESRI on the elasticity of taxable income which provides analysis and insights which are relevant to the consideration of the SPPF⁵⁷. Using an econometric analysis of administrative Revenue data, the research analysed the responsiveness of individuals to changes in income tax (the elasticity of taxable income (ETI)).

The central estimate of the ETI is 0.168, on average, across the whole population of income taxpayers. The analysis also highlights that the results are sensitive to specification and the characteristics of the groupings under review. For example, the data employed permits differentiation between PAYE workers (ETI of 0.145)

⁵⁷ Acheson, J. Stanley, B. Kennedy, S and Morgenroth E. (Forthcoming) 'The Elasticity of Taxable Income'. ESRI and the Department of Finance Joint Research Programme on the Macro-Economy, Taxation and Banking.

and self-assessed (0.363). Taking the central estimate, the research provides an estimate of the SPPF based on the analysis carried out. The analysis states that the estimation of the elasticity of taxable income to changes in the top marginal tax rate equates to an estimate of the SPPF for income tax of 135% for all taxpayers, 132% for PAYE taxpayers and 161% for self-assessed tax payers.⁵⁸ The methodology used to estimate the SPPF is based on that outlined by Saez (2012), where the effect of an increase in the top rate of tax is simulated.

The analysis provides the first empirical assessment of tax efficiency costs in an Irish context and is a valuable input into the review of the SPPF. However, there are a number of points of note in relation to the analysis and its applicability to the consideration of the overall SPPF within the PSC. The analysis is, by definition of the scope, limited to income tax, which is one element of the overall tax base⁵⁹ and not necessarily the sole source of additional revenue generation. Furthermore, the methodology assumes additional that revenue raised is the result of a 1% increase in the top marginal tax rate; it is noted that if an alternative assumption was used i.e. that the revenue raised was from an increase in the lower marginal tax rate, that the behavioural response would be lower. Finally, it is necessary to distinguish between the focus of the research, in assessing potential marginal impacts, and the SPPF which is static in its consideration of tax. While the ETI estimates the behavioural impacts of changes to income, the SPPF refers to the distortionary impact of a given taxation regime in its entirety, rather than the effects of marginal changes.

Finally, other research carried out by the European Commission on the Marginal Cost of Public Funds across the EU for labour taxes and green taxes shows a significant variation of estimates across countries. (Barrios, S. Pycroft, J. and Saveryn, B. 2013). For Ireland, the analysis estimated a MCPF of 1.33 for labour taxes and 0.62 for green taxes. This further highlights the point that the SPPF can be differentiated by type of revenue.

4.5 Conclusion on Shadow Price of Public Funds

With regard to theory, there appears to be a reasonably strong rationale for the inclusion of the SPPF within government appraisal, however it should be noted that elements of the literature are somewhat fragmented and contested. In terms of international comparison, the current rate of 130% is slightly higher than that applied in other countries where it ranges from between 120% and 125% in Australia, France, New Zealand Norway and the USA – though one would expect variance given different tax rates and systems, as well as wage structures and socio-cultural behavioural norms. It is noted that some countries, such as the UK, do not apply any adjustment. Based on the review of theoretical literature, international practice and the research carried out in an Irish context it would appear that the 130% is still appropriate for use. The research carried out on the Elasticity of Taxable Income in Ireland and estimate of the SPPF for income tax are valuable inputs to the consideration of the SPPF. It would appear based on that research that the current rate of 130% for the entire tax base is within the bounds of reason and, in the context of the points highlighted for consideration in relation to the research above, that there is a rationale for it to be maintained at its current level.

⁵⁸ Acheson, J. Stanley, B. Kennedy, S and Morgenroth E. (Forthcoming) 'The Elasticity of Taxable Income'. ESRI and the Department of Finance Joint Research Programme on the Macro-Economy, Taxation and Banking.

⁵⁹ I.e. excludes other revenue such as USC, PRSI, Corporation Tax, VAT etc. Income tax accounted for around 31% of total Government revenue in 2016 (D/Finance Databank).

5. Shadow Price of Labour

The Shadow Price of Labour is an estimate of the net social good attributable to the creation of additional employment, applicable to CBA appraisal. In contrast to normal goods prices, which are decided through the market mechanisms of supply and demand, shadow prices are estimated based a set of assumptions about society. More formally, a shadow price is defined as the good's *social opportunity cost* - the net social gain from having one extra unit, as assessed in terms of a well-defined social criterion, representative of overall social welfare. (Drèze and Stern (1990)). Theoretically, under conditions of distortion free labour markets, the wage rate would represent both the social benefit of marginal labour output and the subjective disutility of workers exertion of effort. However, distortions in the labour market or related markets, displacement costs of moving workers between jobs, or exchequer costs to unemployment, cause a divergence between the social benefit and market price of labour. The shadow price of labour therefore represents the social value of labour.

The shadow price of labour represents the social opportunity cost of employment i.e. the potential benefit to society arising from a marginal employment. Under conditions of labour market distortion, the market and social costs of labour may differ. By estimating the degree of divergence and applying a conversion factor to the market cost of labour, one can estimate the SCL to allow for inclusion in CBA. Estimation of the SCL has been a topic of discussion in the economics since the 1960s, however 'actual estimation and practical applications of shadow pricing in general, and particularly of the [SCL], have been limited' (Del Bo et al, 2011).

The following subsections set out an analysis of international literature, practice and relevant Irish developments in assessing the appropriate rate and application of the SPL in an Irish context. The first subsection details findings from an international literature review. This is followed by details of the use of SPL in Ireland and other jurisdictions before specific analysis related to Ireland and its labour market. The section is concluded with an assessment of the appropriate use of SPL within Irish appraisal and CBA.

5.1 Overview of Literature on Shadow Price of Labour

This section provides a brief overview of some of the main contributions to the SPL theory and estimation. The main theoretical works are first discussed. These models vary in their complexity and according to the set of assumptions employed; they could be categorised as follows: partial equilibrium models, general equilibrium models, and those which incorporate extensions, such as the consideration of migration and trade. Secondly, some of the major empirical works are noted. The contribution of this work has been in attempting to estimate the SPL through a variety of techniques and welfare functions, building on the frameworks developed in theory.

One of the first theoretical analyses of the shadow wage was the contribution of Lewis (1954) who compared stylised closed and open economies with assumed unlimited supplies of labour. The model focused on analysing the relationship between labour and the benefits of capital accumulation, with the aim of elaborating a different framework to that then offered by the neo-classical and Keynesian traditions. A key finding was that in situations where capital formation is only developing (developing countries), the shadow price of labour is very high. This is because the alternative value of worker occupation is minimal, or even negative (the next best job is usually comparatively low-value farm work). This implies a positive relationship between the SPL and unemployment, or employment in low value added sectors. In short, he finds, if there is high unemployment, or a large amount of low quality employment, the SPL will be high.

Little and Mirrless (1974), develop a framework for CBA and project appraisal in developing countries. They make an important contribution to the theory behind the SPL, which is often treated as the classic starting point of the SPL discussion. Because "real wage rates are probably not very sensitive to changes in the demand for labour", they argue, they are not very useful for social assessment, and instead use of the shadow price is

more appropriate. They identify five sources of potential distortions, any of which may have the effect of separating the real wage from the SPL. These are: (i) the effects of distortions in other markets causing workers consumption to exceed their own marginal product of labour (MPL), (ii) workers being drawn from other areas of the economy which are distorted, (iii) unionisation and labour regulation, (iv) the effect of higher wages on productivity, and (v) the cost of drawing labour from rural to urban areas. The MPL represents the productive output of an additional worker in a given sector. Sectors are characterised by different levels of MPL; for example, a worker in a large industry would generally have a higher MPL than a worker in a small urban enterprise, who in turn would have an MPL higher than that of a rural farmer. Given that workers in different sectors contribute different amounts to net output, they note, this implies a differing opportunity costs to displacing workers, hence different SPLs. Their general model for conceptualising the SPL is given as such: "Whatever the direct consequences of creating an extra job, the general principle remains the same. One should try to estimate in what proportions labour is drawn from other sectors, including the wholly unemployed sector, and then estimate the resultant loss of production there. To that one adds the annual cost of compensating a worker for moving from rural to urban areas, and allowance for the human cost, if any, of any increase in the total amount of work done. Their result is the relevant net MPL." The emphasis therefore is on estimating the MPL of the sector from which labour is being drawn. This lost value then compared to the amount of additional output created in the new sector, the difference of which is used to calculate the SPL.

Marchand, Mintz, Pestieau (1984) employ a general equilibrium model to derive the shadow prices of labour and capital. They assume excess labour, three goods, and two periods. They focus on two issues in the paper: how public sector activity affects employment opportunities and market prices, and the measurement of the shadow price of capital assuming unemployment. If public sector activity does not affect market prices (creates no distortion), such as the price of labour, which has outward ripple effects in the economy, then the SPL is equivalent to the wage rate. However when public sector activity distorts prices, this has an effect throughout the economy. They consider the relation between the SPL, the market interest rate and the social discount rate, asking "whether the shadow wage of labour is less than the market rate taking into account these [consequent interventionary] effects". Under the model, interest rates remain flexible and expanding public expenditure causes a convergence between the SPL and the market wage. The distortionary effects of the lump sum taxation result in rationing in the labour market and a wedge between the gross and net costs of capital. The model illustrates the complexity, and high degree of interrelation between the SPL, the market interest rate and the discount rate, as well as the limitations of partial equilibrium approach.

Other authors have followed this approach in analysing the SPL using general full equilibrium models. While an attractive method, it not without issues however; observations tend to be burdened by complexity, and model outcomes can often deliver counter-intuitive results. Johansson (1981) proposes the use of general disequilibrium approach to generate rules for project evaluation, to be used in situations of market imbalances. He assumes a small open economy composed of five commodities: an export good, an import good, a non-traded home good, labour and money. The actors are: a single representative household, three privately owned firms and one non-profit state owned firm financed by lump sum payments. Given the quantity of commodities, there are sixteen potential disequilibrium variations. For the sake of tractability however he looks at three main cases: 'Keynesian Unemployment', 'Classical Unemployment' and 'Repressed Inflation'. He finds that the that state owned firm drives divergence between the market wage and the social opportunity cost of labour, as it can be considered an input in each of the privately owned firms production processes; in this sense the marginal productivity of labour can be viewed as a function of state activity. Honohan (1998) argues that partial state equilibrium models should be rejected in favour of general equilibrium analysis in

order to better model the entire system response. A key part of this argument is in allowing for the consideration of the effects of trade and migration between separate jurisdictions.

Harris and Todaro (1970) model migration and trade in relation to the SPL, often regarded as the seminal framework. They develop a simple static model which proposes a scenario of two regions with uneven development, between which workers are free to migrate. The less developed agrarian region (characterised by a lower MPL) has full employment, whereas the urban region has unemployment. They assume that employment levels in the urban region represent likelihood of finding employment for prospective migrants. The model finds that migration from the rural to urban region is a function of the wage differential (the difference in the marginal productivities of labour of the two regions), and that the wage rate in the urban region is a function of unemployment. A higher wage differential will induce migration flows to the urban region and hence maintain the positive unemployment rate. The implication therefore is that due to the possibility of inward migration, despite positive unemployment in the urban region, the shadow wage will equal the market wage. While this model has been criticised due to its reliance on strong assumptions, its findings are backed up by works such as Heady (1981) which may be viewed as a demonstration of the robustness of Harris and Todaro's result.

Harberger (1971) discusses the role of migration and its effect on the SPL, drawing reference to empirical studies of chronic unemployment in Panama. Considering the Little and Mirrless conception of SPL - the "commonly held notion that the opportunity cost of labour is represented by the product that is forgone from other activities as a consequence of its being labour for a given activity", he rejects the idea that labour may be displaced from agrarian sector without affecting the productivity of the agricultural sector. This, he argues is due to the role of migration, which is modelled as an equalising mechanism; migration will continue from the periphery to the core until rural wages are equal to expected urban wages. The shadow wage therefore will equal the market wage if unemployment remains static.

Building on the theoretical framework, many empirical efforts have aimed at estimating the SPL in real existing economies. Most approaches depend on analysing microdata and using constrained optimisation and regression analysis to derive an estimate of the SPL. Several studies have examined shadow wages by focusing on the MPL of agrarian workers in developing countries. Examples such as these include Skoufias (1994) who uses data collected from small family farms in six small Indian villages during the rainy season crop cycle from 1975-79. The analysis estimates SPL conversion factor at 0.83 for males and 0.63 for females. Jacoby (1993) which first implemented this approach uses data from the Peruvian highlands from the mid-1980s and finds conversion factors of between 0.37 and 0.58. Lal (1979) in estimating shadow prices for Jamaica estimates a conversion factor of 0.73. Londero (2003) uses data from Columbia which is categorised into skilled and unskilled labour, foreign labour, administrative and professional jobs. He arrives at various conversion rates ranging from 0.41 to 1.

As explored in the Harris-Todaro framework, the SPL can be considered as a function of the divergences in labour productivity between economic sectors/regions defined by their dominant economic sector. This explains why a key part of the literature focusses on developing countries, which generally industrialise asymmetrically, therefore generating a shadow wage well below the market wage. Shadow wages also form a part of analysis in the case of industrialised countries however, where emphasis is generally placed directly on different categories of work and on migration. Honohan (1998) aims to determine the sensitivity of unemployment to job creation by using macroeconomic models to estimate the reduction in unemployment resulting from expansion in industrial employment. He finds that the initial reduction in unemployment due to job creation is eroded over time by the effects of immigration (in line with the key finding of the Harris and

Todoro model). The SPL is estimated as the NPV of the effect of increased employment divided by the NPV of the effect of a reduction in unemployment. Even if granting a shadow wage of zero to an unemployed individual, it is found that a SPL conversion factor below 0.8 cannot be supported by the findings. Picazo-Tadeo, Reig-Martinez (2005) calculate the shadow wages for family labour in agriculture. Using the duality between input distance and cost functions, they utilise the input distance to derive the individual labour shadow prices for a sample of Spanish citrus fruit producers, arriving at a conversion factor of 0.68. Del Bo, C., Florio, C., Florio, M. (2011) derive estimate shadow wages and conversion factors at the regional level in the EU based on spatial economic, structural and labour market factors, by developing a set of 'short-cut' formulae based on theoretical grounds.

5.2 Shadow Price of Labour in Ireland

The purpose of this section is to highlight the current and previous application of the SPL in an Irish context. It first details the application of the parameter in the current Public Spending Code before highlighting approaches in previous central guidance and other Irish practice. Current practice, as set out in the Public Spending Code, is detailed in Box 4 below. In summary, the guidance sets a range for the SPL between 80% and 100% where use is justified and analysts are advised to select a rate within this range based on evidence on a number of dimensions including sectoral and regional employment etc.

Box 4: Shadow Price of Labour and Public Spending Code

The Public Spending Code, as currently drafted, states that; in estimating the labour costs for a project, the market rate may not always be appropriate due to distortions and imperfections in the labour market. The social opportunity cost of labour resource may be lower than the market rate due to underemployed resources and a shadow price can be applied to reflect this – usually a percentage of the actual price for labour. This note outlines the acceptable range for applying a shadow price for labour on projects.

As a starting point, market rates for labour costs should be used unless there is clear evidence that shadow prices are required. Where shadow prices are being applied and can be justified, a range of 80% to 100% has been set for the shadow price of labour. With this new range, 80% becomes the minimum shadow price of labour which must be applied in appraisals.

Those involved in the preparation of economic appraisals should apply rates within the 80% to 100% range based on objective evidence and criteria, focussing in particular, on sectoral conditions. Sensitivity analysis must always be conducted on the upper bound of the scale i.e. 100%. This range of acceptable values is consistent with previous centrally-set rules.

In addition, the shadow price of labour should be applied to the cost component of economic appraisals and not to the benefits'.

(Source: Public Spending Code)

In relation to shadow prices in general, previous Department of Finance appraisal guidance did not provide specific values for use. The guidance advocates that market prices are used, as they are generally reliable, unless there are clear reasons not to. It did however note that where shadow prices are used that it is important that the same, or at least similar values are used within sectors, and advised appraisers to consult with the Department of Finance. The guidance goes on to provide the example that when there is high unemployment it could be argued that the market cost of employment should be reduced by a lower shadow price (D/Finance, 2005).

The Working Rules for Cost-Benefit Analysis state that labour costs should generally be included at market prices unless an explicit case can be made for shadow pricing. Where shadow pricing is undertaken the guidance states that the minimum appropriate value would be 80% and that this should always be accompanied by a sensitivity analysis compiled at 100%. The Working Rules for CBA thus highlight a range of values equivalent to that set out currently in the Public Spending Code (CSF Evaluation Unit. 1999).

In the update of the enterprise appraisal model carried out by Murphy et al in 2003, the issue of the appropriate SPL was assessed. This analysis updated the previous work undertaken by Honohan and given the improvements in the labour market at the time, recommended rates of between 90% and 100%. The analysis also provided a regional distinction to the application of the SPL. For example, the analysis included a rate of 80% for the BMW region, a rate of 100% for Dublin and a rate of 95% for the rest of Ireland. The guidance also details that the use of the SPL should vary based on the extent to which the average wage associated with the investment is higher/lower than the average industrial wage in the region and implied a range of between 90%-100% for Dublin, between 80%-100% for the BMW region and between 85%-100% for the rest of the state (Murphy et al, 2003). In terms of updating the SPL, the paper made the following recommendation highlighting the link between the SPL and the labour market; the SPL 'should be reduced if the unemployment rate is $\geq 6\%$ for a minimum of 4 consecutive quarters. When this occurs, the values of the SPL should be reduced by 2 p.p. for every p.p. by which the unemployment rate exceeds 6%' (ibid).

Previous analysis of CBA issues undertaken by Honohan included a specific section on the calculation of the shadow wage. The analysis also states that shadow prices used within an Irish context previous to this were very low by international standards (95% in Canada, 100% in UK) with zero opportunity cost for employees from other countries and the opportunity cost was equal to the market rate for those coming from employment in services, agriculture or manufacturing implying a rate of around 40%. According to Honohan's research, the SPL was subsequently set at 15% of the market wage. (Honohan, 1996).

Honohan's analysis states that a key consideration for the SPL is that of migration, arguing that 'even in the presence of involuntary unemployment, migration could fully eliminate any gap between shadow wage and market wage except to the extent that job creation does have an impact on unemployment' (ibid). This general theory posited here is that for the shadow wage to be lower than the market rate would require the unemployment rate to be sensitive to the level of domestic employment. It is argued that this is not necessarily the case given the close relationship between the Irish and UK labour markets and the impact of migration (ibid). Based on analysis, Honohan states that the shadow wage is equal to 80% at a minimum, given that job creation does have a temporary effect on unemployment and is largely consistent with the theory that there is a small permanent effect of job creation on unemployment (ibid).

In summary, the application of SPL within an Irish context has a tradition of a number of years. In the 1980s, the SPL was low by international standards at between 15% and 40%. Subsequent analysis by Honohan saw the minimum benchmark being increased to 80% while Murphy et al introduced some regional nuance to this but assumed a similar range of values between 90% and 100%. Central guidance provided by the CSF Evaluation Unit put the range of appropriate SPL values at 80% to 100% and the current Public Spending Code sets the range at the same values.

5.3 Shadow Price of Labour and International Practice

The following section sets out an overview of the use of a Shadow Price of Labour parameter in other countries. The purpose of the section is to situate current practice in Irish appraisal within a wider international context.

Australia

The Department of Finance and Administration published its 'Handbook of Cost-Benefit Analysis' in 2006. In relation to the SPL, the guidance states that the valuation of labour inputs merits specific consideration given the complex issues pertaining to labour markets and unemployment. The guidance provides two examples:

- If markets are perfectly competitive, labour can be regarded as similar to any other project input that is subject to tax and should be priced at market rates (willingness to pay)
- If a project increases the supply of labour, the shadow price of labour is the net of tax wage which reflects the cost of attracting labour to forgo the alternative of leisure and/or unpaid work.

The guidance goes on to state that the shadow price of labour is likely to, at a minimum, equal the value of unemployment benefits plus some amount in compensation for forgone leisure given that some workers may be willing to accept a take-home wage which is below the net of tax wage rather than remain unemployed and people place a positive value on leisure or unpaid work (zero opportunity cost in employing unemployed labour). Finally, the guidance states that the choice of a precise figure can be somewhat arbitrary and care should be taken and that analysts should generally assume that labour is fully employed (Commonwealth of Australia (Department of Finance and Administration), 2006).

Canada

In terms of the shadow price of labour, the appraisal guidance in Canada states that labour market externalities may be created by interventions and the opportunity cost of workers who fill new jobs or are displaced from existing employment are not necessarily the same as the market rate. The guidance further states that the difference between the opportunity cost and the market rate will vary based on the type of skills required, labour market unemployment rates, and the duration of the jobs⁶⁰ (Treasury Board of Canada, 2007). Finally, all costs should be based on the resource or opportunity costs and not just the financial costs of goods and services. As such, the Canadian guidance acknowledges the existence of labour market externalities that would imply a shadow price of labour and that all inputs should be measured at opportunity cost (i.e. using SPL) but the guidance does not specify a particular rate for use.

European Commission

The European Commission's 'Guide to Cost-Benefit Analysis of Investment Projects' provides a detailed annex in relation to shadow wages (SPL). The guidance states that due to the previous discussed labour market imperfections etc. that in the financial analysis it is appropriate to value labour inputs at the market wage rate while in economic analysis a shadow wage should be used to reflect the social opportunity cost. The Commission's guidance sets out a methodology for assessing national shadow wages and also provides estimates across the EU at NUTS-II level. The guidance states that Member States are encouraged to develop their own national/regional benchmarks following the approaches detailed in the document. In summary, the EU Commission does not set a recommended SPL parameter for use in appraisal but does state the need to use them and encourages the development of rates based on national data.

Netherlands

The CPB Netherlands Bureau for Economic Policy Analysis and the PBL Netherlands Environmental Assessment Agency published their 'General Guidance for Cost-Benefit Analysis' in 2013. The guidance does not provide specific advice in relation to the SPL. It does, however briefly consider labour market effects and CBA. The guidance states that where a project is directly aimed at having an effect in the labour market, the relevant benefits in terms of either enhancing productivity or increasing labour supply should be captured. In situations

⁶⁰ The guidance states that temporary jobs imply a significantly higher opportunity cost than permanent jobs as permanent jobs tend to mean that little or no unemployment insurance will be claimed.

where projects have an indirect impact on the labour market (such as a temporary increase in demand) there is generally no effect on welfare unless there is an impact on productivity or there is involuntary unemployment (in which case there can be temporary welfare gains) (CPB, 2013).

New Zealand

The New Zealand Treasury's 'Guide to Social Cost Benefit Analysis' provides guidance in relation to the application of the opportunity cost of labour stating that:

- A CBA should generally assume that the opportunity cost of labour is the going wage rate.
- However, to the extent there is unemployment in the relevant skill classes in the project's catchment area, the opportunity cost of labour can be assumed to be half the going wage rate for the skills that the project employs (New Zealand Treasury, 2015).

The rationale provided for this is that for those who are unemployed the value placed on leisure is assumed to be roughly half the going wage rate. The Guidance states that it is inappropriate to assume that no value is placed upon leisure. As such, the NZ guidance sets a SPL of between 50% and 100% depending on interaction of the employment levels and the overall labour market context.

UK

The Green Book produced by HM Treasury does not provide a lot of information in the area of shadow pricing. Indeed, the guidance does not specify a value to be applied in the case of SPL. The guidance explicitly states that costs and benefits should be normally based on market prices as they reflect the opportunity costs. Annex 1 of the Guidance sets out a description of a number of economic concepts that should be kept in mind when considering Government interventions such as economic efficiency, equity, externalities etc. In the material related to additionality, the Guidance states that when 'assessing the level of displacement of an employment creation programme or the impact of recruitment and redundancy decisions on a particular local area, it is necessary to examine the characteristics of the jobs created, or protected, in relation to the characteristics of the local labour market. They must then be compared with similar jobs in other local areas that are not subject to the policy. Such a comparison establishes the 'do nothing' case: what would have happened if the intervention had not gone ahead' (HM Treasury, 2003).

USA

The federal guidance in relation to appraisal in the USA is largely set out in the Office of Management and Budget's (OMB) 'Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs'. In relation to the SPL, the guidance (both 1992 and 2003 iterations) do not appear to specifically highlight the application of SPL. However, the guidance does state that costs should 'reflect the opportunity cost of any resources used, measured by the return to those resources in their most productive application elsewhere' (OMB, 1992).

In summary, it appears that a number of countries do consider and/or apply a shadow price of labour within CBA guidance. However, consideration and/or application of a shadow price of public funds was not evident in a number of guidance materials including France, Netherlands, Norway, the UK and the USA and as such the application of an SPL does not appear to be a universal practice.

Table 5.1: Shadow Price of Labour in International CBA Guidance

Country	Parameter	Rate	Detail
Ireland	Shadow Price of Labour	80-100%	
Australia	Shadow Price of Labour	No set parameter	Minimum is equal to value of unemployment benefits plus some amount in compensation for forgone leisure
Canada	Opportunity Cost of Labour	No set parameter	Acknowledges need for SPL and states that opportunity costs should be used. However, no rate provided.
European Commission	Shadow Wage	Use National Rates (Estimated range is 54%-99%)	Guidance states that national rates should be developed and applied and provides methodology.
France	N/A	N/A	
Netherlands	N/A	N/A	
New Zealand	Opportunity Cost of Labour	100% (50% where relevant sectoral unemployment)	Market rate to generally be used but for involuntarily unemployed with relevant skills then SPL is 50%.
Norway	N/A	N/A	
UK	N/A	N/A	
USA	N/A	N/A	

Source: Various referenced national guidelines

5.4 Analysis of Shadow Price of Labour in Ireland

Having outlined the relevant literature and international practice, the following section considers the relevant application of the shadow price of labour in an Irish context.

Based on the previous analysis of the use of the SPL it is clear that there is a tradition of using the parameter within Ireland where required with early work by Honohan and further updates through both central guidance and other sectoral work (e.g. Murphy et al, 2003). Furthermore, it is clear from the review of the literature that there is a theoretical rationale for the use of the parameter in specific circumstances related to the actual social implications of additional labour and how this can be different to the market rates for employment. It is noted however, that in reviewing international appraisal guidelines, there appears to be significant divergence in relation to the SPL with a number of guidelines not including consideration of the parameter.

As previously highlighted within the literature review, there are a variety of mechanisms that have been used to analyse the appropriate estimate of the SPL. These range from theoretical models of the employment market to empirical analysis either based on detailed micro level data or higher level approaches that aim to provide reliable estimates of the SPL through a shortcut approach. As detailed elsewhere the actual analysis of empirical estimates of the SPL are not that common (Del Bo et al, 2011) and providing an assessment of potential rates empirically for Ireland is beyond the scope of this paper. However, it is acknowledged that this should be an avenue for future research given the fact that the last empirical estimate for the SPL specifically in Ireland was undertaken by Honohan in the 1990s while some analysis has been done at a European level to

analyse appropriate SPL values across member states (EU Commission, 2013). The European Commission's guidance provides estimates for the SPL across the EU at NUTS-II level. For Ireland, the identified rates are 99% for the Southern and Eastern NUTS-II Region and 80% for Border, Midland and Western NUTS-II Region (ibid).

Given the identified evidence, it is deemed that it is still appropriate to apply a shadow price of labour in appraisal practice within Ireland where this is justified. Given that empirical estimation of an appropriate SPL is beyond the scope of this particular paper, the remainder of this section considers developments in the Irish labour market and any implications this may have for the appropriate rate and application of SPL within the current context.

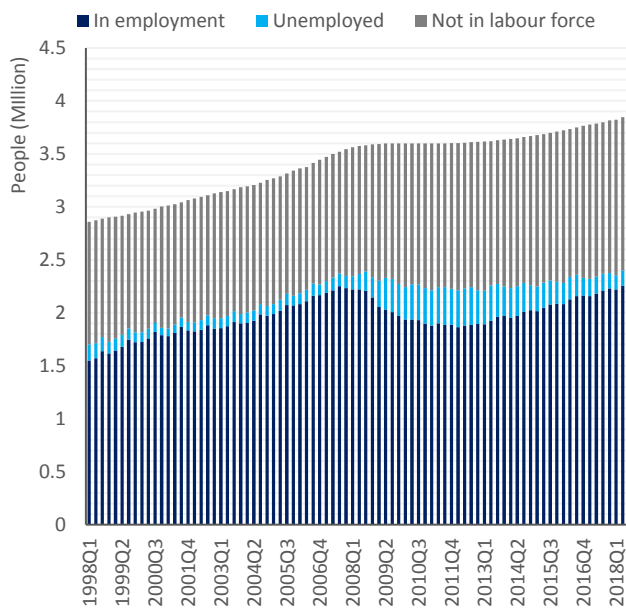
Overview of Labour Market Developments in Ireland

While analysed in greater detail elsewhere, it is necessary to briefly consider developments in the Irish labour market in recent years. This is an important consideration given the links between the estimated shadow price of labour and wider labour market developments such as employment, unemployment and labour market participation. At a high level, it can be seen that there has been a significant positive improvement in the Irish labour market in recent years in line with the wider economic recovery. This recovery has occurred in the context of significant negative developments in the period between 2008 and 2012 after the financial crisis. The total number of people in employment is over 2.2 million and this is slightly higher than the previous peak level of employment in 2007 as demonstrated in Figure 5.1. The number of people in employment has increased by around 375,000 or 20% since the trough in 2011. This is further reflected in the unemployment rate in Figure 5.2 which has decreased from 15.9% in 2011 to 5.8% in Q2 2018. However, the participation rate has remained relatively static since 2011 at around 62%.

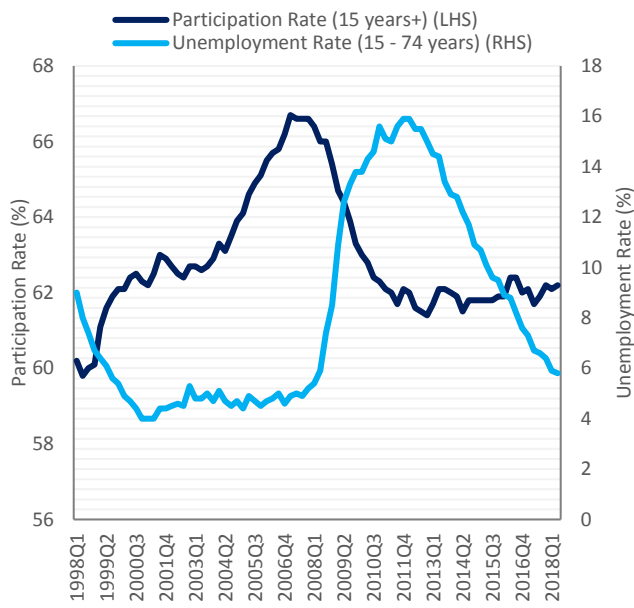
While at a national level it is evident that there has been a significant improvement in the labour market, it is the case that performance varies across a number of dimensions including sector and region. For example, the unemployment rate and participation rate in Dublin in Q2 2018 (5.3% and 66.2% respectively) is significantly different from other regions such as the Midland region (9.7% and 58.8% respectively) and thus from the national average (6% and 62.3% respectively). In addition, the level of skills availability and unemployment related to sectors varies and will change over time. For example, there was a notable and well documented decline in the number of people employed in the construction sector following the economic crash and while remaining significantly below previous levels, this has started to increase in recent years.

Previous work carried out in Ireland on the Shadow Price of Labour has acknowledged the impact of the wider labour market on the appropriate value of the SPL within Ireland. As previously highlighted, work by Murphy et al on the appropriate SPL for Ireland stated a close link between labour market performance and the SPL valuation implying that the SPL should be reduced by 2 percentage points for every percentage point that unemployment exceeds 6%. As Honohan notes, the status of the Irish labour market is not the only important factor in determining the SPL as one must also take account of the high labour mobility exhibited in Ireland (Honohan, 1996). However, in general low levels of unemployment and tightening within the labour market would imply the use of a higher SPL. While such considerations should be reflected in the guidance it is still deemed appropriate to set a range for the SPL given the necessary considerations related to the specifics of the project, sector and region.

Figures 5.1 and 5.2: Labour Market Status and Unemployment/Participation Rate, 1998Q1-2018Q2



Source: CSO LFS



Source: CSO LFS. Note: Seasonally Adjusted

5.5 Conclusion on Shadow Price of Labour

The shadow price of labour has been set at between 80 and 100% in Ireland for a number of years with guidance that market rates for labour costs should be used unless there is clear evidence that shadow prices are required. Given the evidence gathered and the lack of updated empirical work, there is no rationale for significantly changing the application of the parameter in an Irish context.

The work by Honohan defined empirically the relevant SPL in Ireland as not being less than 80%. Furthermore, the European Commission’s guidance provides estimates for the SPL across the EU at NUTS-II level. For Ireland, the identified rates are 99% for the Southern and Eastern NUTS-II Region and 80% for Border, Midland and Western NUTS-II Region (EU Commission, 2013). In the absence of more recent empirical analysis of the SPL in Ireland, it is deemed appropriate to maintain the 80%-100% range within appraisal guidance. However, in terms of application it would be appropriate for the guidance to emphasise the default rate of 100% and to stress the importance of justifying any rate chosen which is lower than that taking into consideration the labour market context from a number of perspectives, given the outlined trends above.

6. Summary

This paper has provided an overview of available evidence across the theoretical literature, practice within Ireland, international practice and relevant data on four central technical appraisal parameters. The following key findings are evident:

Discount Rate

Based on a Social Rate of Time Preference methodology, an appropriate value for the Social Discount Rate in Ireland is **4%**. This is a 1 percentage point decrease from the current discount rate and in line with the rate previously in use in Ireland between 2007 and 2015. In addition, based on recent literature and practice the rate can adopt a declining term structure over long time horizons.

Time Horizon

The relevant time horizon for analysis should be set having regard to the **asset, project or intervention's lifetime** taking into account its nature and impacts. A residual value, to capture any impacts/values beyond the lifetime, should also be included.

Shadow Price of Public Funds (SPPF)

An appropriate valuation for the Shadow Price of Public Funds for application remains **130%** and the parameter should continue to apply to public funding within economic appraisals to reflect distortions related to taxation.

Shadow Price of Labour (SPL)

For the Shadow Price of Labour, the range of **80 to 100%** remains appropriate. However, in terms of application, there should be clear emphasis on the need to justify a SPL different from 1 in the context of current labour market conditions.

Next Steps and Future Research

Further detail on the application of these central parameters should be provided in user guides within the Public Spending Code to ensure ease of application in practice.

In general further research and estimation of related parameters in an Irish context would be highly beneficial to future reviews. For example, this would include the specific elements of the discount rate calculation.

The parameters should be reviewed every 3 or 4 years to ensure that they continue to reflect best practice and the most recent data and information.

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Appendix One: Project Steering Group

In completing the analysis contained within this paper, the author's convened a project steering group who provided comments, observations and views on the work throughout its development. The group consisted of members of the Irish Government Economic and Evaluation Service from across a number of Government Departments and two members from external research bodies. The authors would like to thank the group members for their participation in the project. The details of the group's membership are set out below.

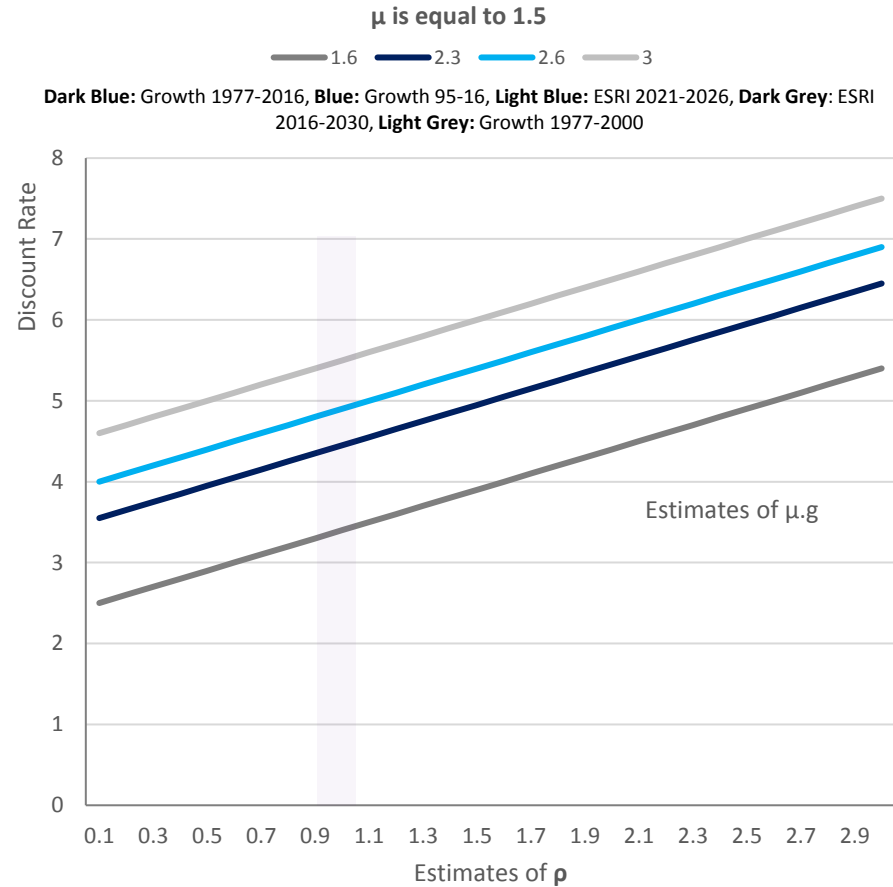
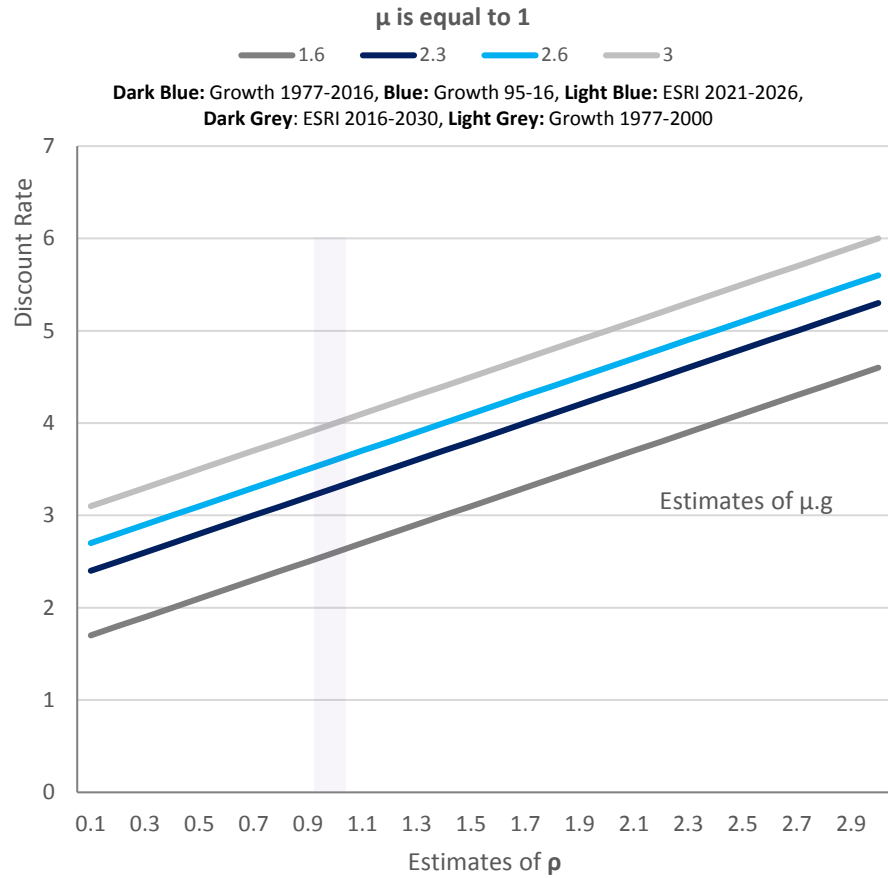
Table 8.1: Steering Group Members

Name	Organisation
Jasmina Behan (Chair)	Head of IGEES, Department of Public Expenditure and Reform
Daniel O'Callaghan (Author)	IGEES Unit, Department of Public Expenditure and Reform
Seán Prior (Author)	IGEES Unit, Department of Public Expenditure and Reform
Breda Rafter	Government Accounting Unit, Department of Public Expenditure and Reform
Alan Scarlett	Department of Transport, Tourism and Sport
Eoin Corrigan	Department of Housing, Planning and Local Government
Evin McMahon	Department of Climate Action, Communications, and Environment
David Hegarty Replaced by Paul Cotter (D/Finance) and Kevin Daly (D/BEI)	Department of Business, Enterprise and Innovation (Formerly Department of Finance)
Bernard Harris Replaced by Anthony Cawley	Department of Agriculture, Food and the Marine
Edgar Morgenroth	Dublin City University (Formerly Economic and Social Research Institute)
Rory O'Donnell	National Economic and Social Council

Appendix Two: Discount Rate Analysis

Figure 9.1 and 9.2 set out the detailed analysis of potential values for the discount rate based on the available evidence and the Social Rate of Time Preference methodology.

Figure 6.1 and 6.2: Potential Values of the Social Discount Rate (Elasticity of Marginal Utility of Consumption Equal to 1 and 1.5).



Appendix Three: Discount Rate Schedule Analysis

The purpose of this section is to provide further analysis on potential discount rate schedules. As outlined within Section 2.5, there are a number of potentially appropriate discount rate schedules within an Irish context depending on the methodology that is used. In particular the discount rate schedules outlined in Table 7.1 below have been analysed.

Table 7.1: Potential Long Run Discount Rates and Indicative Step Schedules

Approach								
Years	0-30	31-50	51-70	71-100	101-150	150-250	251-400	
Newell and Pizer	4%	3.5%	3%	2.5%	1.5%	1%	0.5%	
Years	0-30	31-60	61-100		101-175	176-275	276+	
Parameter Uncertainty	4%	3.5%	3%		2.5%	2%	1.5%	
Years	0-30	31-50	51-100		101-200	201+		
Individual Time Preference	4%	3.5%	2%		1%	0.5%		

In terms of analysing the effect of each discount rate schedule it is possible to compare the extent to which €100 is valued in a future year for each schedule. Table 7.2 sets out this analysis. It highlights the value that €100 is given within the analysis under different discount rate schedules. The analysis includes an exponential 5% and 4% rate, each of the three assessed methodologies and the schedules for Norway and the UK⁶¹.

Table 7.2: Value of €100 by Discount Schedule and Year

Year	5.0%	4.0%	Newell and Pizer	ITP	Parameter Uncertainty	Norway	UK
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
20	37.7	45.6	46.2	45.6	45.6	45.6	50.3
40	14.2	20.8	22.9	21.9	21.9	20.8	26.5
60	5.4	9.5	12.5	12.7	11.0	11.5	14.7
80	2.0	4.3	7.6	8.6	6.1	6.7	8.3
100	0.8	2.0	5.1	5.8	3.4	4.5	5.1
120	0.3	0.9	3.6	4.7	2.1	3.0	3.1
140	0.1	0.4	2.8	3.9	1.3	2.0	2.0
160	0.0	0.2	2.2	3.2	0.8	1.4	1.4
180	0.0	0.1	1.8	2.6	0.5	0.9	0.9
200	0.0	0.0	1.5	2.1	0.3	0.6	0.6
220	0.0	0.0	1.3	1.9	0.2	0.4	0.5
240	0.0	0.0	1.2	1.7	0.1	0.3	0.3
260	0.0	0.0	1.1	1.6	0.1	0.2	0.3
280	0.0	0.0	1.0	1.4	0.1	0.1	0.2
300	0.0	0.0	0.9	1.3	0.1	0.1	0.1
320	0.0	0.0	0.8	1.2	0.0	0.1	0.1
340	0.0	0.0	0.8	1.1	0.0	0.0	0.1
360	0.0	0.0	0.7	1.0	0.0	0.0	0.1
380	0.0	0.0	0.7	0.9	0.0	0.0	0.1
400	0.0	0.0	0.7	0.8	0.0	0.0	0.1

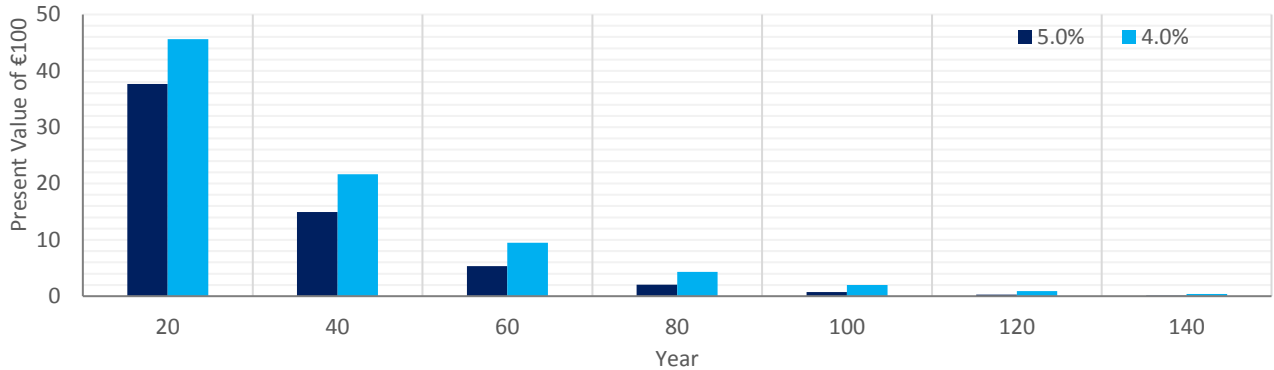
Note: UK discount factor from Green Book published factors to year 120 and estimated thereafter

⁶¹ As detailed earlier in the paper the Norway schedule is for 4% between years 0 and 40, 3% between years 40 and 75 and 2% thereafter. The UK rate meanwhile is for 3.5% between years 0 and 30 and then a 0.5 percentage point drop at years 31, 76, 126, 201 and 301.

A number of points can be observed through the analysis:

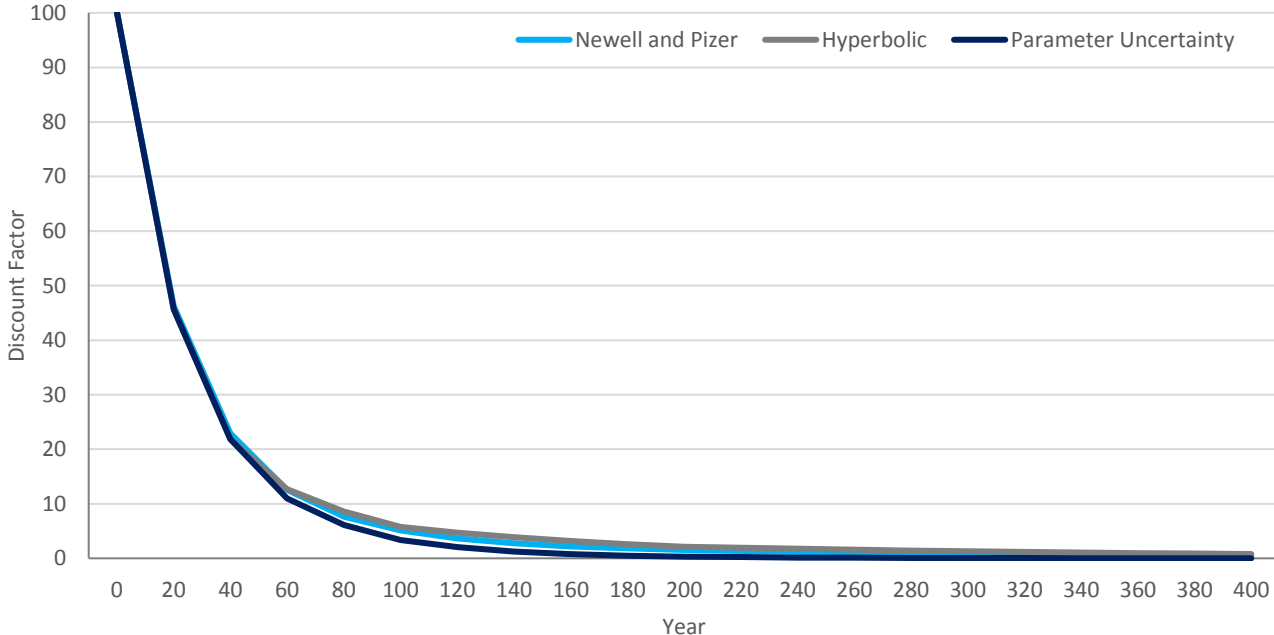
The **transition from a 5% exponential discount rate to a 4% exponential discount rate has a significant effect** on the net present value of flows that occur in distant years. For instance, in year 180 the value of €100 is €2 under a 5% rate while it is more than double at €4.30 under a 4% rate. As such, the change in the central rate increases the value of future flows significantly in present terms.

Figure 7.1: Present Value of €100 Under 5% and 4% Discount Rate



The three estimated discount rate schedules have different impacts. The schedule which places the greatest weight on future values is the hyperbolic approach, followed by the Newell and Pizer approach and then the Parameter Uncertainty approach. This is displayed in the discount factors in Figure 7.2. At year 100 the Hyperbolic schedule has a factor of 0.058, the Newell and Pizer approach has a factor of 0.051 and the Parameter Uncertainty approach has a factor of 0.034.

Figure 7.2: Discount Factor for Discount Rate Schedules



The discount rate schedule which is closest in nature in terms of impact to that used in the UK and Norway is the Parameter Uncertainty approach. Table 7.3 below compares each of the declining discount rate schedules to a constant discount rate and displays the additional valuation given to €100 in each year. As can be observed, the Newell and Pizer and Hyperbolic approaches present an impact which is higher than that implied by the schedule used in Norway or the UK. The Parameter Uncertainty approach has a lower impact than Norway or the UK but it is closer in nature than the other two methodologies.

Table 7.3: Additional Value for €100 Compared to Exponential Discounting

	Newell and Pizer	Hyperbolic	Parameter Uncertainty	Norway	UK
40	2.1	1.0	1.0	-	1.3
60	3.0	3.2	1.5	2.0	2.0
80	3.3	4.2	1.7	2.4	1.9
100	3.1	3.8	1.4	2.5	1.9
120	2.7	3.8	1.2	2.1	1.5

Note: Each schedule compared to 4% except UK which is compared to the initial rate of 3.5% set out in their schedule.