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Estimations of SDR in selected countries

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Abstract

This paper provides new estimates of the social discount rate (SDR), one of the key parameters used in the cost-benefit analysis framework to assign a present monetary value to costs and benefits occurring at different points in time and spreading over a long-term period. The paper draws upon work carried out in the framework of the ongoing H2020 Future Circular Collider Innovation Study to calculate an ad hoc SDR to be used in the socio-economic impact assessment of the Future Circular Collider (FCC). The countries selected for the purpose of this estimation were those contributing to CERN budget, including both EU27 Member States and non-EU Member States. Beyond providing a new estimate of SDR, this paper also discusses the impacts of COVID-19 pandemic crisis on the SDR by providing two different scenarios (before and after).

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Keywords: social discount rate, cost-benefit analysis, discounting
JEL codes: H43, D61

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1. Introduction

Investment projects typically entail costs and generate benefits occurring at different points in time and spreading over a long-term period. Therefore, the challenge is to express them in a consistent and comparable way so as to be evaluated when the assessment is carried out and the decision is taken. In technical jargon, one has to discount them; for this purpose, a discount rate is adopted.

Discounting is used deliberately by policymakers, economists or financial analysts and unconsciously by every individual whenever they take an investment decision whose consequences extend over a number of years. When evaluating government policies or projects, the social discount rate (SDR) allows for directly comparing net benefits that occur in a different period and, subsequently, for aggregating them to obtain a single measure of the project value (the net present value)[1].

The SDR reflects how society values well-being today versus well-being in the future. This has important implications for resource allocation in investment projects. Higher values of SDR reflect the fact that people have preferences for consuming resources today instead of investing them and thus postponing consumption in the future. In this case, society's preferences are for increasing welfare today through increased consumption of products and services instead of reducing it today to be better off in the future. In contrast, lower values of the parameter indicate that society is more ready to renounce part of its consumption today in favour of investing it for future benefits. The limit is a zero SDR, which means that society has no time preferences in choosing between present or future consumption.

The SDR is therefore related to society's preferences. Its value depends on many factors both at the country level, e.g. the level of economic development, and at the international level, such as global economic crises and health-related shocks influencing the population's probability of surviving and being able to consume in the future.

Empirical evidence from the economic literature[2] shows that the SDR is higher in developing countries, often characterised by a GDP higher growth rate than in countries with more mature economic systems and lower mortality rates (people are more willing to invest in the future since their life expectancy is higher). Also, in turbulent times caused by economic downturns and health-related shocks, uncertainty about the future increases and current consumption reduces, leading to lower SDRs as compared to normal times.

After a brief introduction to the rationale for discounting and different approaches to calculating the SRD, the objective of this paper is to present a recent empirical estimation of SDR in selected countries. To conclude, some remarks on the COVID-19 effects on these estimates are provided for EU countries.

1 It is worth clarifying that the SDR is used for the purpose of the economic analysis of an investment project while the financial discount rate should be used to discount inflows and outflows in the context of financial analysis. More specifically, the financial discount rate represents the opportunity cost of capital to the perspective of the financial investor(s). In a perfectly competitive economy and under equilibrium the two rates coincide between them and with the financial market interest rate. However, this does not apply in practice since capital markets are in fact distorted by taxation, capital rationing, information asymmetries and other market failures. For more details on this difference see European Commission (2014) and European Commission (2021).

2 See for instance Zhuang (2007), Lopez (2008).

2. The rationale for discounting

A fundamental question - underlying SDR use - is why it is necessary to discount the future. There are three main reasons – put forward from the literature[3] - to justify this argument.

The first one relates to the phenomenon of the **pure time preference of consumers**. The latter indeed prefer to receive the same amount of goods and services sooner rather than later. This happens because individuals expect an increasing level of consumption over time) and because individuals have a pure time preference due to impatience, myopia and the risk of not being alive in the future. Available experimental evidence from both economics and psychology supports this view.[4] Thus, governments should discount the future costs and benefits associated with public projects to take into account this preference.

The second argument goes beyond the issue of time preferences. It is related to the assumption that **societies will grow wealthier over time** due to economic growth: future generations will benefit from increasing levels of income/consumption and, therefore, it would not be efficient to adopt an egalitarian approach that trades one Unit of consumption today for one Unit of consumption in the future.

The third argument is that resources committed to a project have an **opportunity cost**, thus meaning that they could be employed in another return-generating investment. Therefore, to induce the investment, the expected economic rate of return (ERR) from the investment[5] should be at least high as the social discounting rate, representing the opportunity cost of funding for the economy as a whole.

In practice, a zero-discount rate implies that equal weights are given by consumers to the utilities occurring to them at any point in time, i.e. today's and future consumption are indifferent from the utility point of view. A positive discount rate indicates a preference for current over future consumption, whereas the opposite is true if the discount rate is negative. In this sense, every discount rate entails a judgement concerning the future, which affects the weight attributed to future benefits or costs. A relatively high discount rate gives a small weight to benefits or costs that occur further in the future, thus weakening projects with back-end loaded benefits and strengthening the case for projects with front-end loaded benefits (Boardman et al. 2018).

Because of the above reasons, one can observe that different SDRs are adopted by governments across the world. This divergence is due to the different perceptions of the social opportunity cost of public funds. To clarify, the impatience of individuals and their preference for immediate over future consumption is related to their level of wealth: poor individuals have more urgency to consume today considering the high risk and uncertainty about the future; the fact that in some distant future, it can be richer is less important for them.

The adoption of a social discount rate becomes particularly relevant when long-term investment projects are to be financed (e.g. those addressing climate changes and global warming), considering that their benefits are likely to spread in the distant future. Here, the problem of choosing an appropriate discount rate is further complicated by the consideration of intergenerational equity. In

[3] See for instance Arrow and Lind 1970, Dasgupta, et al 1972, Arrow et al. (1996), Frederick et al 2002, Lopez 2008.

[4] The philosopher Derek Parfit provided an argument for such consumption impatience, by stating that an individual is aware that his own identity changes over time. Consequently, the individual would perceive his future identities, which are different from the current one, as distinct persons from himself. This logic would justify the fact of giving less weight to utilities of these other selves (Parfit 1971).

[5] It is the rate at which the cost and benefits of a project, discounted over its life, are equal. A project with a negative economic return or lower than the social discount rate is rejected since it uses too many socially valuable resources to achieve benefits for all citizens.

this regard, some economists[6] promote the application of intergenerational distributional weights as a means of incorporating intergenerational equity preferences in policy analysis.

The review of current practices around the world (see below) confirms the use of a time-declining discount rate for intergenerational projects or a lower constant discount rate for certain environmental and energy projects which entail long-run consequences, affecting, for instance, the sustainability of raw materials, preventing/reducing global warming (reduction of CO_2 emissions), nuclear waste and species extinction.

6 See for instance Dasgupta et al (2000) and Scarborough, H. (2012).

3. Estimating the social discount rate

The SDR represents the opportunity cost of capital from an inter-temporal perspective for society as a whole. Different approaches have been proposed in the literature to estimate this parameter. The most popular ones are the social rate of return on private investment (SRRI)[7] and the social rate of time preference (SRTP)[8]. Other methods exist and could be used for inter-temporal discounting, although they are more rarely applied in practice. Among these, the weighted average method and the shadow price of capital approach can be mentioned.

The table below briefly describes these approaches along with their limitations.

Table 1. Approaches for the empirical estimation of SDR

Approach	Brief description	Limitations
The social rate of return on private investments (SRRI)	It is based on the idea that public investments displace private investments and, for this reason, the SDR should reflect the marginal social opportunity cost of the latter. The rationale is simply that private investment generates future income and then valuable consumption in the future. This leads to an SDR equal to the marginal social opportunity cost of funds in the private sector. In other words, according to this approach, the returns from the public investment should be at least as big as one that could be obtained from private investment. If this were not the case, there would be an inefficient allocation of resources, and welfare could be increased by the reallocation of funds away from public to private investments. Boardman et al. (2018) argue that probably the best proxy for the marginal rate of return on private investment is the real before-tax rate of return on corporate bonds. The reason why one should look at the marginal, not the average return on private investment, is because of diminishing returns of the scale of project portfolios, which implies that rational investors conclude the most profitable deals first so that returns decrease in the number of projects	Many economists (Arrow and Lind 1970; Barrett et al. 1999; Boardman et al. 2018) note the SRRI approach tends to be biased toward high estimates of the SDR for three main reasons: (i) externalities, monopoly, rationing, incomplete information, and other market failures distort private investment returns and may generate private investment returns higher than the social ones; (ii) the observed private return on investments usually includes a risk premium, which should not be included in the SDR because the government has a much larger portfolio than any private investor and consequently is able to exploit risk pooling; (iii) SRRI is typically estimated on observed returns in the private financial markets which are subject to volatility and the role of persisting asset bubbles (e.g. economic crisis occurred in 2008). Average long-term series stock exchange returns may correct this bias, but overall, the results will be much higher than the returns to consumers under the SRTP approach. Dasgupta, Marglin, and Sen (1972) note that the marginal opportunity cost of capital can be used to estimate the SDR only when the total amount of capital available for investment in the economy is fixed. Such a context would justify the assumption that one euro of public investment displaces one euro of private investment. Yet, when the amount of capital is not fixed, and agents satisfy, at least partially, the capital needed for financing public projects by postponing their current consumption, then the return required by consumers is less than the marginal rate of return on private investment. This would lead to a social discount rate that is lower than the marginal opportunity cost of capital for the economy. When consumption is postponed, a better estimate for the SDR is provided by the social rate of time preference approach (see below).

7 It relies on the SOC - Social Opportunity Cost of Capital paradigm based on the rate of return that would be expected on funds left in the private sector.

8 SRTP is appropriate when the government is considering new government activities (Young, 2002). Also, according to most economists (e.g. Evans and Sezer, 2005, Florio, 2014, etc.), this approach is grounded on a robust theoretical basis, as it does not rely merely on financial data but, above all, on social preferences. The SRRI approach is suggested to be applied only when the estimations of SRTP are unavailable or clearly unreliable (Young, 2002).

Approach	Brief description	Limitations
The social rate of time preference (SRTP)	SRTP represents the rate at which society is willing to postpone a unit of current consumption in exchange for more future consumption. The rationale underlying this approach are two. First, funds for government projects ultimately come from the reduced consumption of individuals (Boardman et al., 2018). Second, the government should consider the welfare of both current and future generations and solve an optimal planning programme based on individual preferences for consumption and additional parameters. The SRTP can be estimated according to two methods: i) by looking at the return on holding government bonds or other low-risk marketable securities; ii) based on a formula obtained from the Ramsey growth model (see Section 4 below).	By focusing on the consumption side, it disregards the displacement effect that public projects might have on private investment. Different methods applied to determine the model components (e.g. the elasticity of the marginal utility of consumption, or the pure rate of time preference) can influence the results of SDR calculation.
Weighted average approach (WAA)	When a public investment is considered to have a displacement impact on both private investment and future consumption, the SDR could be estimated by a weighted average of the investment rate of return and the rate of return to the saver (time preferences). Depending on further assumptions and specifications, the SDR can take various forms. In a closed economy, it can be equal to the SRRI if the supply of funds is perfectly inelastic, and therefore only private investments are displaced, but not consumption, whereas it can be equal to the SRTP if the demand of funds is perfectly inelastic. Thus, it is realistic to assume that a value lying in between these two extremes is more probable.	The same limitations of the SRRI apply to this approach: (i) private returns may be bad signals of the social opportunity costs; (ii) appropriate weights should be attached to the return of private investments and of the saver; (iii) it relies on the assumption that benefits are consumed immediately and not reinvested, thus ignoring the higher social value of future consumption and over-discounting project's benefits.
The shadow price of capital	Under this approach, investment flows are converted into 'consumption equivalents' through the shadow price of capital. These flows are then discounted at the social rate of time preference. This approach is intended to correct for the distortions in private investment returns and which are referred to the fact that while consumption provides an immediate benefit, investment generates a stream of benefits that occur in the future. This approach considers as total costs those arising from the displacement of current private consumption, but also future consumption, which is due to the crowding out of private investment.	This approach is difficult to apply in practice as it would require information on several parameters related to investment and consumer choices (e.g. marginal social cost of capital, SRTP, depreciation rate, the marginal propensity to save, the proportion of displaced and generated consumption and private investment due to project costs and benefits.). Also, the dependence of this rate on the length of the project would force us to estimate a specific SDR for every project. Depending on different assumptions, which vary from project to project, the value of the shadow price of capital could vary from one to infinity (Lyon 1990).

Source: Authors based on Boardman et al. (2018), Broughel (2017), Dasgupta et al. (1972), Florio (2014 e 2019), Moore et al. (2020).

Significant variations in social discount rates adopted by governments exist across the world, with developing countries generally applying higher rates than developed countries. This difference depends, first, on the estimation method used and, second, on the specific underlying parameters, reflecting different perceptions of the social opportunity cost of public funds and different inter-generational ethical values. SRTP is widely used in developed countries, especially European ones. Using a higher SDR reduces the value of the future stream of costs and benefits compared with a lower rate. Therefore, a higher SDR implies that society values benefit less the further they are in the future.

The table below provides an overview of the variance of SDR adopted worldwide, together with their respective theoretical foundations. SDR can range from 2.5 per cent in France to 12 per cent in Pakistan and India. It is interesting to point out that some countries – such as the Netherlands and New Zealand – adopt different discount rates depending on the sectors/nature of projects, while others, such as France, Denmark, Germany, Ireland, and the United States – suggests the use of a declining discount rate for intergenerational investments.

Table 2. SDR recommended by selected countries and multilateral development banks

Theoretical foundation	Country	Social discount rate (real)	Source
SRRI/SOC	Australia	7 per cent with a sensitivity range from 3 per cent to 10 per cent	Australian Government (March 2020)
SRRI/SOC	Canada	8 per cent, with sensitivity tests over the range of 3–10 per cent	Treasury Board Secretary (2007) confirmed by Treasury Board Secretary (2020)
SRRI/SOC	Denmark	4 per cent under 35 years (given by the sum of 3 per cent risk-free rate and 1 per cent risk premium). Reduced to 3 per cent from 36 to 70 years and to 2 per cent from year 71 onwards.	Mouter (2018)
SRRI/SOC	India	12 per cent	Campos et al. (2015)
SRRI/SOC	Japan	4 per cent	ITF (2015)
SRRI/SOC	Norway	4 per cent under 40 years (given by the sum of 2.5 per cent risk-free rate and 1.5 per cent risk premium). Reduced to 3 per cent from 40 to 75 years and to 2 per cent from year 76 onwards.	NOU (2012)
SRRI/SOC	New Zealand	5 per cent or 6 per cent depending on the sector. (i) Default rate (for projects that are difficult to categorise, including regulatory proposals and most social sector projects): 5 per cent; (ii) office and accommodation buildings, water, energy, hospitals, hospital energy plans, road, and other transport projects: 5 per cent; (iii) telecommunications, media and technology, IT, R&D: 6 per cent).	New Zealand Government (2015) New Zealand Government (2020)
SRRI/SOC	Pakistan	12 per cent	Campos et al. (2015)
SRRI/SOC	The Netherland	5.5 per cent (2.5 per cent real risk-free + 3 per cent premium for macroeconomic risk), which can be reduced by up to 1.5 per cent depending on project-specific macroeconomic risk factors. The overall rate was revised from 5.5 per cent to 3 per cent by the Netherlands Discount Rate Working Group in 2015. Also, different rates for specific policy areas are suggested (3 per cent as a default rate or for investments in nature,	CPB and PBL (2013) Netherlands Discount Rate Working Group (2015) O'Callaghan et al. (2018)

Theoretical foundation	Country	Social discount rate (real)	Source
		CO_2 and health; 4.5 per cent for public physical investments/infrastructure and 5 per cent for investments in education).	
SRRI/SOC	Philippines	10 per cent	Moore et al. (2020)
SRRI/SOC and SRTP	Latin American countries	Values from Government/agencies based on SRRI/SOC approach; Argentina: 12 per cent; Bolivia: 12 per cent; Chile: 6 per cent; Colombia: 12 per cent; Costa Rica: 12 per cent; Mexico: 10 per cent; Peru: 11 per cent; Uruguay: 12 per cent. Value calculated by Moore et al. on the basis of the SRTP approach: average SDR of 3.77 per cent, ranging from 2.14 per cent for Paraguay to 5.83 per cent for Chile.	Moore et al. (2020)[9]
SRRI/SOC and SRTP	United States	7 per cent (SRRI) as a reference rate 3 per cent (SRTP) to be applied in circumstances where the regulation primarily and directly affects private consumption OMB (2003) recommends a lower rate for 'intergenerational' projects, while US EPA (2013, 2018) recommends 2.5 per cent (SRTP) to account for the intergenerational nature of climate damages. DOE suggests a real discount rate of 3 per cent for projects related to energy conservation, renewable energy resources, and water conservation.	OMB (2003) US EPA (2013, 2018) OECD (2018) Cahill and O'Connell (2018) US Department of Commerce, National Institute of Standards and Technology (2013)
SRTP	European Union	5 per cent is used in cohesion countries and 3 per cent for the other member states	European Commission (2014)
SRTP	France	2.5 per cent (falling to 1.5 per cent from 2070) plus a risk premium of 2 per cent (rising to 3 per cent from 2070) multiplied by a sector-specific beta value. When the macroeconomic sensitivity (β) of a project is not known, the Quinet Commission recommends the rate of 4.5 per cent	Quinet (2013) and Ni (2017)
SRTP	Germany	3 per cent for short-term period (evaluations up to 20 years). 1.5 per cent (constant) for cross-general evaluations (evaluations extending over 20 years), which should be combined with a sensitivity analysis using a discount rate of 0 per cent.	German Federal Environment Agency (UBA 2012)
SRTP	Ireland	a. 4 per cent (for projects with long time horizons a declining discount rate applies) b. Range from 2.6 per cent to 3.9 per cent for all sectors. 1.7 per cent for carbon emissions and other long-term environmental damage	a. Department of Public Expenditure and Reform (2019 and confirmed in January 2021)i b. Cahill and O'Connell (2018)
SRTP	Italy	3 per cent	Invitalia (2014)

[9] Moore et al. (2020) provides a new estimation for the SDR basing on SRTP approach for the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela

Theoretical foundation	Country	Social discount rate (real)	Source
SRTP	Malta	5.5 per cent	Planning and Priorities Co-ordination Division (2013)
SRTP	Sweden	3.5 per cent	ASEK Guidelines (2020)
SRTP	UK	3.5 per cent for years 0–30, 3 per cent for years 31–75, and 2.5 per cent from year 76 onwards. For health projects: 1.50 per cent for years 0–30; 1.29 per cent for years 31–75 and 1.07 per cent from year 76 onwards.	HM Treasury (2020a) Freeman et al. (2018)
SRTP	Value recommended for an international governmental organisation	The mean recommended SDR is 2.27%, with a range from 0 to 10%. More than three-quarters of experts are comfortable with the median SDR of 2%, and over 90% of respondents find an SDR in the range of 1 to 3% acceptable.	Drupp et al. (2015 and 2018)
SRTP	OECD countries	Average rate of 4.78% for energy and 4.64% for transport	OECD (2018)
SRTP	European Investment Bank	A value ranging from 3.5 per cent to 5.5 per cent, depending on the degree of maturity and expected growth rate of the national economy.	European Investment Bank (2013)[10]
SRRI/SOC	World Bank	10–12 per cent	Moore et al. (2020)
SRRI/SOC	African Development Bank	6 per cent for infrastructure 9 per cent for social sector projects	Moore et al. (2020)
SRRI/SOC	Inter-American Development Bank	12 per cent	Moore et al. (2020)

Source: Authors based on different sources.

Note: This review builds on previous attempts carried out in literature[11] and provides additional up-to-date information on the most recent estimates made.

[10] This guide is currently under review

[11] See for instance Florio 2014, European Commission 2014 and Moore et al. 2020, etc.

4. An empirical estimation for selected countries

It is worth clarifying that our SDR estimates were carried out in the framework of the ongoing H2020 Future Circular Collider Innovation Study[12] and were specifically addressed to calculate an ad hoc SDR to be used in the socio-economic impact assessment of the Future Circular Collider (FCC)[13]. For this reason, the countries selected for the purpose of our estimation were those contributing to the CERN budget, including both EU27 Member States and the non-EU Member States[14].

We adopted the SRTP approach[15], which – as mentioned above – is widely suggested in the literature – since capturing the three main arguments to justify the need for discounting (see Section 2) – and is also widely adopted by most developed countries (see Section 3). More specifically, the SDR has been calculated following Florio and Sirtori (2013) by applying the formula obtained from the Ramsey growth model (Ramsey, F. P. 1928):

$$SDR = SRTP = \rho + \varepsilon * g$$

where:

- ρ is the pure time preference. It captures the impatience and myopia of people to consume as soon as possible instead of delaying consumption to the future. In line with Ramsey's model, we set the impatience or myopia component (which refers to the observation that individuals favour present over future consumption) equal to zero[16] , and we measured the life change by considering the annual crude death rate of the population (number of deaths over population) and assuming that consumption is anticipated when the risk of death or human race extinction increases[17].The most up-to-date death rate figures - at the moment of our calculation - are provided by Eurostat for the year 2020.[18] These figures are overall constant across time, with an average 2020 value for EU 27 Member States of 1.15 (ranging from 0.65 in Ireland to 1.80 in Bulgaria).
- ε is *the elasticity of marginal utility of consumption.* In technical jargon, it represents the percentage change in an individual's marginal utility corresponding to each percentage change in consumption. In other words, this parameter measures the extent to which the satisfaction (utility) from additional consumption decreases as the level of consumption rises. When the current level of consumption provides "saturation", increasing consumption even more still provides satisfaction but to a lower extent. Assuming there is some growth (g > 0), consumption

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13 Basing on the estimations presented in this paper, the SDR for the FCC was calculated as weighted average of the social discount rates estimated for the countries contributing to finance CERN. The weight was given by the contribution of each country to CERN budget.

14 CERN Member States: Austria, Belgium, Bulgaria, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, UK, Switzerland, Israel, Norway.
Associate Member States in the pre-stage to Membership: Cyprus, Serbia, Slovenia.
Associate Member States: Lithuania, Turkey, Croatia, India, Pakistan, Ukraine.

15 The theoretical foundation of the SRTP is the Ramsey–Cass–Koopmans model or Ramsey growth model (Ramsey, 1928; Cass 1965, Koopmans, 1963). It is a neoclassical model of economic growth based primarily on the work of Ramsey (1928). According to the model, there is a social planner (the government) that solves an inter-temporal optimization problem of social utility with respect to consumption, considering the welfare of both current and future generations. The Ramsey–Cass–Koopmans model differs from the Solow–Swan (Solow, 1956; Swan, 1956) model in that the choice of consumption is explicitly microfounded at a point in time and so endogenizes the savings rate.

16 As pointed out by Ramsey and other economists, it is ethically indefensible to set this term different from zero (see Ramsey 1928, page 543). A positive value would mean that future generations are made worse off only because they are borne later and this would be unacceptable from the society point of view.

17 It is worth clarifying that the risk of death from a societal perspective is, however, not the same as the risk of death of an individual. Actually, the latter can be expected to be much higher than the one for a generation as a whole. This is due to the fact that it would take a global catastrophe to extinguish all human life, whose probability of occurrence is obviously much less than the probability of a single human person dying.

18 Source: Eurostat, Demographic balance and crude rates.

has a lower unit utility in the future.[19] The term $(\varepsilon * g)$ will still be positive, but ε decreases as g increases. There are a number of methods[20] to estimate ε. The most common ones are those based on (progressivity of) taxation models, which influence people's demand for goods and services: as income increases, taxes increases more than proportionally and available income for consumption decreases. We estimate the elasticity of marginal utility of consumption based on social preferences revealed by taxation[21]. We used the latest available OECD Taxation Database[22] to determine ε. Country elasticity has been calculated as the mean of elasticity at different income levels, including the social security contribution paid by the employee[23]. Results of their calculation show that elasticity values for EU27 Member States[24] range from 1.00 (Hungary) and 1.98 (the Netherlands), with an average of 1.53.

- g is *the (expected) per-capita growth rate of consumption*. It is proxied by the real growth rate of the per-capita GDP under the assumption that the GDP properly reflects the dynamics of consumption over time. For the purpose of our calculation, we considered long time series of both historical data and forecast values of per capita GDP real growth. These data are provided by the International Monetary Fund (IMF)[25]. They include a set of consolidated data and projections. Although IMF projections go until 2026, we prudentially based our calculation on data until 2021, which already takes into account the Covid-19 effects. While annual data have been considered for the elasticity (2020) and for the pure time preference component (2020), g has been computed as an average of values covering almost two decades (from 2002 to 2021) in order to account for different economic cycles.[26] The simple average value of per capita GDP growth over the period considered (2002-2021) is 1.87 per cent for the EU27 Member States, with values ranging from -0.40 (Italy) and 4.93 (Lithuania).

With these three elements $-\rho$, ε and g — we estimated the SRTP for a sample of countries, as shown in the table below. The average SDR for the selected countries is equal to 3.42 per cent. Focusing on the EU-27 member states, we found an average SDR equal to 3.53 per cent - and a median value of 2.47 per cent - with the lowest social discount rate and the highest one applying, respectively, to Italy (0.53 per cent) and Lithuania (7.86 per cent). By considering the mean and the median value, one can say that an SDR of 3 per cent can be a good reference value for EU Member States. Nevertheless, this value appears to be overestimated for some countries (e.g. Italy, France, Spain,

[19] A sustained increase of consumption due to continued growth is one of the fundamental assumptions of a positive social discount rate.

[20] The literature (see for instance Florio 2014, Moore et al 2020) suggests different approaches to estimate this parameter, amongst which the most mentioned ones include: i) surveying individuals, politicians or experts ii) measuring people behaviour in the markets by considering, for instance, their savings as a proxy of how much consumption they wish to transfer over time; iii) considering the society's judgment about how consumption should be transferred across people at different times (the revealed social values approach).

[21] The progressivity of national income tax rates is a proxy of how much people wish to transfer across people over time. This approach follows two assumptions: (i) income tax structure is based on the principle of equal absolute sacrifice which means that it is designed such that the marginal utility of tax burden is the same for all individuals and therefore rich people should pay more in tax according to a progressive tax system; (ii) iso-elasticity utility functions which implies that a social planner displays constant relative risk aversion independently of scale. For our estimation, country elasticity was calculated as the mean of elasticity at the different income levels including the social contribution paid by employees.

[22] https://www.oecd.org/tax/tax-policy/tax-database/. OECD, Part I, Table I.4 and I.5. This publication includes marginal and average tax rates for individuals who earn 67 per cent, 100 per cent, or 167 per cent of the average wage (single with no children) and for married persons with two children at 100 per cent, 133 per cent, or 167 per cent of average wage. Latest available data refer to 2020. We accessed the database in April 2022.

[23] As highlighted by Evans (2005), average elasticity is very similar to elasticity calculated at the average production wage, i.e. the average annual gross wage earnings of an adult, full-time manual worker in the manufacturing sector.

[24] The value is missing for the following five countries: Bulgaria, Croatia, Cyprus, Malta, and Romania.

[25] World Economic Outlook Database, April 2021. Data extracted in October 2021. GDP is expressed in constant national currency per person. Data are derived by dividing the constant price GDP by total population. The unit is purchasing power parity, percent change.

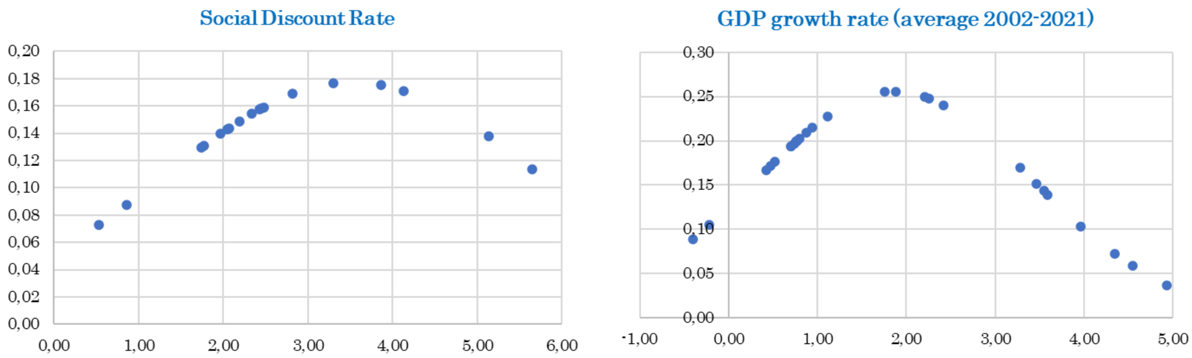
[26] In compliance with the approach followed by Florio and Sirtori (2013).

etc.) and underestimated for others (e.g. Baltic countries). This suggests that while it is good to have a reference value at the EU level, it would be more suitable to adopt a national value when available.

If comparing our estimation with previous calculation provided by Florio and Sirtori (2013), the following observations can be highlighted:

- Both estimations were obtained by following the SRTP approach and rely on the Ramsey formula. Both estimations considered a long time series for the parameter g (20 years), while the latest available year was considered for parameters ρ and ε. Data used by Florio and Sirtori (2013) refer to 2011 for ρ and ε and 2000-2018 for g.
- Both our calculation and the one provided by Florio and Sirtori (2013) show a large deviation between the average SDR and the median value, respectively 3.53 per cent versus 2.47 per cent and 2.99 per cent versus 2.65 per cent. This can be mostly explained by the fact that there is a skewed distribution of SDRs across EU-27. Differences in GDP growth rates of countries drive such a deviation. The Figure below shows such a deviation with reference to our calculation.

Figure 1. GDP and SDR (normal) distribution amongst the selected countries



Source: Authors elaboration

- Our calculation provides a higher average SDR for EU27 countries: 3.53 per cent versus 2.99 per cent provided by Florio and Sirtori (2013) see Table 3 below[27]. However, it is worth pointing out that our calculation includes a higher number of EU countries (22 countries versus 19 considered by Florio and Sirtori, 2013). The additional countries considered in our calculation (e.g. Latvia, Lithuania and the Slovak Republic) have been experiencing a relatively higher GDP growth which results in a higher SDR.
- If we consider the same countries (in total, 19) included in the calculation provided by Florio and Sirtori (2013), we found the same value for SDR (2.99). This is explained by the fact that although some countries in the sample have economically grown during the period 2002-2021 (e.g. Cyprus, Poland, Portugal, Hungary, Ireland, etc.), others have experienced a significant decrease in GDP growth rate (especially Italy and Greece)[28]. Overall, the SDR remains stable for the sample of countries considered in the calculation provided by Florio and Sirtori (2013).

[27] For the sake of comparison, the United Kingdom has been excluded in both cases.

[28] GDP annual growth entering in Florio and Sirtori (2013) calculation is equal to 0.96 and 0.10 for Greece and Italy respectively. In our calculation, the annual GDP growth is equal to -0.22 and -0.40 for Greece and Italy respectively (see Table 3).

Table 3. Estimation of the SRTP in selected countries

Country	ρ (proxied by the annual crude death % rate 2020)	g (GDP annual growth % rate; 2002-2021)	ε (elasticity rate; 2020)	SDR	SDR (2013)[29]
	(1)	(2)	(3)	(4)	
Austria	1.03	0.71	1.48	**2.07**	2.65
Belgium	1.10	0.74	1.68	**2.34**	2.05
Bulgaria	1.80	3.96	n/a	**n/a**	n/a
Croatia	1.41	1.88	n/a	**n/a**	n/a
Cyprus	0.72	0.70	n/a	**n/a**	n/a
Czech Republic	1.21	2.25	1.30	**4.13**	4.75
Denmark	0.94	0.76	1.44	**2.04**	1.75
Estonia	1.19	3.54	1.81	**7.61**	6.52
Finland	1.00	0.88	1.63	**2.43**	3.42
France	0.99	0.52	1.52	**1.78**	1.74
Germany	1.19	0.95	1.33	**2.45**	2.84
Greece	1.22	−0.22	1.69	**0.85**	2.39
Hungary	1.45	2.42	1.00	**3.87**	3.67
Ireland	0.65	3.28	1.95	**7.06**	4.21
Italy	1.25	−0.40	1.81	**0.53**	1.13
Latvia	1.52	4.34	1.33	**7.31**	n/a
Lithuania	1.56	4.93	1.28	**7.86**	n/a
Luxembourg	0.73	0.80	1.82	**2.19**	2.17
Malta	0.79	2.21	n/a	**n/a**	n/a
Netherlands	0.97	0.76	1.98	**2.48**	2.30
Poland	1.26	3.59	1.08	**5.13**	4.43
Portugal	1.20	0.47	1.62	**1.97**	1.67
Romania	1.55	4.54	n/a	**n/a**	n/a
Slovak Republic	1.08	3.46	1.32	**5.65**	n/a
Slovenia	1.14	1.75	1.23	**3.30**	3.25
Spain	1.04	0.42	1.65	**1.74**	2.09
Sweden	0.95	1.12	1.68	**2.82**	3.80
United Kingdom	0.90	0.59	1.65	**1.88**	2.61
Switzerland	0.88	0.78	1.57	**2.11**	
Israel	n/a	1.37	2.13	**n/a**	
Norway	0.75	0.63	1.47	**1.67**	
Serbia	1.69	3.85	n/a	**n/a**	
India	n/a	5.37	n/a	**n/a**	
Pakistan	n/a	1.92	n/a	**n/a**	
Turkey	0.53	3.91	1.33	**5.71**	
Ukraine	1.48	2.65	n/a	**n/a**	
Min	0.53	-0.40	1.00	**0.53**	
Max	1.80	5.37	2.13	**7.86**	
Average	1.13	1.98	1.55	**3.42**	
Min EU27	0.65	-0.40	1.00	**0.53***	1.13**
Max EU27	1.80	4.93	1.98	**7.86***	6.52**
Average EU27	1.15	1.87	1.53	**3.53***	2.99**
Median EU27	1.14	1.12	1.57	**2.47***	2.65**

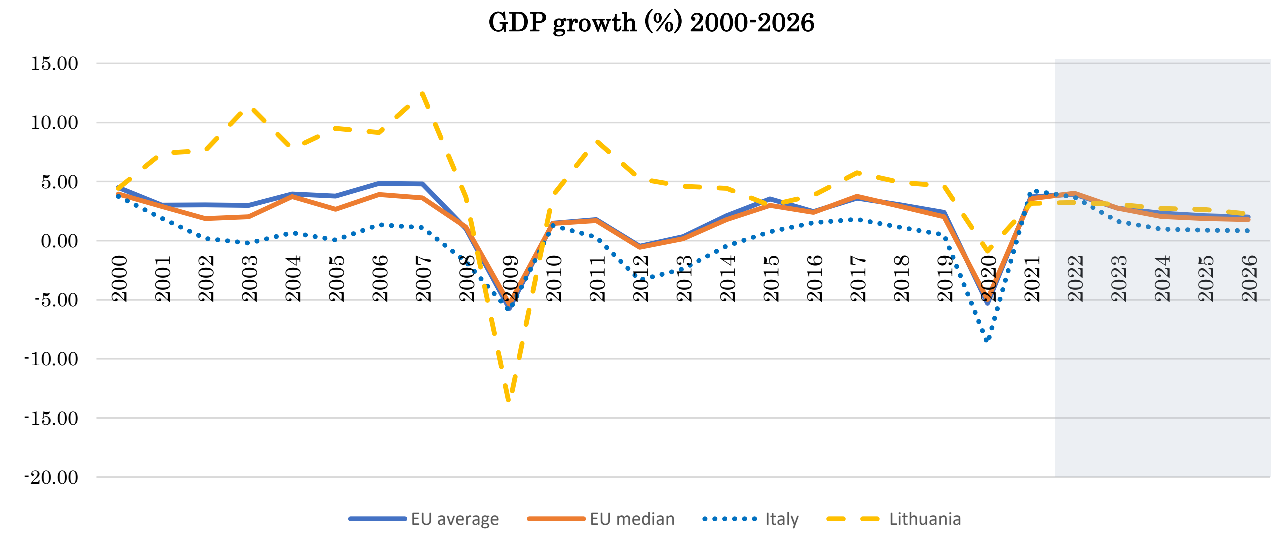
Source: Authors. **Note** EU Member States are highlighted in bold. *Missing countries: Bulgaria, Croatia, Cyprus, Malta, Romania **Missing countries: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, Romania, Slovak Republic.

[29] Calculation from Florio, M. and Sirtori, E. (2013). Values of parameters – used for the calculation – refer to 2011 (p and e) and 2000-2018 for g.

5. The Covid-19 effects on the SRTP in selected countries

To complement our analysis, we assessed the COVID-19 effects on the estimates provided in the previous section (in what follows cited as *baseline scenario*). Specifically, we re-calculated the SRTP in the selected countries by considering two scenarios: (i) the SRTP in the selected countries before COVID-19, thus meaning that – for the parameter *g,* we considered the GDP annual growth rate between 2002-2019; (ii) the SRTP in the selected countries after COVID, thus meaning that – for the parameter *g* we considered a longer time series of the GDP annual growth rate going from 2022 to 2026, The Figure below shows the trend (2002-2026) for the average and the median GDP growth rate for EU countries along with the GDP growth rate for the two countries recording the lowest and highest SDR in the baseline scenario (Italy and Lithuania, see the previous section).

Figure 2. GDP growth rate (2022-2026)



Source: Authors elaboration on the basis of IMF data.

Note: data from 2022 to 2026 are projections retrieved from IMF.

For the sake of this test, we only changed parameter g (proxied by GDP growth rate) while we assumed that the other parameters – entering the Ramsey formula, i.e., ρ (proxied by the annual crude death % rate) and ε (elasticity rate) – were equal to 2019 values in both scenarios[30].

Tables 4 and 5 below show the results of these calculations. Both scenarios provide an average SDR higher than the one provided in the previous section. This allows to raise the following observations:

As compared to the baseline scenario, the relatively higher average SDR of the two scenarios shows that society's preferences are for increasing welfare today through increased consumption of products and services instead of reducing it today to be better off in the future. Indeed, when future generations are expected to be wealthier than today, and per capita GDP growth rises through time, this would result in an increase in the SDR to shift priority to the poorer current generation. On the other hand, uncertainty in future growth prompts the application of lower (and even declining) SDR in order to place greater emphasis on future generations (O' Mahony, 2021).

Longer projections considered in Scenario 2 show a more positive trend in GDP which might not take into account the risk of an increasing economic crisis due to subsequent COVID waves (and, more recently, the Russian-Ukraine war).

[30] By observing the evolution of these parameters, we observed that they slightly increased in 2020 because of COVID-19 while they decreased in 2021 by going back to the pre-COVID values.

Table 4. Scenario 1: estimation of SRTP in selected countries before COVID-19

Country	ρ (proxied by the annual crude death % rate 2019)	g (GDP annual growth % rate; 2002-2019)	ε (elasticity rate; 2019)	SDR
	(1)	**(2)**	**(3)**	**(4)**
Austria	0.94	1.01	1.44	**2.39**
Belgium	0.95	1.00	1.69	**2.64**
Bulgaria	1.55	4.31	n/a	**n/a**
Croatia	1.27	2.25	n/a	**n/a**
Cyprus	0.71	1.02	n/a	**n/a**
Czech Republic	1.05	2.62	1.29	**4.43**
Denmark	0.93	0.91	1.44	**2.24**
Estonia	1.16	3.92	1.77	**8.10**
Finland	0.98	1.02	1.77	**2.78**
France	0.91	0.74	1.41	**1.95**
Germany	1.13	1.14	1.33	**2.64**
Greece	1.17	-0.02	1.74	**1.13**
Hungary	1.33	2.72	1.00	**4.05**
Ireland	0.63	3.38	1.88	**6.99**
Italy	1.06	-0.20	1.70	**0.73**
Latvia	1.45	4.76	1.24	**7.34**
Lithuania	1.37	5.35	1.23	**7.96**
Luxembourg	0.69	0.95	1.80	**2.40**
Malta	0.73	2.87	n/a	**n/a**
Netherlands	0.88	0.92	1.88	**2.60**
Poland	1.08	3.94	1.07	**5.27**
Portugal	1.09	0.72	1.65	**2.28**
Romania	1.34	4.91	n/a	**n/a**
Slovak Republic	0.98	3.89	1.28	**5.95**
Slovenia	0.99	2.11	1.27	**3.67**
Spain	0.88	0.73	1.63	**2.07**
Sweden	0.86	1.38	1.72	**3.23**
United Kingdom	0.90	0.97	1.66	**2.50**
Switzerland	0.79	0.95	1.56	**2.27**
Israel	n/a	1.58	2.08	**n/a**
Norway	0.76	0.59	1.47	**1.63**
Serbia	1.46	4.01	n/a	**n/a**
India	n/a	5.81	n/a	**n/a**
Pakistan	n/a	2.28	n/a	**n/a**
Turkey	0.53	4.04	1.36	**6.02**
Ukraine	1.39	2.90	n/a	**n/a**
Min	0.00	-0.20	1.00	**0.73**
Max	1.55	5.81	2.08	**8.10**
Average	0.94	2.26	1.53	**3.66**
Min EU27*	0.63	-0.20	1.00	**0.73**
Max EU27*	1.55	5.35	1.88	**8.10**
Average EU27*	1.04	2.16	1.51	**3.77**
Median EU27*	0.99	1.38	1.53	**2.71**

Source: Authors.

Note: EU Member States are highlighted in bold. *Missing countries: Bulgaria, Croatia, Cyprus, Malta, Romania

Table 5. Scenario 2: estimation of SRTP in selected countries after COVID-19

Country	ρ (proxied by the annual crude death % rate 2019)	g (GDP annual growth % rate; 2002-2026)	ε (elasticity rate; 2019)	SDR
	(1)	**(2)**	**(3)**	**(4)**
Austria	0.94	0.94	1.44	**2.29**
Belgium	0.95	0.89	1.69	**2.46**
Bulgaria	1.55	3.99	n/a	**n/a**
Croatia	1.27	2.34	n/a	**n/a**
Cyprus	0.71	0.93	n/a	**n/a**
Czech Republic	1.05	2.44	1.29	**4.20**
Denmark	0.93	0.95	1.44	**2.30**
Estonia	1.16	3.52	1.77	**7.39**
Finland	0.98	1.01	1.77	**2.77**
France	0.91	0.76	1.41	**1.98**
Germany	1.13	1.10	1.33	**2.59**
Greece	1.17	0.38	1.74	**1.83**
Hungary	1.33	2.66	1.00	**3.99**
Ireland	0.63	3.10	1.88	**6.46**
Italy	1.06	0.00	1.70	**1.06**
Latvia	1.45	4.25	1.24	**6.71**
Lithuania	1.37	4.50	1.23	**6.91**
Luxembourg	0.69	0.83	1.80	**2.19**
Malta	0.73	2.58	n/a	**n/a**
Netherlands	0.88	0.93	1.88	**2.63**
Poland	1.08	3.58	1.07	**4.89**
Portugal	1.09	0.95	1.65	**2.66**
Romania	1.34	4.41	n/a	**n/a**
Slovak Republic	0.98	3.42	1.28	**5.34**
Slovenia	0.99	2.04	1.27	**3.59**
Spain	0.88	0.77	1.63	**2.13**
Sweden	0.86	1.17	1.72	**2.87**
United Kingdom	0.90	0.87	1.66	**2.34**
Switzerland	0.79	0.74	1.56	**1.95**
Israel	n/a	1.44	2.08	**n/a**
Norway	0.76	0.88	1.47	**2.06**
Serbia	1.46	3.98	n/a	**n/a**
India	n/a	5.45	n/a	**n/a**
Pakistan	n/a	2.10	n/a	**n/a**
Turkey	0.53	3.60	1.36	**5.41**
Ukraine	1.39	2.95	n/a	**n/a**
Min	0.00	0.00	1.00	**1.06**
Max	1.55	5.45	2.08	**7.39**
Average	0.94	2.12	1.53	**3.50**
Min EU27*	0.63	0.00	1.00	**1.06**
Max EU27*	1.55	4.50	1.88	**7.39**
Average EU27*	1.04	2.02	1.51	**3.60**
Median EU27*	0.99	1.17	1.53	**2.72**

Source: Authors.

Note: EU Member States are highlighted in bold. *Missing countries: Bulgaria, Croatia, Cyprus, Malta, Romania

6. Conclusions

The estimation discussed in this paper allows us to draw the following conclusions:

(i) SDRs estimates adopting the social rate of time preference approach are highly dependent on the estimate for g, which, in turn, is highly dependent on the time period that is analysed. Future uncertainty requires the use of plausible scenarios rather than determinist values based on historical trends or forecasts. By employing economic scenarios, the average discount rate for EU countries is calculated in a range of 3.53% and 3.77%.

(ii) If no national estimations are available, an SDR of 3% could be considered a good estimate for EU Member States. Such a value is halfway between the mean and the median values under the different tested scenarios.

(iii) With lower SDR, more projects would likely pass a Cost-Benefit Analysis (a higher weight is given to benefits occurring in the future). Therefore, a revision of SDRs is arguably more relevant today as governments are planning public infrastructure investment programs to drive economic recovery post-COVID-19.

(iv) A low discount rate reduces only to a limited extent the value of future flows, thus favouring projects whose benefits occur in the medium-long run. It is therefore beneficial for all projects that can have a crash outflow at the start, followed by several years of either monetary or non-monetary benefits such as climate change and energy-related investments.

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