An innovative methodology for the assessment of the social discount rate: an application to the European states for ensuring the goals of equitable growth

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Abstract

Purpose – The European Commission has established the reference value of the social discount rate (SDR) to be used in the cost-benefit analysis according to the subdivision of the states relating to the beneficiaries of the Cohesion Fund. This criterion does not allow to adequately consider the economic, social and environmental conditions of each European states for ensuring an equitable and inclusive growth. The aimof the work is to provide an innovative methodology for assessing the "adjusted" SDR according to the socioeconomic and environmental conditions that differently affect the sustainable development of each European state.

Design/methodology/approach – Through the implementation of a methodological approach that consists of ordered and sequential phases and the synergic adoption of the Multi-Criteria Techniques with the Data Envelopment Analysis, a corrective coefficient of the SDR established by the European Commission is determined.

Findings – The results obtained for the 27 European states highlight how the different conditions of each of them could affect the correct choice of the SDR to be used in the Cost-Benefit Analysis.

Originality/value – The proposed research represents a useful reference for identifying national reference SDR values for each European state, consistent with its specificities and with the goals of inclusive growth of the countries and of social and territorial cohesion. Furthermore, the traceability of the methodology in its phases will allow to adapt the SDR to sudden events or exogenous shocks.

Keywords Sustainable environment, Cost-benefit analysis, Index approach, Economic assessment, Multicriteria assessment, Social discount rate

Paper type Research paper

1. Introduction

In the context of the current geopolitical situation, the Cohesion Policy constitutes an important European Union (EU) strategy aimed at reducing the development disparities among the regions of the member states and at strengthening the economic, social and territorial cohesion (European Commission A, 2021; Camera dei Deputati, 2019). With a view to guaranteeing uniform, inclusive and equitable sustainable growth (in the three economic, environmental and social components), the need to define effective tool for supporting efficient territorial governance, consistent with the Sustainable Development Goals of the 2030 Agenda (United Nations, 2015), is always central. In this sense, in the multiannual

The authors are available to share the input dataset used for the analysis in Excel format.

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financial framework 2021–2027, the European Cohesion Policy focuses on five main strategic goals (Official Journal of the European Union, 2021) to achieve a “smarter Europe” (through the promotion an innovative economic transformation based on the digitalization), “a greener, low-carbon Europe” (by favoring the circular economy and the green investments into zero-emissions and resilient net economy), “a more connected Europe” (by strengthening the mobility), “a more social Europe” (by supporting the quality employment, the education, the professional skills and the social inclusion), and “a Europe closer to citizens” (through the promotion of sustainable and integrated development of territory and local initiatives). The choice of high-quality projects to reach these goals, which are able to ensure the best cost-benefit ratio and the highest impact on the growth and the employment, is essential to define sustainable and effective territorial development strategies (Anelli *et al.*, 2022). In this context, the Cost-Benefit Analysis (CBA) is explicitly requested, together with other tools, for the decision-making processes related to the co-financing of “large public projects” – ,that is. characterized by a total investment cost higher than € 50m - included in the Operational Programs (OPs) of the European Regional Development Fund (ERDF) and in the Cohesion Fund (European Commission, 2014; European Parliamentand Council, 2013) and it is recognized as a reference for projects that require funding within the National Recovery and Resilience Plan (NRRP) (Superior Council of Public Works and Ministry of Infrastructure and Sustainable Mobility, 2021).

In order to appropriately manage and use the available NRRP and public financial resources, the implementation of evaluation methodological approaches plays a central role to support the public administrations choices processes for the definition of the projects most consistent with the plan goals (Tajani *et al.*, 2022; Hwang, 2016; Priemus *et al.*, 2008). In general terms, by adopting a long-term time horizon, the CBA is an analytical tool used to estimate the advantages or disadvantages generated by an investment, evaluating its costs and benefits as a measure of the impact on social well-being (Tajani *et al.*, 2018; Morano *et al.*, 2020; Mishan and Quah, 2020). Within the economic evaluations of the urban projects aimed at verifying the convenience to carry out an intervention from the point of view of the local community, the Social Discount Rate (SDR) constitutes a fundamental parameter to be assessed. Having estimated these social costs and benefits, by adjusting the market prices of the financial analysis and by evaluating the non-market impacts, the discounting – through the SDR – of the economic items that occur at different times is needed. It, in fact, reflects the social point of view about the preference level of future costs and benefits compared to the present ones and often is linked to the political targets set by each local and central government. It should be highlighted that an appropriate use of the discount procedure affects the results of the analysis, because it allows to allocate “weights” to all cash flows and to express valid judgments of economic performance on public projects to be developed.

By taking into account the relevant opportunity given by the European tools to support the EU Member States for the recovery after the COVID-19 pandemic (e.g. Next Generation EU – in which the NRRP is included), the analysis of the social sustainability of the projects constitutes an essential step to orient the investments for the services and infrastructures improvement. Although the need to use standard and official values for the costs and benefits discounting in the economic analysis is detected to easily compare the outputs related to different initiatives and select the “best” one, the *ad hoc* quantification of the SDR would avoid wrong discount mechanisms. For example, setting the SDR too high may mean that socially desirable projects are rejected; conversely, setting it too low may result in resources being wasted on economically inefficient projects (Zhuang *et al.*, 2007; Tajani and Morano, 2015; Castillo and Zhangallimbay, 2021).

In the framework outlined, the urge to “reward” projects whose benefits occur in the long term is connected to the cogence of adopting different procedures for estimating the SDR able to take into account the heterogeneity of the factors that characterize each territorial context in social, environmental and economic terms, with a view to a homogeneous development of nations that will delete or, at least reduce, the existing disparities. In this sense, the totality of the costs and benefits deriving from the implementation of the initiative should be calculated including the impacts progressively more distant in time, adequately considered in accordance to the time in which they may occur (Weitzman, 1998; Gollier, 2002; Frederick *et al.*, 2002). The "meteor effect" which consists in the greater thinning of the financial values referring to more distant years than those closer to the present (Nesticò and Galante, 2015; Maselli and Nesticò, 2020).

In general terms, the value of the SDR should reflect the sacrifice that the community is willing to burden for the replacement of current benefits with future ones (i.e. the principle of the "cost-opportunity" for the community). Taking into account this target in the SDR determination, several official entities have established appropriate values for the discount rate to be used in the CBAs, among which are the European Commission (2014) for the European states, the Conferenza dei Presidenti delle Regioni e delle Province Autonome (2001) for Italy, the HM Treasury (2013) for the UK; Commissariat General du Plan (2005) for France; Ministerio de Transportes, Turismo y Communicaciones (1991) for Spain. In addition to them, numerous studies (Florio and Sirtori, 2013; Hussain *et al.*, 2005; Catalano and Pancotti, 2022) have explored the different approaches for the SDR assessment. These methods – e.g. the Social Rate of Return on private Investments (SRRI) (Boardman *et al.*, 2017; Arrow and Lind, 1978; Dasgupta *et al.*, 2000), the Social Rate of Time Preference (SRTP) (Samuelson, 1937; Simonotti, 1984; Ramsey, 1928), the Social Opportunity Cost (SOC) approach (Burgess and Zerbe, 2011a, b; Young, 2002) and the Shadow Price of Capital (SPC) approach (Liu, 2003; Abelson and Dalton, 2018; Lyon, 1990) - also explained in the European Guidelines (European Commission, 2014) – are focused on the time preference (Fujii and Karp, 2008; Lowry and Peterson, 2011; Creedy and Guest, 2008) and the social welfare function (Kelleher, 2017; Heath, 2017; Pigou, 1920), in terms of intergenerational well-being (Dasgupta, 2008; Buchholz and Schumacher, 2010; Collard, 1996) and equity (Lind, 1995; Botzen and van den Bergh, 2014). Each approach presupposes the introduction of proxy variables to express the SDR - for example. the real before-tax rate of return on corporate bonds for the marginal rate of return on private investment assessment in the SRRI method, the expected per capita consumption and the risk of death or extinction of the human species for the measure of the pure time preference in the Ramsey formula (Ramsey, 1928) for the determination of the SSTP, etc. However, the inevitable uncertainty associated with the determination of these parameters that leads to determine the SDR in the mentioned approaches constitutes a significant limitation. By considering the outputs variability due to different SDR values, the assessment of these factors plays a central role in the definition of the rate to be used in CBA, as it can generates funding disparity between more deserving projects and less performing ones for the communities. These projects are intended for sustainable and equitable growth of all nations in economic, environmental and social terms, therefore, in the SDR determination the specificities of the geographical context in which the project will be realized should be included, in view to "reward" the initiatives developed in the nations with worse social, economic and environmental issues and to fill the gaps where the sustainable development is more enhanced. Moreover, the current climate changes emergences can't be neglected in the SDR determination.

2. Aim

The work is consistent with the framework outlined. The aimof the proposed research is to provide an innovative methodology for the assessment of the SDR "adjusted" according to the socio-economic and environmental conditions that differently affect the CBA's economic evaluation of national projects to be financed in each country. In fact, the current differences of the “official” SDR values are only associated to the subdivision of the 27 European states into Member States (SDR equal to 3%) and beneficiaries of the Cohesion Fund 2014–2020 (SDR equal to 5%). In particular, the proposed methodology is aimed at determining adequate corrective coefficients of the SDR established by the European Commission through the definition of composite indicators based on the main economic, social and environmental issues that characterize the sustainable development conditions of each state.

It should be highlighted that the developed methodology tries to overcome the uncertainty in the assessment of the parameters for the SRTP evaluation - for example. in the Ramsey formula, expected growth rate of per capita consumption, elasticity of the marginal utility of consumption, and risk of death and extinction, etc. -, that are generally difficult to be determined, due to complex underlying models for which a high reliability of information data arerequired. In particular, the proposed methodology constitutes a high practice, transparent and reliable SDR assessment procedure, that are able to avoid tortuous calculations in the computational steps that are needed in the classic SRTP approaches.

The aim of the work is achieved through the implementation of a methodology based on 9 sequential and ordered phases and the synergic adoption of the MultiCriteria Techniques with the Data Envelopment Analysis (DEA) for determining the composite indicators (or corrective coefficients) as the results of the aggregation of a sample of 17 elementary indicators that represent the main socioeconomic and environmental conditions of each European state. The different importance that each elementary indicator could assume for every European state is considered relevant for highlighting the real conditions, therefore, a weighting process is carried out. Moreover, an “ideal State” among the 27 European states analyzed is appropriately defined for considering a benchmark, or a reference composite indicator to which every socioeconomic and environmental conditions that characterize the 27 European States is compared for obtaining the final corrective coefficient. The main output of the research consists of an abacus in which the “official” SDR, the corrective coefficient obtained and the “adjusted” SDR resulting from the application of this coefficient to the “official” one are associated with each states analyzed.

The reminder of the work is as follows: Section 3 provides a literature review on several studies aimed at assessing the SDR in different geographical contexts; Section 4 describes the proposed methodology; Section 5 is related to its application to the 27 European states; Section 6 pertains to the discussion of the obtained results in Section 7 the conclusions of the work are remarked.

3. Literature review

During the recent decades, the methods for the economic evaluation of urban projects have been improved in order to obtain an ever-increasing accuracy of the results for guiding investment decisions (Di Liddo *et al.*, 2020). The procedure of cash flows’ discounting is a critical aspect of these methods, as the discount rate’s parameters are not immediately retrievable and determinable they can affect the CBA outputs, therefore the investment decisions.

In the reference literature, several research for defining methodologies able to estimate the SDR have been developed. Many of them intend to validate the official SDR – included in Guidelines for CBA —implementation developed by local governments (European Commission, 2014) -, to define efficient parameters to be used for the verification of investment convenience for the community. For example, Zhuang *et al.* (2007) have highlighted that the choose of an appropriate SDR is crucial for CBA due to the important implications for resource allocations, by pointing out that too high discount rates could preclude many socially desirable public projects from being undertaken, whereas too low risks could cause a lot of economically inefficient investments. Furthermore, the authors have focused on the relevance of time value, demonstrating that a relatively high SDR attaches less weight to benefit and cost flows that occur in distant period and favors projects with benefits happened at earlier times; version the other handa low SDR promotes projects with benefits arise at later dates. Similarly, Feldstein (1964) has pointed out the difficulty of choosing between alternative time-streams of social benefits and costs in the evaluation of public investment projects, by arguing that the discount-rate calculation defines a functional relationship that makes outputs at different points in time commensurable with each other by assigning equivalent present-values to them.

Within the reference literature built over time, different economists have proposed several alternative techniques for the determination of the SDR in the presence of market distortions. Lopez (2008) has provided the SDR for nine Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Honduras, Nicaragua, Mexico, Peru), by demonstrating that depending on the growth expectations of the social planner, they can vary from about 3 to 4% in a future low growth scenario to 5–7% in a high growth scenario. Moreover, in the research the author has argued that the selection of an appropriate discount rate in these countries should depend on the horizon of the project, by decreasing in correspondence of the growth of analysis time period (4.4% for 25 years horizon, 4.2% for 50 years horizon and 3.9% for 100 years horizon).

In the UK context, the SDR has been assessed by Evans and Sezer (2002), in order to compare the Treasury approved official rate, by defining an appropriate one of about 4% for long-term social projects, that is. lower by 2% compared to that recommended by HM Treasury (2013) equal to 6%.

With the purpose of defining an innovative way of interpreting the SDR in the CBAs applied to transport sector, Marabucci (2018) has developed an approach that involves the use of different discount rates, after dividing the project's life cycle into subperiods. In each subperiod, the effective value that the community attributes to the benefits of different generations should be analyzed more precisely, introducing a set of distributive weights, variable as a function of time, which are able to "correct" the distortion deriving from a unique discount rate.

Starting from the scientific and methodical literature analysis and using the SRTP approach, Kazlauskienė and Stundziene (2016) have assessed the rate on the national level of Lithuania on the basis of statistical data of the reference context, identifying a range of values between 3.5 and 4.3%,which are lower than 5% indicated by European Commission. Then, Jalil (2010), following the review of the various methods of measuring SDR, applied the Monte Carlo simulation to calculate the rate value for Bangladesh, by providing helpful insights in the decision-making framework of public projects.

The need to use correct SDR in the CBA for the economic evaluation of public projects has been argued especially associated with the achievement of a fair allocation of the fiscal burden between generations in the research of Akbulut and Seçilmiş (2019). By using the SRTP approach, the rate obtained for Turkey is equal to 4.88% through the personal tax method and to 4.41% using the food demand method. In the same national context and by using the same method, Halicioglu and Karatas (2013) have estimated SDR equal 5.06%.

In Australia, instead, Abelson and Dalton (2018) have determined the SDR, for all sectors and territories, approximately equal to 6.5%, by highlighting the importance of appropriate rates assessment due to their influence on the acceptance or refusal of many public projects. In France, Evans (2004) has estimated a 3.8% discount rate for application in social project appraisal, on the base of social time preference. In Germany, with reference to the health technologies economic evaluations, Schad and John (2012) have shown an appropriate discount rate value in the range of 1.75–4.2%. In the same national context (Germany), Goldmann (2019) has also proposed an SDR for transport infrastructure project evaluation that considers the production efficiency, the systematic traffic demand risk and the increasing uncertainty in the long-run. Kossova and Sheluntcova (2016) have provided a methodology of estimating SDR for government projects to be carried out in Russia and post-Soviet countries related to different industries (healthcare, education, social services, and roads construction, etc.), by funding the two values respectively equal to 3.2% for SRTP and 3.9% for SOC. To estimate the social discount rates of six transition economies – Czech Republic, Estonia, Hungary, Latvia, Poland, Slovak Republic – Seçilmiş and Akbulut (2019) have used two different approaches, . the tax technique and the food demand method, and have assessed the SDR in a values range between 3.3% (Hungary) and 6.91% (Estonia), through the first approach, and between 1.94% (Czech Republic) and 3.5% (Latvia) with the second technique.

In addition, the issue of discounting is the focus of the research developed by O'Mahony (2021), that has pointed out the relevance of the selection of plausible economic scenarios, rather than historical trends or forecasts, in order to establish a valid SDR for Ireland using the Ramsey formula. On the basis of comparison with international surveys, practices and estimation of the real yield on government bonds, the SDR is in a range of values between 1.7 and 2.8%, by demonstrating that the higher Irish government's estimated SDR of 4%, is not reliable and needs reduction.

Castillo and Zhangallimbay (2021) have evidenced the need to continuously update the parameters required for the appraisal of public investments, by remarking that 1) in Ecuador an unvarying rate of 12% is ordinarily used, 2) the standard rate is very far from incorporating the changing dynamics of social preferences over time, and 3) for different time periods, the rates range from 2% for evaluation horizons longer than 51 years to 11% for the short term (0–5 years). With reference to the long-term energy sector transition policies in Poland, the estimation of the SDR has been performed for comparing the constant 5% rate deriving from the EU recommendations on discounting for CBA, by using three datasets and by implementing market rates via Consumption Rate of Interest (CRI) and SOC, and prescriptive Ramsey and Gollier approaches based on Social Welfare Function (SWF) (Foltyn-Zarychta *et al.*, 2021).

A review of the academic literature on long-term SDR on discounting and the way in which different approaches have been incorporated into institutional guidelines, has been outlined by Groom *et al.* (2022), in order to provide a tool for policymakers to update discounting recommendations.

The need to define successful development strategies in coherence with the limited available financial resources has led to an always increasing importance of the project evaluation methodologies, mainly to measure the value of all investment effects for the communities and to implement the most sustainable initiatives in a wide-ranging temporal perspective (Boardman *et al.*, 2006).

4. Methodology

The proposed innovative methodology for the assessment of the SDR "adjusted" according to the main influencing socio-economic and environmental issues that could affect the economic evaluation of the CBA of each European atate consists of 9 sequential and ordered phases and involves the synergic adoption of the Multi-Criteria Techniques and the DEA. In Figure 1 the flowchart of the proposed methodology is shown.

The initial operation (shase 1) consists of the identification of a sample of elementary indicators – a unique one for all the 27 European States – that is able to give information on the socio-economic and environmental conditions of the analyzed states, according to the influential issues on the economic evaluation of the CBA. After having identified the sample, in the phase 2 the normalization with an appropriate technique is carried out and then,

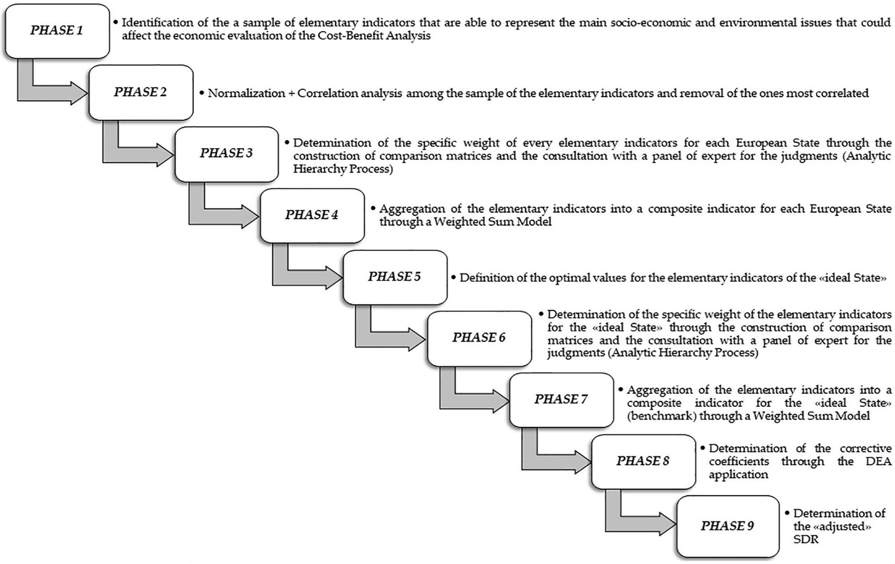

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Figure 1. Flowchart of the proposed methodology

through the correlation analysis, the highly correlated elementary indicators are removed in order to avoid redundancy of the information and to reduce the robustness of the assessment. Once the final sample of elementary indicators to be used for evaluating the corrective coefficients is defined in the phase 3 the importance of each of them is determined through the construction of pairwise comparison matrices. The involvement of a panel of experts composed of four CBA analysis independent specialists and two EU entourage governmental profiles with a knowhow within the CBA project selection decisions, has been selected for proceeding into this phase. The 27 *mxm* pairwise comparison matrices composed of *m* number of the elementary indicators that constitute the final sample are proposed to the panel of experts for formulating the verbal judgments. The Analytic Hierarchy Process (AHP) technique is applied: 1) the verbal judgments are transformed into values through the Saaty scale (1989), 2) the Consistency Ratio is calculated for verifying the consistency of the judgments and 3) the weight of each elementary indicator is established. Subsequently, in the phase 4 a Weighted Sum Model (WSM) is used to determine the composite indicator that relates to the *i-th* European State. Once having done the Phases n.3 and n.4 for all the 27 European States, in Phase 5 the profile of the "ideal state" is defined according to the optimal values that the elementary indicators considered could assume among the ones already detected for the states. In this way, the elementary indicators of the "ideal state" have the best values between the minimum and maximum range of those collected for the 27 States, according to the positive or negative influence that they have on the related issues (e.g. social, economic or environmental). In the subsequent Phase 6, the determination of the specific weight that each elementary indicator has for the "ideal state" is accomplished through the AHP application, as was previously done in the Phase 3 for each State. A WSM is then used in the Phase 7 for determining the composite indicator that relates to the "ideal state" – as done in the Phase 4 for the European states - and that, therefore, constitute the benchmark of the assessment. In fact, the Phase 8 contains the application of the DEA, in particular the Benefit of Doubt (BoD) approach that allows to determine the corrective coefficients as the ratio between the *m-th* composite indicator associated to the *i-th* European state - obtained in the phase 4 – and the composite indicator of the "ideal state", or the so-called benchmark, - obtained in the phase 7 – by applying the following Eq. (1):

$$\text{Corrective coefficient} = \frac{\textit{actual performance of the } i - th \textit{ European State}}{\textit{benchmark performance of the "ideal State"}} = \frac{CI_i}{CI_{is}} \quad (1)$$

where CI_i is the composite indicator determined for the *i-th* European State and CI_{is} is the one obtained after the Phase 7 of the proposed methodology for the "ideal state", that is. the benchmark. After having used Eq. (1) for determining the corrective coefficients pertaining to each of the 27 European States, the "adjusted" SDR is calculated. The phase 9, in fact, provides for the product between the obtained corrective coefficient of the *i-th* European state and the "official" SDR, or the one established by the European Commission according to the subdivision of the States relating to the beneficiaries of the Cohesion Fund.

5. Application of the proposed methodology to the European states

In accordance with the described phases, the proposed methodology is applied to the 27 European states for the assessment of the "adjusted" SDR, as follows.

5.1 Phase 1

The identification of a sample of 17 elementary indicators is achieved according to the reference literature (see Section 3) and the aims of the proposed methodology. The considered indicators, in fact, have been chosen in order to widen the set of criteria generally used for the determination of the SDR with the SRTP approach and, at the same, take into account the three pillars of the sustainable development – social, economic and environmental -. Moreover, although the other methods with a solid theoretical background and usually proposed in the reference literature provide for a high attention to the socio-economic sustainability of the projects in the medium-long period, the entire environmental sphere is totally neglected, even if the significance of the environmental topics is continuously growing and absolutely relevant in the SDR's assessment. In this way, the 17 selected indicators adequately represent the main issues affecting the SDR determination in the CBA at the country level. As the only source of data for all the sample, the Eurostat site https://ec.europa.eu/eurostat/databrowser/explore/all/all_themes?lang=en&display=list&sort=category (European Commission B, 2021) is utilized, given the availability of up-to-date and transparent data relating to the topics of research and built in a robust manner. In particular, most of the information related to the environmental sphere of each State are retrieved from the Eurostat's statistics for the European Green Deal https://ec.europa.eu/eurostat/cache/egd-statistics/ (European Commission C, 2021). In Table 1 the description of each elementary indicators is provided.

As can be seen from the list of indicators, among the 17 collected, the first six (from *a)* to *e)*) relate to the social sphere of the sustainable development, including housing conditions, poverty statu and educational status, gender disparity, mortality causes and income distribution. The following six related toits economic issues, such as inflation and the public debt, or the financial expenditure for social and environmental improvements and the labor forces with the value of total final output of goods and services produced by the economy of the European state. The remaining five ones are able to represent the main environmental efforts of each European state for the sustainable development, like the greenhouse gas emissions, the extension of green areas, the use of renewable energy or waste recycling and the household energy consumption level. In this way the chosen 17 elementary indicators are considered adequate to represent the main issues affecting the SDR determination in the CBA for each state.

Table 1. List of the 17 elementary indicators with their description and reference data

Category	Elementary indicator	Description	Data
Social	*a) Gender pay gap*	The indicator measures the difference between average gross hourly earnings of male paid employees and of female paid employees as a percentage of average gross hourly earnings of male paid employees. All employees working in firms with ten or more employees, without restrictions for age and hours worked, are included	2020
	b) Risk of poverty	This indicator corresponds to the sum of persons who are: at risk of poverty after social transfers, severely materially deprived or living in households with very low work intensity. Persons are considered to be at risk of poverty if they have an equivalized disposable income below the risk-of-poverty threshold, which is set at 60% of the national median disposable income. Severely materially deprived persons experience at least 7 out of 13 deprivations items: cannot afford i) to pay rent or utility bills, ii) keep home adequately warm, iii) face unexpected expenses, iv) eat meat, fish or a protein equivalent every second day, v) a one week holiday away from home, vi) have access to a car/van for personal use; vii) replace worn out furniture; viii) replace worn-out clothes with some new ones; ix) have two pairs of properly fitting shoes; x) spend a small amount of money each week; xi) have regular leisure activities; xii) get together with friends/family for a drink/meal at least once a month; and xiii) have an Internet connection. People living in households with very low work intensity are those aged 0–64 living in households where the adults (aged 18–64) work 20% or less of their total work potential during the past year. In order to measure child poverty, the indicator is available for the age group 0–17	
	c) Mortality rate	This indicator measures the weight of the death on the entire population. It is calculated as the ratio between the number of deaths by age and sex and the population on 1 January 2020	
	d) Housing conditions	Severe housing deprivation rate is defined as the percentage of population living in the dwelling, which is considered as overcrowded, while also exhibiting at least one of the housing deprivation measures. Housing deprivation is a measure of poor amenities and is calculated by referring to those households with a leaking roof, no bath/shower and no indoor toilet, or a dwelling considered too dark	
	e) Income distribution	The indicator is a measure of the inequality of income distribution. It is calculated as the ratio of total income received by the 20% of the population with the highest income (the top quintile) to that received by the 20% of the population with the lowest income (the bottom quintile)	
	f) Young people status	The indicator measures the share of the population aged 15– 29 who are not employed and not involved in education or training. The numerator of the indicator refers to persons who meet the following two conditions: (a) they are not employed (i.e. unemployed or inactive according to the International Labour Organisation definition) and (b) they have not received any education or training (i.e. neither formal nor nonformal) in the four weeks preceding the Labour Force Survey (LFS). The denominator includes the total population aged 15 to 29 (excluding those who did not answer the questions on 'participation in regular (formal) education and training'). The data is presented by citizenship, showing the shares for citizens of the reporting country and for non-EU citizens	2021

(continued)

Table 1.

Category	Elementary indicator	Description	Data
Economic	*g) Inflation rate*	Harmonised Indices of Consumer Prices (HICPs) are designed for international comparisons of consumer price inflation. HICP is used for example by the European Central Bank for monitoring of inflation in the Economic and Monetary Union and for the assessment of inflation convergence as required under Article 121 of the Treaty of Amsterdam. For the U.S. and Japan national consumer price indices are used in the table	2021
	h) Gross debt	The Treaty on the Functioning of the European Union defines this indicator as the ratio of government debt outstanding at the end of the year to gross domestic product at current market prices. For this calculation, government debt is defined as the total consolidated gross debt at nominal value in the following categories of government liabilities (as defined in ESA 2010): currency and deposits (AF.2), debt securities (AF.3) and loans (AF.4). The general government sector comprises the subsectors of central government, state government, local government and social security funds. For further methodological guidance and interpretation, please refer to the Eurostat Manual on Government Deficit and Debt. Total government gross debt in million EUR is shown as well	
	i) Unemployment rate	Unemployment rates represent unemployed persons as a percentage of the labour force. The labour force is the total number of people employed and unemployed. Unemployed persons comprise persons aged 15 to 74 who were: a. without work during the reference week, b. currently available for work, i.e. were available for paid employment or self-employment before the end of the two weeks following the reference week, c. actively seeking work, i.e. had taken specific steps in the four weeks period ending with the reference week to seek paid employment or self-employment or who found a job to start later, i.e. within a period of, at most, three months	2020
	j) GDP per capita	The indicator is calculated as the ratio of real Gross Domestic Product (GDP) to the average population of a specific year. GDP measures the value of total final output of goods and services produced by an economy within a certain period of time. It includes goods and services that have markets (or which could have markets) and products which are produced by general government and non-profit institutions. It is a measure of economic activity and is also used as a proxy for the development in a country's material living standards. However, it is a limited measure of economic welfare. For example, neither does GDP include most unpaid household work nor does GDP take account of negative effects of economic activity, like environmental degradation	2021
	k) Social investments	Expenditure on social protection contain: social benefits, which consist of transfers, in cash or in kind, to households and individuals to relieve them of the burden of a defined set of risks or needs; administration costs, which represent the costs charged to the scheme for its management and administration; other expenditure, which consists of miscellaneous expenditure by social protection schemes (payment of property income and other). It is calculated in current prices	2020
	l) Environmental investments	This indicator measures the resources used by resident units in a given period for protecting the natural environment. It is calculated as a sum of current expenditure on environmental protection (EP) activities and investments for EP activities, including net transfers to the rest of the world	2019

(*continued*)

Category	Elementary indicator	Description	Data
Environmental	*m) Renewable energy*	The indicator measures the share of renewable energy consumption in gross final energy consumption according to the Renewable Energy Directive. The gross final energy consumption is the energy used by end-consumers (final energy consumption) plus grid losses and self-consumption of power plants. This indicator is calculated on the basis ofDirective 2009/28/EC on the promotion of the use of energy from renewable sources. The calculation is based on data collected in the framework of Regulation (EC) No 1099/2008 on energy statistics and complemented by specific supplementary data transmitted by national administrations to Eurostat	2020
	n) Municipal waste recycling	The indicator measures the share of recycled municipal waste in the total municipal waste generation. Recycling includes material recycling, composting and anaerobic digestion. The ratio is expressed in percent (%) as both terms are measured in the same unit, namely tones	
	o) Household energy consumption	This indicator measures how much energy households consume for space heating and cooling. For information purposes, the energy consumption in households for water heating, cooking, lighting and electrical appliances as well as other end uses are presented as well. Since the indicator refers to final energy consumption, only energy used by end consumers is considered. The related consumption of the energy sector itself is excluded (for example, natural gas used to produce electricity). It is worth noting that efficiency improvements in space heating and cooling can be only quantified after taking into consideration weather effects (e.g. cold winters and hot summers). The data are given per capita and presented in gigajoule as well as in kilogram(s) of oil equivalent, which is a normalized unit of energy equivalent to the approximate amount of energy that can be extracted from one kilogram of crude oil	2019
	p) Green lands	The indicator measures the proportion of forest ecosystems in comparison to the total land area. Data used for this indicator is derived from the Land Use and Cover Area frame Survey (LUCAS). The LUCAS land use and land cover classification has been adapted to FAO forest definitions, distinguishing between the categories 'forests' and 'other wooded land'. LUCAS surveys are carried out *in situ*, this means that observations are made and registered on the ground by field surveyors. A mixed panel approach is used, so some points are visited in subsequent years. In the field, the surveyor classifies the land cover and the visible land use according to the harmonized LUCAS Survey land cover and land use classifications	2018
	q) Air pollution rate	The indicator measures total national emissions (from both ESD and ETS sectors) including international aviation of the so called 'Kyoto basket' of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and the so-called F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen triflouride- (NF3) and sulfur hexafluoride (SF6)) from all sectors of the GHG emission inventories (including international aviation and indirect CO2). The indicator is presented in two forms: as net emissions including land use, land use change and forestry (LULUCF) as well as excluding LULUCF. Using each gas' individual global warming potential (GWP), they are being integrated into a single indicator expressed in units of CO2 equivalents. The GHG emission inventories are submitted annually by the EU Member States to the United Nations Framework Convention on Climate Change	2020

Source(s): Table created by author

Table 1.

5.2 Phase 2

Given the different unit of measures of each elementary indicator, the normalization of the entire sample is carried out through the application of the min-max technique. Subsequently, the correlation analysis is performed with the construction of the Pearson's matrix (see Supplementary_material_ Figure A1) of order 17, as the number of the indicators in the sample. The Pearson's coefficient shows high correlation between two couple of indicators respectively pertaining to the social and economic category. In particular, the *b) risk of poverty* with the *e) income distribution* (0.91) for the social category and the *j) GDP per capita* with the *k) social investments* (0.82) for the economic one. In order to reduce the redundancy of the information, the elementary indicators with the highest overall level of correlation within the entire sample are removed: *e) income distribution* and *k) social investments.* The final sample is constituted by 15 elementary indicators.

5.3 Phase 3

The AHP multicriteria technique is utilized for the determination of the weight that each elementary indicator has for aspecific European state. The choice to consider different weights for the states is linked to the real diverse importance covered by each sector within the state, so that the final corrective coefficient of the SDR established by the European Commission can effectively represent the socioeconomic and environmental specific condition. For this reason, for each European state a pairwise comparison matrix of order 15 is constructed. Firstly, in order to determine the weight a panel of experts composed by four CBA analysis independent specialists and two EU entourage governmental profiles with a knowhow within the CBA project selection decisions are designated for providing the preference's judgments regarding the indicator's weights for every European State. Pairwise comparisons express how much more important one indicator is compared to the others. For each indicator, the question "how important is the indicator *x* to the indicator *y*?" is formulated for each member of the considered panel of experts.

After having received all the verbal judgments formulated by the panel of experts, they are transformed into specific values by using the Saaty's scale (see Supplementary_material_ Figure A2). The subjectivity level of the entire process is controlled by verifying the consistency of the judgments expressed by the panel of experts with the calculation of the Consistency Ratio, given by the ratio of the Consistency Index and the Random Index as shown in Eq. (2).

$$\text{Consistency ratio} = \frac{\mathit{Consistency\ Index}}{\mathit{Random\ Index}} = \frac{[(\lambda_{max} - 15)/(15 - 1)]}{1.58} \tag{2}$$

Where λ_{max} is the maximum eigenvalue of the matrix, 15 is the order *n* of all the pairwise comparison matrices and 1.58 is the Random Index of all of them. If the Consistency Ratio is less than the pre-established value of 0.1, the consistency of the weight's determination process is verified. In Table 2 the specific weights of each elementary indicator for the *i-th* European state after the weight's determination process are reported, with also the value of the Consistency Index, ever less than the threshold value of 0.1.

By analyzing the distribution of the weights among the European states, it is evident that the elementary indicator *a) gender pay gap* is the overall most important, especially for 4 States out of 27, followed by the *b) risk of poverty, g) inflation rate, l) environmental investments, n) municipal waste recycling* and *p) green lands* for 3 different states out of 27.

5.4 Phase 4

The aggregation of the 15 elementary indicators and their weights is carried out through the WSM MultiCriteria technique. In this way 27 composite indicators that represent the actual performance of the *i-th* European State (see Eq. 1) are obtained, as shown in Figure 2.

Table 2. Weights of the elementary indicators for each of the 27 European States and the Consistency Index (C.I.)

State	Elementary indicators a)	b)	c)	d)	f)	g)	h)	i)	j)	l)	m)	n)	o)	p)	q)	C.I.
Austria	0.83	0.46	0.12	0.21	0.35	0.53	0.43	0.34	0.42	1.00	0.60	0.89	0.96	0.65	0.49	0.0020
Belgium	0.28	0.67	0.16	0.19	0.47	0.74	0.71	0.42	0.48	1.00	0.25	0.89	0.75	0.41	0.65	0.0043
Bulgaria	0.61	1.00	0.24	0.64	0.86	0.57	0.14	0.37	0.08	0.46	0.41	0.54	0.23	0.73	0.45	0.0000
Cyprus	0.64	0.78	0.14	0.18	1.00	0.70	0.85	0.69	0.46	0.77	0.45	0.38	0.32	0.98	0.96	0.0000
Croatia	0.61	0.69	0.21	0.43	0.82	0.63	0.50	0.51	0.19	0.79	0.62	0.52	0.59	1.00	0.42	0.0000
Denmark	0.95	0.71	0.18	0.30	0.58	0.55	0.29	0.48	0.88	0.87	0.80	1.00	0.91	0.36	0.65	0.0000
Estonia	1.00	0.67	0.15	0.16	0.51	0.91	0.10	0.41	0.20	0.66	0.53	0.45	0.72	0.88	0.54	0.0000
Finland	0.75	0.44	0.12	0.07	0.42	0.40	0.34	0.45	0.43	0.39	0.73	0.61	0.90	1.00	0.52	0.0003
France	1.00	0.75	0.17	0.38	0.79	0.57	0.82	0.67	0.53	0.81	0.45	0.87	0.73	0.66	0.49	0.0000
Germany	0.82	0.57	0.15	0.08	0.33	0.62	0.36	0.21	0.41	0.63	0.32	1.00	0.62	0.46	0.51	0.0004
Greece	0.46	0.76	0.15	0.40	0.77	0.11	1.00	0.98	0.20	0.34	0.36	0.30	0.28	0.67	0.41	0.0001
Hungary	0.77	0.55	0.18	0.53	0.53	1.00	0.40	0.24	0.16	0.49	0.23	0.49	0.55	0.37	0.38	0.0009
Ireland	0.62	0.69	0.10	0.12	0.53	0.57	0.36	0.41	1.00	0.25	0.34	0.73	0.58	0.33	0.85	0.0001
Italy	0.19	0.70	0.15	0.43	1.00	0.37	0.78	0.52	0.31	0.52	0.34	0.75	0.46	0.53	0.38	0.0002
Latvia	1.00	0.71	0.19	0.81	0.53	0.62	0.23	0.46	0.15	0.57	0.69	0.57	0.54	0.80	0.33	0.0001
Lithuania	0.66	0.77	0.22	0.43	0.65	1.00	0.26	0.55	0.19	0.56	0.50	0.75	0.54	0.64	0.48	0.0005
Luxemburg	0.03	0.55	0.09	0.11	0.32	0.07	0.12	0.38	1.00	0.28	0.19	0.76	0.80	0.50	0.98	0.0001
Malta	0.81	1.00	0.18	0.13	0.66	0.24	0.53	0.45	0.46	0.77	0.32	0.28	0.09	0.27	0.48	0.0000
The Netherlands	0.64	0.45	1.00	0.10	0.24	0.54	0.27	0.28	0.48	0.69	0.23	0.83	0.44	0.16	0.58	0.0001
Poland	0.20	0.47	0.15	0.55	0.61	1.00	0.28	0.18	0.16	0.80	0.27	0.57	0.41	0.52	0.59	0.0000
Portugal	0.72	0.78	0.21	0.38	0.59	0.24	0.92	0.56	0.29	0.68	0.79	0.54	0.14	1.00	0.47	0.0000
Czech Republic	0.99	0.43	0.20	0.19	0.67	0.85	0.29	0.21	0.28	1.00	0.39	0.89	0.79	0.73	0.84	0.0014
Romania	0.12	1.00	0.19	0.98	0.92	0.78	0.25	0.34	0.11	0.23	0.39	0.20	0.35	0.49	0.31	0.0034
Slovakia	1.00	0.55	0.19	0.32	0.92	0.76	0.46	0.54	0.26	0.73	0.41	0.87	0.66	0.98	0.56	0.0000
Slovenia	0.16	0.46	0.20	0.25	0.36	0.44	0.45	0.33	0.28	0.69	0.48	1.00	0.47	0.99	0.50	0.0078
Spain	0.48	0.86	0.15	0.27	0.64	0.66	0.70	1.00	0.31	0.55	0.40	0.61	0.20	0.67	0.39	0.0000
Sweden	0.50	0.49	0.12	0.17	0.25	0.52	0.19	0.48	0.52	0.60	1.00	0.56	0.53	0.96	0.27	0.0001

Source(s): Table created by author

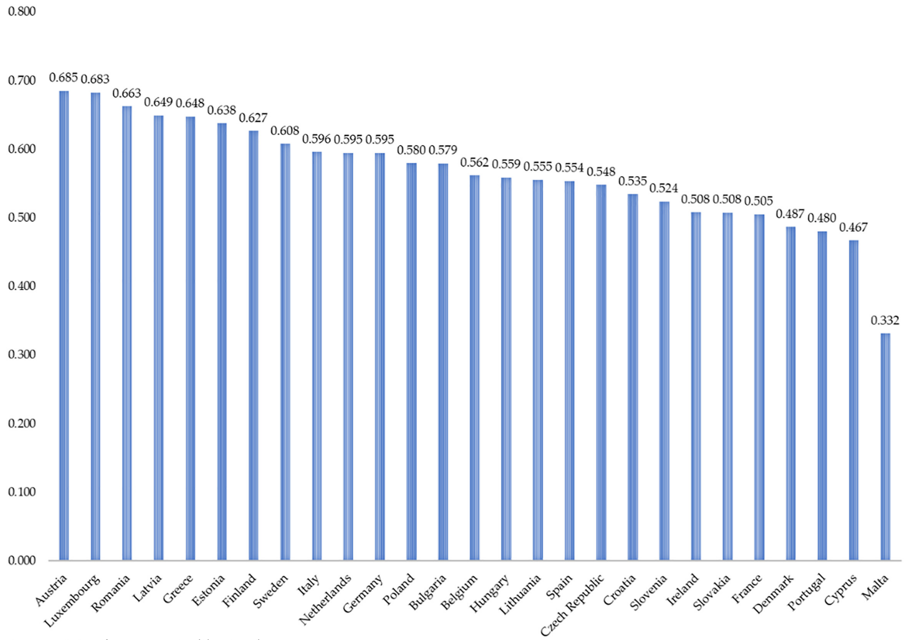

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Figure 2. Composite indicators' values obtained that represent the actual performance of each European state

All the obtained values pertain to the range of [0; 1] in order to be easily compared. In fact, by their examination it is possible to highlight that the highest actual performance is covered by Austria (0.685), followed by Luxembourg (0.683), Romania (0.663) and Latvia (0.649). Italy is in the ninth position with 0.596, falling within the 10 European states with the most elevated performances. The last position is obtained for Malta with a value of 0.332, the European state with the most critical conditions according to the socio-economic and environmental issues considered through the sample of the 15 analyzed elementary indicators. The obtained results are consistent with the empirical evidence: Austria has only 4 out of 15 elementary indicators with negative performances with respect to the European average status and optimal values for most of the indicators with the highest weights, such as the green lands (46.4% of total land areas), the recycling rate of municipal waste (61.8% of total municipal waste) and environmental investments (3.5% of GDP). Malta, instead has 6 out of 15 elementary indicators with negative performances with respect to the European average, such as the *b) risk of poverty* (19.9%), the *j) GDP per capita* (22,250.000 €/per capita instead of 28,155.93 €/per capita of the European average), the *l) environmental investments* (1.5% of the GDP instead of 1.9% of the GDP of the European average), the *m) renewable energy* rate (10.7% of the GDP instead of 24.4% of the European average), the *n) municipal waste recycling* rate (10.5% of the total instead of 39.7% of the European average) and the extension of *p) green lands* (10.4% of the total land area instead of 40.4% of the European average). Moreover, only for the *b) risk of poverty* and the *j) GDP per capita* elementary indicators occur the highest weights. The results of the composite indicators that represent the current performance of each European state, or the actual socio-economic and environmental conditions in accordance with the 15 analyzed elementary indicators, already highlight a possible differentiation of the SDR values to be adopted by each of them in their CBA analysis. It is important to highlight that the Eurostat's indicators refer to the period between

2018 and 2021, and therefore the analysis is carried out on the basis of the conditions at that time for each state.

5.5 Phase 5

The features of the profile of the "ideal state" are defined by examining the optimal performances retrieved for each elementary indicators among the 27 European states, according to their functional relationship (direct or inverse) with respect to the analyzed socio-economic or environmental issue. In particular, the "ideal state" has the minimum collected value of the elementary indicators for which their growth has a negative influence – such as the social ones - and the maximum value of the elementary indicators for which their decrease has a negative influence – such as the GDP per capita or the extension of the green lands -. In this way, the "ideal state" is characterized by the best possible combinations of socio-economic and environmental conditions, ideally achievable by the European states. In Table 3 the features of the "ideal state" are shown.

5.6 Phase 6

The determination of the weights of the 15 elementary indicators of the "ideal state" is carried out in the same way as the other European states, by applying the AHP multi-criteria technique and with the support of the same panel of experts used in the phase 3. A pairwise comparison matrix of order 15 is constructed and the consistency of the preference's judgments of the panel of experts is verified with Eq. (2) for reducing the subjectivity of this process. In Table 4 the results are reported.

5.7 Phase 7

For determining the composite indicator of the "ideal state" that represents the benchmark for all the 27 European States, a WSM is used, as in the Phase 4 for determining the actual performance's composite indicators of the other states. Due to the features defined for the "ideal state" for the socioeconomic and environmental conditions and the weights determined for each of the 15 elementary indicators analyzed, the obtained value of the benchmark's composite indicators is equal to 0.835. In Figure 3 the differences among the actual performances of all the 27 European states with respect to the benchmark "ideal state" are shown.

State	Elementary indicators													
	a)	b)	c)	d)	f)	g)	h)	i)	j)	l)	m)	n)	o)	p)	q)
	%	%	%	%	%	%	%	%	M€/per capita	%	%	%	G./per capita	%	G.T./per capita
Ideal state	0.7	11.5	6.5	1.0	5.1	0.6	18.1	2	86,550	3.50	60.10	68.30	1.50	69.90	4.50

Note(s): All the values are normalized by diving by the respective maximum value
Source(s): Table created by author

Table 3. Values of the 15 elementary indicators for the "ideal state"

state	Elementary indicators														C.I.
	a)	b)	c)	d)	f)	g)	h)	i)	j)	l)	m)	n)	o)	p)	q)	
Ideal State	0.03	0.31	0.00	0.07	0.22	0.11	0.09	0.14	1.00	0.94	0.97	0.96	0.05	0.93	0.25	0.0008

Source(s): Table created by author

Table 4. Weights of the 15 elementary indicators for the "ideal state" and Consistency Index value

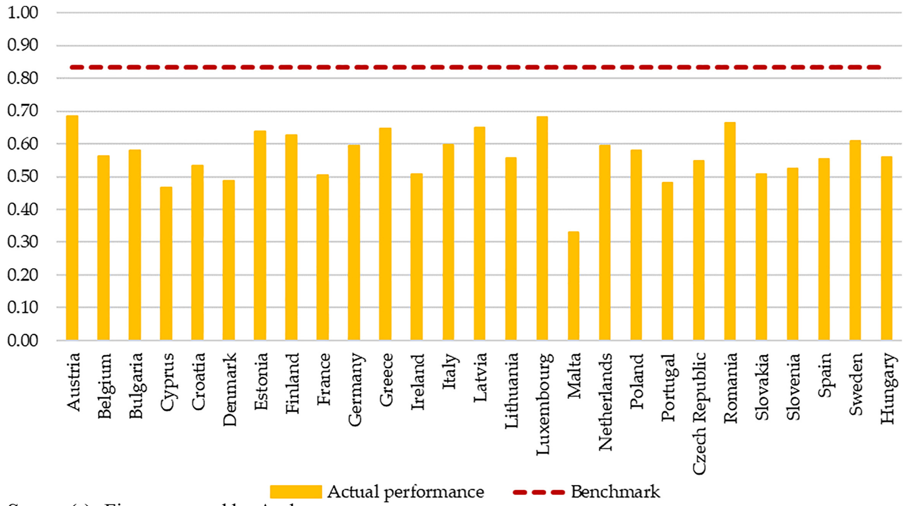

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Figure 3.
Overview of the actual performance distribution among the 27 European States and the benchmark "ideal state"

The analysis of the actual performance of the European states with respect to the benchmark "ideal state" highlights a generally homogeneous situation. The average distance from the benchmark is equal to 27% points, with the minimum value related to Austria which is 15% points less than the benchmark and the maximum distance covered by Malta which is 50% points far away from the "ideal state". The main descriptive statistics of the composite indicators show that the standard deviation of the actual performances is equal to 0.08, there is an average of 0.57, whereas the sample variance is equal to 0.006. The comparison between the 27 European states and the benchmark "ideal state" is useful for highlighting the several differences, in terms of socioeconomic and environmental conditions, that affect the actual performance of each state. In fact, the distance between each European state and the "ideal state" remarks the necessity of efforts for ensuring an equitable growth: i.e. major efforts for the states whose composite indicator shows critical conditions.

5.8 Phases 8 and 9

The application of Eq. (1) to each of the 27 European states allows to obtain the corrective coefficient of the SDR established by the European Commission, or the 3% for the Member States and the 5% for the beneficiaries of the Cohesion Fund 2014–2020 (these official SDR values are consistent with the reference period 2018–2020 to which most of the selected indicators pertain). Hence, by dividing the *m-th* composite indicator obtained from phase 4 with the benchmark obtained from the phase 7 of the proposed methodology, the values of the corresponding corrective coefficients are established. In this way an abacus in which the "official" SDR, the corrective coefficient obtained and the "adjusted" SDR resulting from the application of this coefficient to the "official" one arefound (Table 5).

6. Results discussion

In Figure 4 the "official" SDR values are shown, 3% (gray) for the Member States and 5% (black) for the beneficiaries of the Cohesion Fund 2014–2020. It should be recalled that, as the majority of the indicators have been detected before 2021, the "official" SDR values are

State	"Official" SDR	Corrective coefficient	"Adjusted" SDR	Δ
Austria	3%	0.82	2.46%	−18%
Belgium	3%	0.67	2.02%	−33%
France	3%	0.61	1.82%	−39%
Germany	3%	0.71	2.14%	−29%
Italy	3%	0.71	2.14%	−29%
Spain	3%	0.66	1.99%	−34%
Sweden	3%	0.73	2.18%	−27%
Denmark	3%	0.58	1.75%	−42%
Finland	3%	0.75	2.25%	−25%
Ireland	3%	0.61	1.82%	−39%
Luxemburg	3%	0.82	2.45%	−18%
The Netherlands	3%	0.71	2.14%	−29%
Estonia	5%	0.76	3.82%	−24%
Greece	5%	0.78	3.88%	−22%
Latvia	5%	0.78	3.89%	−22%
Malta	5%	0.40	1.99%	−60%
Poland	5%	0.69	3.47%	−31%
Bulgaria	5%	0.69	3.47%	−31%
Cyprus	5%	0.56	2.80%	−44%
Croatia	5%	0.64	3.20%	−36%
Hungary	5%	0.67	3.35%	−33%
Lithuania	5%	0.66	3.32%	−34%
Portugal	5%	0.58	2.88%	−42%
Czech Republic	5%	0.66	3.28%	−34%
Romania	5%	0.79	3.97%	−21%
Slovakia	5%	0.61	3.04%	−39%
Slovenia	5%	0.63	3.14%	−37%

Source(s): Table created by author

Table 5. Abacus of the "official" SDR, the corrective coefficient obtained and the "adjusted" SDR

referred to the multiannual financial framework 2014–2020. In Figure 5 the "adjusted" SDR values are more spatially heterogeneous. In particular, five clusters have been defined according to the "adjusted" SDR values: the first one (yellow) refers to [1.7%; 2.0%], the second one (orange) is related to [2.1%; 2.4%], the third one (red) concerns the range [2.5%; 3.0%], the fourth one (blue) is with regards to the interval [3.1%; 3.4%], the fifth one (green) includes the SDR values among [3.5%; 4.0%].

Interesting insights can be outlined, taking into account that a low SDR value may cause undesirable projects to be approved, whereas a high SDR value may result in a possible rejection of desirable projects (Harrison, 2010). At the same time it is well-known that a low SDR allows public organizations to allocate a larger share of tax revenues to the long-term intergenerational projects (Bazelon and Smetters, 1999) and a high SDR can discriminate future generations (Seçilmiş and Akbulut, 2019; Rambaud and Torrecillas, 2005). It should be recalled that the obtained "adjusted" SDR could be used as reference for the selectedprojects to be realized in each European state within the economic evaluation processes. Among all the 27 European states, an average reduction (Δ) of −32% of the "official" SDR can be observed. In particular, if the subdivision of SDR promoted by the European Commission for the states beneficiaries or not of the Cohesion Fund is considered, for all the 12 Member States there is an average reduction of −30%, the "adjusted" SDR is on an average of 2.10%, ranging from 1.7% of Denmark to 2.5% of Austria, instead of the "official" SDR equal to 3%. The beneficiaries States of the Cohesion Fund get an average reduction of −34% with the lowest "adjusted" rate of 2.0% for Malta and the highest one for the Romania with 4.0%. The global overview returns the need of a reduction of about −1% in the "official" SDR for all the

Figure 4.
The "official" SDR values among the 27 European states

Source(s): Figure created by Author

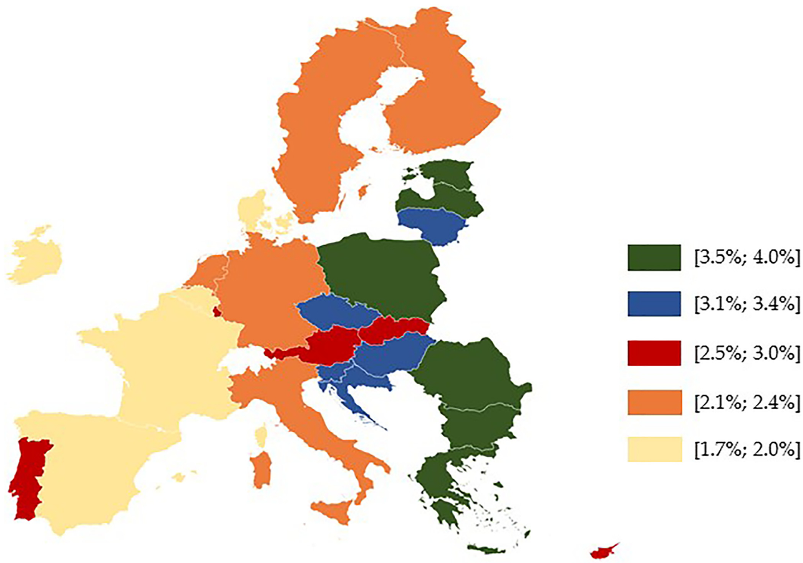

Figure 5.
The "adjusted" SDR values obtained by the application of the proposed methodology

Source(s): Figure created by Author

Member states with also Romania, Latvia, Greece and Estonia of the Cohesion Fund; and a decrease of about -2% for the remaining States. The actual socio-economic and environmental conditions clearly affect these results, but also other issues – not considered in the analysis – can help to justify them. The reasons of this slight reduction for the Member States could be linked to the general well-established economic structure and growth: for all of them the well-known "shadow economy", defined as mostly the legal economic and productive activities that are deliberately hidden from official authorities and that, if recorded, would contribute to GDP – is relatively small, according to the study carried out by Schneider (2012). For the beneficiaries of the Cohesion Fund, Romania, Latvia, Greece and Estonia are the states with the better actual performances, as can be seen from the highest values of the composite indicators. In fact, the negative strong correlation that exist between the actual performances and the reduction of the "official" SDR allows to observe an increase in the reduction (Δ) as the composite indicators value decreases.

In order to analyze the higher reductions (Δ) of the "official" SDR values among the 27 European state, in Table 6 the reasonable justifications - linked to the considered indicators – which may have laed to the reductions among the Member states and the beneficiary of the Cohesion Fund are summarized. In particular, Denmark, France and Ireland are considered for the Member States and Malta, Cyprus, and Portugal for the beneficiaries of the Cohesion Fund.

7. Conclusions

The SDR to be used in the CBA for the decision-making process for selecting investments capable of ensuring sustainable development of all states plays a fundamental, as well as decisive, role in allowing an adequate assessment of the aspects on which fair and inclusive growth depends. In fact, due to its intrinsic feature to financially compare the cash flows that occur at different periods of time in the evaluation conducted from the point of view of the community, it follows that even its small changes significantly influence the decision results and, consequently, the priority order of the interventions to be financed when it comes to choosing among several initiatives. In this sense, the total amount of costs and benefits related to the intervention should be calculated including the impacts progressively more distant in time, adequately considered in accordance with the "meteor effect" that consumes the financial values that occurred in the most distant years to an ever greater extent than those closest to current events. This entails a progressive thinning of the discounted cash flows further away in time, so as to make their contribution increasingly negligible compared to current events. The value of the SDR is crucial for the analysis of effectiveness, it is strictly connected to the riskiness of the investment, and it is defined taking into account the "cost-opportunity" principle. According to the European Commission, among the 27 European states, 15 are considered as beneficiaries of the Cohesion Fund and therefore a SDR equal to 5% is established to be used in the CBA. For the other 12 States, or the Member states, a SDR equal to 3% is considered to be adequate in the CBA process. This subdivision does not allow to adequately take into account the real socio-economic and environmental conditions that differently affect the equitable growth of the states and, therefore, avoid an effective CBA process aimed at managing and using the available financial resources among all the European states.

This research is part of the framework outlined. The aim was to provide an innovative methodology for the assessment of the "adjusted" SDR according to the influencing socio-economic and environmental specificities on the sustainable development of each European state. In particular, the proposed methodology has allowed to determine adequate corrective coefficients of the SDR established by the European Commission to be used in the CBA, through the definition of composite indicators based on the main economic, social and

Table 6. Results discussion synthesis for Denmark, France and Ireland (Member States) and Malta, Cyprus and Portugal (beneficiaries of the Cohesion Fund)

Member state	Δ ↓	Justifications/Major critical issues that can lead to the reduction of the "official" SDR values
Denmark	−42%	• It has the fourth lowest performance (0.487) • Environmental: the household energy consumption rate and the extension of the green lands are considerably greater than the European average and, respectively equal to 18.80% and 16.40%. Moreover, the recycling rate of municipal waste is less than −2.9% the average of the Member States. The household energy consumption rate has a weight of 0.91 • Social: the gender pay gap is +2.24% higher than the average of the Member States and the housing conditions are 0.2% worse. The gender pay gap has a weight of 0.95
France	−39%	• It has the fifth lowest overall actual performance (0.505) • Social: The gender pay gap is, in fact, greater than 4.1% of the average of Member States and the housing conditions and the young people status are respectively worse than 1.2% and 2.7%. The gender pay gap has the greatest weight (1.00) • Environmental: the renewable energy rate, the recycling rate of municipal waste and the extension of the green lands are equal to 19.1%, 42.3% and 32.8%, which ison average less than 5.5% of the other Member states. The recycling rate of municipal waste has a significant weight (0.87) • Economic: The economic conditions of France appear not very robust for the government gross debt (112.9%), the unemployment rate (8.4%) and the real GDP per capita (32,530.00 €). The first elementary indicator is higher than 36.7% with respect to the other states, whereas the unemployment rate is higher than the 1.1% and there is a difference of −10,975.83 € with the GDP per capita of the remaining Member States. The government gross debt, the young people status and the unemployment rate have respectively high weights equal to 0.82, 0.79 and 0.67
Ireland	−39%	• It has the seventh lowest overall actual performance (0.508) • Social: the 20.1% of the population is potentially exposed to the risk, a percentage higher than 0.6% of the other Member States. This elementary indicator weighs for 0.69 on the entire performance • Environmental: The rates of renewable energy, recycling of municipal waste, household energy consumption and extension of green lands are low, with an average of −9.76% with respect to the other Member States. The greenhouse gas emissions are higher than the 3.1% with respect to the other Member States. The latter has a relevant wight equal to 0.85, and also the recycling of municipal waste rate and the household energy consumption with 0.73 and 0.58 • economic: the economic condition is characterized by the small expenditure on environmental protection, only 0.7% of the GDP with respect to 2.0% of the Member States

(*continued*)

Table 6.

Member state	Δ ↓	Justifications/Major critical issues that can lead to the reduction of the "official" SDR values
Choesion Fund Beneficiaries	*Δ ↓*	*Justifications/major critical issues that can lead to the reduction of the "official" SDR*
Malta	−60%	• It has the lowest overall actual performance (0.331) • Social: The social conditions of Malta fall within the European average but the most weighted indicators are the gender pay gap and people at risk of poverty (0.81 and 1.00), and for the latter Malta appears to be among the European states with the higher percentages • Environmental: It is the state that, in absolute terms, has the least percentages of renewable energy (10.70%), recycling rate of municipal waste (10.40%) and extension of green lands (10.40%). Those aspects affect its environmental conditions • Economic: It has an expenditure on environmental protection less than −0.9% of the average of the European states and then −0.3% of the other beneficiaries of the Cohesion Fund. The expenditure on environmental protection has a significant weight (0.77)
Cyprus	−44%	• It has the second lowest overall actual performance (0.467) • Social: The rate of young people neither in employment nor in education and training (NEET) is higher +0.9% than the average of the beneficiaries states. This indicator is the most important of the Cyprus with a weight equal to 1.00 • Environmental: Cyprus needs more efforts for increasing the expenditure on environmental protection (1.7%), the renewable energy rate (16.9%), the recycling rate of municipal waste (16.4%), the extension of green lands (43.2%) reducing the greenhouse gas emissions (10.30%), the young people status (13.8%), the government gross debt (103.6%) and the unemployment rate (7.6%). The importance attributed to the extension of green lands (0.98), the greenhouse gas emissions (0.96) and the government gross debt (0.85) is substantial • Economic: The government gross debt is +33.4% higher than the average of the other beneficiaries and also the unemployment rate with +0.8% and the expenditure on environmental protection (−0.1%) are issues which deviate negatively from the reference mean. All these indicators weight for an average of 0.77 on the overall performance of the state
Portugal	−42%	• It has the third lowest overall actual performance (0.480) • Social: The social conditions of the Portugal even if fall within the reference average (beneficiaries state) deviate on average by −0.5% from the social conditions of the Member States and weight 0.54 on the overall performance of the state • Environmental: The most affecting issue relates to the rate of recycling municipal waste and is −5.7% lower than the other beneficiaries states and this also comes to weigh up to 0.54 on the overall performance • Economic: The government gross debt, the unemployment rate and the expenditure on the environmental protection are respectively +33.4%, +0.8% and −0.1% worse than the other beneficiaries. Among these the first weight 0.92, the second 0.56 and the environmental protection's expenditure 0.68, showing significant relevance

Source(s): Table created by author

environmental issues. The developed methodology improves the generally adopted SRTP's criteria based on socio-economic parameters, such as expected growth rate of per capita consumption, elasticity of the marginal utility of consumption, risk of death and extinction. In particular, all these parameters are often difficult to be determined, due to the complex underlying models that require computation processes characterized by a scarce availability of information data for the assessment of the factor's values. In this sense, the methodology implemented in this research presents a higher practicality in the indicators' detection and, at the same time, a greater flexibility to be applied in different geographical contexts. Therefore, the innovation of the methodological approach mainly concerns the "rapidity" of the SDR measurement: it neglects tortuous calculation procedures and overcomes the uncertainties associated to computational steps of the SRTP approach. Therefore, the phases that define the methodology allows a more transparent and reliability SDR assessment.

The application of the proposed methodology based on 9 sequential and ordered phases and the synergic adoption of the multicriteria Techniques with the DEA to the 27 European states have provided an abacus in which the "official" SDR, the corrective coefficient obtained and the "adjusted" SDR resulting from the application of this coefficient to the "official" one have been associated with each states analyzed. The obtained results have highlighted the following issues: 1) how the importance of each socio-economic and environmental aspects can be different according to the structure of the state, its governmental management and the public policy priorities; 2) how the real socio-economic and environmental conditions can significantly determine the needs of more or less financial resources due to the determinable SDR; 3) how a transparent and clear methodology for the determination of the SDR can efficiently support the CBA processes within each state. Moreover, among the several innovative contributions provided by the proposed research the most relevant is methodological and it is represented by the synergic application of the Multi-Criteria Techniques – AHP and WSM – and of the DEA – Benefit of Doubt Approach-with their advantages that can give with the composite indicators, or the capacity to synthetize complex and not-so transparent phenomena or issues like the assessment of the most suitable SDR for the aims of the research field. It is important to highlight that the results summarize the current EU context based on the reference data of the used Eurostat database (2018–2021), therefore in the ongoing geo-political situation the significant inflation could determine a variation of the considered indicators and, consequently, the "official" SDR. In this sense, the methodology consists of a procedure for the continuous updating and monitoring of the SDR values by varying the indicators inputs and the specific national conditions.

Another strength of the methodology is that it consists of a "relative" approach and not the "absolute" one, because the specificities, the goals and the needs of each European state are taken into account, in order to compare the SDR values both according to spatial (among the nations) and temporal (over the time) points of view.

The shortcomings of the proposed assessment methodology mainly relate to the limited number of considered indicators. Therefore, in the future insights of the research it could be possible to use another assessment technique that is able to manage a wider sample of input data for considering also other aspects related to, for example, demographic indicators, cultural issues, social consumption, and houses prices index . Possible further developments may concern 1) the update of the SDR values according to the ones reported in the Economic Appraisal Vademecum 2021–27 drafted by the European Commission, as soon the values of the Eurostat indicators will refer to 2021–2027 period (European Commission D, 2021) and 2) the verification of the consistency of the obtained results to real case studies of European interventions, in order to analyze the investment decisions in the 27 European states.

References

Abelson, P. and Dalton, T. (2018), "Choosing the social discount rate for Australia", *Australian Economic Review*, Vol. 51 No. 1, pp. 52-67, doi: 10.1111/1467-8462.12254.

Akbulut, H. and Seçilmiş, E. (2019), "Estimation of a social discount rate for Turkey", *Socio-Economic Planning Sciences*, Vol. 67, pp. 78-85, doi: 10.1016/j.seps.2018.10.001.

Anelli, D., Tajani, F. and Ranieri, R. (2022), "Urban resilience against natural disasters: mapping the risk with an innovative indicators-based assessment approach", *Journal of Cleaner Production*, Vol. 371, doi: 10.1016/j.jclepro.2022.133496.

Arrow, K.J. and Lind, R.C. (1978), "Uncertainty and the evaluation of public investment decisions", *Uncertainty in Economics*, Vol. 60 No. 3, pp. 364-378, doi: 10.1016/B978-0-12-214850-7.50031-0.

Bazelon, C. and Smetters, K. (1999), "Discounting inside the Washington DC beltway", *Journal of Economic Perspectives*, Vol. 13 No. 4, pp. 213-228, doi: 10.1257/jep.13.4.213.

Boardman, A.E., Greenberg, D.H., Vining, A.R. and Weimer, D.L. (2006), *Cost-benefit Analysis: Concepts and Practice*, Cambridge University Press, Upper Saddle River, NJ, ISBN 978-1-108-41599-6.

Boardman, A.E., Greenberg, D.H., Vining, A.R. and Weimer, D.L. (2017), *Cost-benefit Analysis: Concepts and Practice*, Cambridge University Press, Upper Saddle River, NJ, ISBN: 978-1-108-41599-6.

Botzen, W.W. and van den Bergh, J.C. (2014), "Specifications of social welfare in economic studies of climate policy: overview of criteria and related policy insights", *Environmental and Resource Economics*, Vol. 58 No. 1, pp. 1-33, doi: 10.1007/s10640-013-9738-8.

Buchholz, W. and Schumacher, J. (2010), "Discounting and welfare analysis over time: choosing the η", *European Journal of Political Economy*, Vol. 26 No. 3, pp. 372-385, doi: 10.1016/j.ejpoleco.2009.11.011.

Burgess, D.F. and Zerbe, R.O. (2011a), "Appropriate discounting for benefit-cost analysis", *Journal of Benefit-Cost Analysis*, Vol. 2 No. 2, pp. 1-20, doi: 10.2202/2152-2812.1065.

Burgess, D.F. and Zerbe, R.O. (2011b), "Calculating the social opportunity cost discount rate", *Journal of Benefit-Cost Analysis*, Vol. 2 No. 3, pp. 1-10, doi: 10.2202/2152-2812.1065.

Camera dei Deputati – Ufficio rapporti con l'Unione Europea – XVIII Legislatura (2019), "La nuova politica di coesione 2021-2027", No. 11, available at: http://documenti.camera.it/leg18/dossier/pdf/AT011.pdf (accessed 17 December 2022).

Castillo, J.G. and Zhangallimbay, D. (2021), "The social discount rate in the evaluation of investment projects: an application for Ecuador", *CEPAL Review no.134*, available at: https://hdl.handle.net/11362/47523 (accessed 18 October 2022).

Catalano, J. and Pancotti, C. (2022), "Estimation of SDR in Selected Countries", Working Paper No. 01/2022, CSIL Centre for Industrial Studies, Milan, available at: https://www.csilmilano.com/wp-content/uploads/2022/06/WP2022_01.pdf

Collard, D. (1996), "Pigou and future generations: a Cambridge tradition", *Cambridge Journal of Economics*, Vol. 20 No. 5, pp. 585-597, doi: 10.1093/oxfordjournals.cje.a013636.

Commissariat General du Plan (2005), available at: https://www.strategie.gouv.fr/

Conferenza dei Presidenti delle Regioni e delle Province Autonome (2001), "Studi di fattibilità delle opere pubbliche. Guida per la certificazione da parte dei Nuclei regionali di valutazione e verifica degli investimenti pubblici", available at: http://www.regioni.it/fascicoli_conferen/Presidenti/2001/20010308/guida_studi_fatt_8_03_01.pdf (accessed 25 November 2022).

Creedy, J. and Guest, R. (2008), "Discounting and the time preference rate", *Economic Record*, Vol. 84 No. 264, pp. 109-127, doi: 10.1111/j.1475-4932.2008.00450.x.

Dasgupta, P. (2008), "Discounting climate change", *Journal of Risk and Uncertainty*, Vol. 37 Nos 2/3, pp. 141-169, doi: 10.1007/s11166-008-9049-6.

Dasgupta, P., Mäler, K.G. and Barrett, S. (2000), "Intergenerational equity, social discount rates, and global warming", in Portney, P.R. and Weyant, J.P. (Eds), *Discounting and Intergenerational Equity*, Routledge, New York, p. 27, available at: https://www.academia.edu/60923534/Discounting_and_Global_Environmental_Change

Di Liddo, F., Morano, P., Tajani, F. and Torre, C.M. (2020), "An innovative methodological approach for the analysis of the effects of urban interventions on property prices", *Valori e Valutazioni*, Vol. 26, pp. 25-49, ISSN: 203362404.

European Commission (2014), "Guide to cost-benefit analysis of investment projects. Economic appraisal tool for cohesion policy 2014-2020", available at: https://wayback.archive-it.org/12090/20221203224508/https://ec.europa.eu/inea/sites/default/files/cba_guide_cohesion_policy.pdf (accessed 17 November 2022).

European Commission A (2021), "EU cohesion policy", available at: https://ec.europa.eu/ (accessed 27 October 2022).

European Commission B (2021), "Eurostat", available at: https://ec.europa.eu/eurostat/databrowser/explore/all/all_themes?lang=en&display=list&sort=category (accessed 21 October 2022).

European Commission C (2021), "Eurostat. Statistics for the European green deal", available at: https://ec.europa.eu/eurostat/cache/egd-statistics/ (accessed 21 October 2022).

European Commission D (2021), "Economic appraisal Vademecum 2021-2027 - general principles and sector applications", doi: 10.2776/182302. available at: https://jaspers.eib.org/LibraryNP/EC%20Reports/Economic%20Appraisal%20Vademecum%202021-2027%20-%20General%20Principles%20and%20Sector%20Applications.pdf.

European Parlament and Council (2013), "Regolamento (UE) No. 1303/2013 del Parlamento Europeo e del Consiglio del 17 dicembre 2013, recante disposizioni comuni sul Fondo europeo di sviluppo regionale, sul Fondo sociale europeo, sul Fondo di coesione, sul Fondo europeo agricolo per lo sviluppo rurale e sul Fondo europeo per gli affari marittimi e la pesca e disposizioni generali sul Fondo europeo di sviluppo regionale, sul Fondo sociale europeo, sul Fondo di coesione e sul Fondo europeo per gli affari marittimi e la pesca, e che abroga il regolamento (CE) n. 1083/2006 del Consiglio", available at: https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:32013R1303&from=IT (accessed 18 December 2022).

Evans, D. (2004), "A social discount rate for France", *Applied Economics Letters*, Vol. 11 No. 13, pp. 803-808, doi: 10.1080/1350485042000254638.

Evans, D. and Sezer, H. (2002), "A time preference measure of the social discount rate for the UK", *Applied Economics*, Vol. 34 No. 15, pp. 1925-1934, doi: 10.1080/00036840210128753.

Feldstein, M.S. (1964), "The social time preference discount rate in cost benefit analysis", *The Economic Journal*, Vol. 74 No. 294, pp. 360-379, doi: 10.2307/2228484.

Florio, M. and Sirtori, E. (2013), "The Social Cost of Capital: Recent Estimates for the EU Countries", Working Paper no.03/2013, CSIL Centre for Industrial Studies, Milan, doi: 10.2139/ssrn.2723379.

Foltyn-Zarychta, M., Buła, R. and Pera, K. (2021), "Discounting for energy transition policies—estimation of the social discount rate for Poland", *Energies*, Vol. 14 No. 3, p. 741, doi: 10.3390/en14030741.

Frederick, S., Loewenstein, G. and O'donoghue, T. (2002), "Time discounting and time preference: a critical review", *Journal of Economic Literature*, Vol. 40 No. 2, pp. 351-401, doi: 10.1257/002205102320161311.

Fujii, T. and Karp, L. (2008), "Numerical analysis of non-constant pure rate of time preference: a model of climate policy", *Journal of Environmental Economics and Management*, Vol. 56 No. 1, pp. 83-101, doi: 10.1016/j.jeem.2007.11.004.

Goldmann, K. (2019), "Time-declining risk-adjusted social discount rates for transport infrastructure planning", *Transportation*, Vol. 46 No. 1, pp. 17-34, doi: 10.1007/s11116-017-9780-4.

Gollier, C. (2002), "Time horizon and the discount rate", *Journal of Economic Theory*, Vol. 32, pp. 445-493, doi: 10.1006/jeth.2001.2952.

Groom, B., Drupp, M.A., Freeman, M.C. and Nesje, F. (2022), "The future, now: a review of social discounting", *Annual Review of Resource Economics*, Vol. 14, pp. 467-491, doi: 10.1146/annurev-resource-111920-020721.

Halicioglu, F. and Karatas, C. (2013), "A social discount rate for Turkey", *Quality and Quantity*, Vol. 47, pp. 1085-1091, doi: 10.1007/s11135-011-9585-z.

Harrison, M. (2010), "Valuing the Future: the social discount rate in cost-benefit analysis", ISBN:978-1-74037-313-5, SSRN, available at: https://ssrn.com/abstract=1599963

Heath, J. (2017), "Climate ethics: justifying a positive social time preference", *Journal of Moral Philosophy*, Vol. 14 No. 4, pp. 435-462, doi: 10.1163/17455243-46810051.

HM Treasury (2013), "The Green Book Appraisal and evaluation in central government: treasury guidance", available at: https://www.gov.uk/(accessed 27 October 2022).

Hussain, M., Mumma, G. and Saboor, A. (2005), "Discount rate for investments: some basic considerations in selecting a discount rate", *Pakistan Journal of Life and Social Sciences*, Vol. 3 Nos 1-2, pp. 1-5, available at: http://www.pjlss.edu.pk/pdf_files/2005_1%20&%202/PJLSS_2005_1-5.pdf (accessed 24 September 2022).

Hwang, K. (2016), "Cost-benefit analysis: its usage and critiques", *Journal of Public Affairs*, Vol. 16 No. 1, pp. 75-80, doi: 10.1002/pa.1565.

Jalil, M.M. (2010), "Approaches to measuring social discount rate: a Bangladesh perspective", DOI: 10.2139/ssrn.1921987, SSRN, available at: https://ssrn.com/abstract=1921987

Kazlauskienė, V. and Stundžienė, A. (2016), "Estimation of social discount rate for Lithuania", *Trendy Ekonomiky a Managementu*, Vol. 26 No. 2, pp. 39-47, doi: 10.13164/trends.2016.26.39.

Kelleher, J.P. (2017), "Pure time preference in intertemporal welfare economics", *Economics and Philosophy*, Vol. 33 No. 3, pp. 441-473, doi: 10.1017/S0266267117000074.

Kossova, T. and Sheluntcova, M. (2016), "Evaluating performance of public sector projects in Russia: the choice of a social discount rate", *International Journal of Project Management*, Vol. 34 No. 3, pp. 403-411, doi: 10.1016/j.ijproman.2015.11.005.

Lind, R.C. (1995), "Intergenerational equity, discounting, and the role of cost-benefit analysis in evaluating global climate policy", *Energy Policy*, Vol. 23, pp. 379-389, doi: 10.1016/0301-4215(95)90162-Z.

Liu, L. (2003), "A marginal cost of funds approach to multi-period public project evaluation: implications for the social discount rate", *Journal of Public Economics*, Vol. 87 Nos 7-8, pp. 1707-1718, doi: 10.1016/S0047-2727(01)00179-7.

Lopez, H. (2008), "The social discount rate: estimates for nine Latin American countries", World Bank policy research working paper No. 4639, SSRN, available at: https://ssrn.com/abstract=1149572

Lowry, R. and Peterson, M. (2011), "Pure time preference", *Pacific Philosophical Quarterly*, Vol. 92 No. 4, pp. 490-508, doi: 10.1111/j.1468-0114.2011.01408.x.

Lyon, R.M. (1990), "Federal discount rate policy, the shadow price of capital, and challenges for reforms", *Journal of Environmental Economics and Management*, Vol. 18 No. 2, pp. S29-S50, doi: 10.1016/0095-0696(90)90036-X.

Marabucci, A. (2018), "Il tasso sociale di sconto nelle Analisi Costi Benefici applicate ai trasporti: una proposta alternativa", *Rivista di economia e politica dei* trasporti, Vol. 1 No. 3, pp. 1-18, 3, ISSN 2282-6599.

Maselli, G. and Nesticò, A. (2020), "A probabilistic model for the estimation of Declining Discount Rate", *Valori e Valutazioni*, Vol. 24 No. 1, ISSN:20362404.

Ministerio de Transportes, Turismo y Communicaciones (1991), "Manual de evaluacion de inversiones en ferrocarriles de via ancha. Anexo 1", available at: https://www.gob.pe/mtc

Mishan, E.J. and Quah, E. (2020), *Cost-benefit Analysis*, Routledge, London, ISBN: 978-1-138-49274-5.

Morano, P., Tajani, F. and Anelli, D. (2020), "A decision support model for investment through the social impact bonds. The case of the city of Bari (Italy)", *Valori e Valutazioni*, Vol. 24, pp. 163-179, ISSN: 20362404.

Nesticò, A. and Galante, M. (2015), "An estimate model for the equalisation of real estate tax: a case study", *International Journal of Business Intelligence and Data Mining 14*, Vol. 10 No. 1, pp. 19-32, doi: 10.1504/IJBIDM.2015.069038.

O'Mahony, T. (2021), "Cost-benefit analysis in a climate of change: setting social discount rates in the case of Ireland", *Green Finance*, Vol. 3 No. 2, pp. 175-197, doi: 10.3934/GF.2021010.

Official Journal of the European Union (2021), "Law 231/60 - regulation (EU) 2021/1058 of the European parliament and of the Council of 24 june 2021 on the European regional development Fund and on the cohesion Fund", available at: https://eur-lex.europa.eu/(accessed 15 October 2022).

Pigou, A.C. (1920), *The Economics of Welfare*, Macmillan & Co, London, ISBN: 9781351304368, doi: 10.4324/9781351304368.

Priemus, H., Flyvbjerg, B. and Van Wee, B. (2008), *Decision-making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation*, Edward Elgar Publishing, Massachusetts, ISBN: 9781845427375.

Rambaud, S.C. and Torrecillas, M.J.M. (2005), "Some considerations on the social discount rate", *Environmental Science and Policy*, Vol. 8 No. 4, pp. 343-355, doi: 10.1016/j.envsci.2005.04.003.

Ramsey, F.P. (1928), "A mathematical theory of saving", *The Economic Journal*, Vol. 38 No. 152, pp. 543-559, doi: 10.2307/2224098.

Saaty, T.L. (1989), "Decision making, scaling, and number crunching", *Decision Sciences*, Vol. 20 No. 2, pp. 404-409, doi: 10.1111/j.1540-5915.1989.tb01887.x.

Samuelson, P.A. (1937), "A note on measurement of utility", *The Review of Economic Studies*, Vol. 4 No. 2, pp. 155-161, doi: 10.2307/2967612.

Schad, M. and John, J. (2012), "Towards a social discount rate for the economic evaluation of health technologies in Germany: an exploratory analysis", *The European Journal of Health Economics*, Vol. 13 No. 2, pp. 127-144, doi: 10.1007/s10198-010-0292-9.

Schneider, F. (2012), "Size and development of the shadow economy of 31 European and 5 other OECD countries from 2003 to 2012: some new facts", available at: http://www.econ.jku.at/Schneider (accessed 3 September 2022).

Seçilmiş, E. and Akbulut, H. (2019), "Social discount rates for six transition countries", *Ekonomický Časopis (Journal of Economics)*, Vol. 67 No. 6, pp. 629-646, available at: http://hdl.handle.net/11159/4227

Simonotti, M. (1984), "Il saggio di sconto sociale e il saggio di capitalizzazione nei giudizi di previsione", *Ce.S.E.T: atti degli incontri. XIV - Aspetti economici, estimativi e normativi dell'utilizzazione del suolo*, Firenze University Press, 20.1.1984, doi: 10.1400/15881.

Superior Council of Public Works and Ministry of Infrastructure and Sustainable Mobility (2021), "Linee Guida per la Redazione del Progetto di Fattibilità Tecnica ed Economia da porre a base dell'affidamento di Contratti Pubblici di Lavori del PNRR e PNC, following the provisions of Art. 48, Comma 7, of Law Decree 31 May 2021, No. 77, Converted into Law 29 July 2021, No. 108", available at: https://www.mit.gov.it/nfsmitgov/files/media/notizia/2022-01/1.%20Linee_Guida_PFTE.pdf (accessed 18 November 2022).

Tajani, F. and Morano, P. (2015), "An evaluation model of the financial feasibility of social housing in urban redevelopment", *Property Management*, Vol. 33 No. 2, pp. 133-151, doi: 10.1108/PM-02-2014-0007.

Tajani, F., Di Liddo, F. and Ranieri, R. (2022), "The effective use of national recovery and resilience plan funding: a methodological approach for the optimal assessment of the initiative costs", *Land*, Vol. 11 No. 10, p. 1812, doi: 10.3390/land11101812.

Tajani, F., Morano, P. and Ntalianis, K. (2018), "Automated valuation models for real estate portfolios: A method for the value updates of the property assets", *Journal of Property Investment and Finance*, Vol. 36 No. 4, pp. 324-347, doi: 10.1108/JPIF-10-2017-0067.

United Nations (2015), "Agenda 2030", available at: https://unric.org/it/agenda-2030/(accessed 12 November 2022).

Weitzman, M.L. (1998), "Why the far-distant future should be discounted at its lowest possible rate", *Journal of Environmental Economics and Management*, Vol. 36 No. 3, pp. 201-208, doi: 10.1006/jeem.1998.1052.

Young, L. (2002), "Determining the Discount Rate for Government Projects (No. 02/21)", Working Paper No.02/2021, New Zealand Treasury, available at: http://hdl.handle.net/10419/205496

Zhuang, J., Liang, Z., Lin, T. and De Guzman, F. (2007), "Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis: A Survey (No. 94)", Working Paper No.94, Economics and Research Department, Asian Development Bank, May 2007, available at: http://hdl.handle.net/10419/109296.

(The Appendix follows overleaf)

Appendix

	Gender pay gap	Risk of poverty	Mortality rate	Housing conditions	Income distribution	Young people status	Inflation rate	Gross debt	Unemployment rate	GDP per capita	Social investments	Environmental investments	Renewable energy	Municipal waste recycling	Household energy consumption	Green lands	Air pollution rate
Gender pay gap	1	−0.197497189	0.110177358	−0.117564369	−0.062273469	−0.23329714	0.080220548	−0.202790521	−0.081487049	−0.195618362	−0.100750117	0.256132341	0.331982218	0.110470493	0.306735409	0.144133302	−0.235328356
Risk of poverty	−0.197497189	1	−0.052972176	0.679621115	0.913220226	0.633736454	0.08868834	0.112895839	0.428925779	−0.31245426	−0.363171409	−0.458317045	0.008756977	−0.403468278	−0.371053367	0.023827388	−0.287081044
Mortality rate	0.110177358	−0.052972176	1	−0.009202671	0.020253582	−0.183206046	0.073729073	−0.114192771	−0.129590556	−0.000474196	0.132129466	0.162975415	−0.151060025	0.220506629	−0.060438164	−0.311635948	0.059011184
Housing conditions	−0.117564369	0.679621115	−0.009202671	1	0.623442901	0.665344881	0.346396742	−0.003888272	0.093260016	−0.551726898	−0.536825586	−0.191998666	0.10532699	−0.326020689	−0.228867567	0.124125761	−0.379964885
Income distribution	−0.062273469	0.913220226	0.020253582	0.623442901	1	0.541315135	0.093235968	−0.028900645	0.328269809	−0.30934477	−0.322258125	−0.389173204	0.073982702	−0.290519499	−0.359263698	0.064590909	−0.24357382
Young people status	−0.23329714	0.633736454	−0.183206046	0.665344881	0.541315135	1	0.063649718	0.359325764	0.352489029	−0.543252424	−0.545955313	−0.309024346	−0.161871192	−0.434044163	−0.343816847	0.115123734	−0.282385005
Inflation rate	0.080220548	0.08868834	0.073729073	0.346396742	0.093235968	0.063649718	1	−0.509204513	−0.350287899	−0.149558663	−0.15287258	0.205555058	−0.105576684	0.156175143	0.336016397	−0.010854913	0.246378592
Gross debt	−0.202790521	0.112895839	−0.114192771	−0.003888272	−0.028900645	0.359325764	−0.509204513	1	0.623594163	−0.172277854	−0.013495472	−0.006339849	−0.149724388	−0.122039572	−0.292685634	0.021049927	−0.257823406
Unemployment rate	−0.081487049	0.428925779	−0.129590556	0.093260016	0.328269809	0.352489029	−0.350287899	0.623594163	1	−0.07058702	−0.078046533	−0.312323813	0.194462423	−0.260986485	−0.239622469	0.298403954	−0.257287279
GDP per capita	−0.195618362	−0.31245426	−0.000474196	−0.551726898	−0.30934477	−0.543252424	−0.149558663	−0.172277854	−0.07058702	1	0.817868601	−0.164657364	−0.054457209	0.417361227	0.436597419	−0.296513844	0.649317118
Social investments	−0.100750117	−0.363171409	0.132129466	−0.536825586	−0.322258125	−0.545955313	−0.15287258	−0.013495472	−0.078046533	0.817868601	1	0.193366161	0.021083599	0.638081208	0.565159411	−0.241227405	0.47715236
Environmental investments	0.256132341	−0.458317045	0.162975415	−0.191998666	−0.389173204	−0.309024346	0.205555058	−0.006339849	−0.312323813	−0.164657364	0.193366161	1	0.109315736	0.47964392	0.384702045	0.041851777	−0.034924598
Renewable energy	0.331982218	0.008756977	−0.151060025	0.10532699	0.073982702	−0.161871192	−0.105576684	−0.149724388	0.194462423	−0.054457209	0.021083599	0.109315736	1	0.007496515	0.262187731	0.697515795	−0.409093838
Municipal waste recycling	0.110470493	−0.403468278	0.220506629	−0.326020689	−0.290519499	−0.434044163	0.156175143	−0.122039572	−0.260986485	0.417361227	0.638081208	0.47964392	0.007496515	1	0.626656113	−0.038801339	0.376582753
Household energy consumption	0.306735409	−0.371053367	−0.060438164	−0.228867567	−0.359263698	−0.343816847	0.336016397	−0.292685634	−0.239622469	0.436597419	0.565159411	0.384702045	0.262187731	0.626656113	1	0.183549185	0.436099059
Green lands	0.144133302	0.023827388	−0.311635948	0.124125761	0.064590909	0.115123734	−0.010854913	0.021049927	0.298403954	−0.296513844	−0.241227405	0.041851777	0.697515795	−0.038801339	0.183549185	1	−0.202400494
Air pollution rate	−0.235328356	−0.287081044	0.059011184	−0.379964885	−0.24357382	−0.282385005	0.246378592	−0.257823406	−0.257287279	0.649317118	0.47715236	−0.034924598	−0.409093838	0.376582753	0.436099059	−0.202400494	1

Figure A1.
Pearson correlation matrix

Rating Scale	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
2	Weak	Between equal and moderate
3	Moderate importance	Experience and judgment slightly favor one element over another
4	Moderate plus	Between moderate and strong
5	Strong importance	Experience and judgment strongly favor one element over another
6	Strong plus	Between strong and very strong
7	Very strong or demonstrated importance	An element is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	Between very strong and extreme
9	Extreme importance	The evidence favoring one element over another is one of the highest possible order or affirmation

Figure A2.
Saaty scale used for transforming the panel of expert judgments into values

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