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Article

Pooling Expert Opinion on Environmental Discounting: An International Delphi Survey

José Martínez-Paz[a,#], Carmen Almansa[b], Valero Casasnovas[b], and José Colino[a]

[a]Department of Applied Economics, University of Murcia, Murcia, Spain

[b]Department of Business Management, Public University of Navarra, Navarra, Spain

[#]**Corresponding author. E-mail**: jmpaz@um.es

Abstract

The primary aim of this study is to examine the various issues involved in environmental discounting using a Delphi survey of a worldwide panel drawn from specialists in issues relating to discounting and long-term investment evaluation. The environmental discount rate is applied when performing cost–benefit analysis (CBA) on projects with environmental impact, in order to aggregate tangible and intangible effects. A review of the preceding literature shows that, after decades of academic debate, opinions have gradually converged. Furthermore, public administrations have begun to echo the need for a new look at the long-term discounting. One of the main findings of this study is the virtual unanimity of experts regarding the need to modify the approach to intergenerational discounting. The survey also yields a proposal for specific values for discount rates, based on the time horizon for the project under evaluation. The application of the resulting rates in the socio-economic evaluation of a project of environmental restoration provides numerical evidence of the importance of the choice of both discount rate and discount strategy.

Keywords: discount rate, social discounting, environmental discounting, cost benefit analysis, river restoration, Delphi, Segura River, discounting strategy

INTRODUCTION

The cost-benefit analysis (CBA) is an economic valuation technique that is taken into consideration as a decision criterion in public investment evaluation (Gramlich, 1990). CBA considers the existence of social costs and social benefits in the development of an economic activity, as well as the flows included in private or financial evaluations. These considerations are especially important in environmental programmes, plans or projects, since many environmental goods and services, such as clean air or biodiversity, lack a market value despite the fact that they have economic value, which must be fixed so as to be included in the analysis. CBA includes social profitability criteria because this aspect is evaluated in terms of the increase or decrease in global welfare, and hence, criteria involving intergenerational equity and sustainability can be incorporated (Almansa and Martínez-Paz 2011a).

Once the costs and benefits are identified and valued in monetary terms, they must be aggregated with the aim of obtaining synthetic evaluation indicators. To undertake this aggregation, we must understand that the resulting costs and benefits are not simultaneous in time, and because of the existing preference for the present, a discount rate must be applied in order to adjust the different times of incidence (Harrison 2010). The discount rate is intended to represent society's preference for consumption in the present over the future (Henderson and Bateman 1995). The higher the discount rates are, the higher the preference for present consumption will be, since the benefits to be enjoyed in the present will be more appreciated than those held in reserve to be enjoyed

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in the future (Gollier 2002). Then, the discounting means to underestimate future generations' preferences (Roumboutsos 2010). As Barro (2015) pointed out recently, "Discount rates play a central role in the literature on environmental protection that revolves around the Stern Review (Stern 2007)." As an example, Nordhaus (2007) refutes Stern's result about the net profit of investing in preventive measures on climate change, pointing out the very low discount rate used in this review (a real discount rate of 1-4%), which can be inconsistent with theoretical models and empirical evidence.

The resulting controversy on environmental or intergenerational discounting continues to fuel academic debate (Chen 2012; Davidson 2014). Nevertheless, the review of the literature carried out for this article shows that over the past decade, despite some continuing discrepancies, disagreement has given way to a clearer awareness of the need to adopt new approaches with a greater capacity to reconcile discounting with intergenerational equity or sustainability (Almansa and Martínez-Paz 2011a). For an overview of the various approaches to discounting, see, for example, Pearce et al. (2003), Guo et al. (2006) and Almansa and Calatrava (2007).

Presented below is a brief summary of the various ways of adapting discount rates to accommodate society's intergenerational distributional concerns, as they appear in the scientific literature, according to classifications made by Almansa and Calatrava (2007):

a) To address environmental concerns, the social discount rates (SoDR), below the standard discount rates (SDR), are used in the evaluation of a social project (Rabl 1996; Gollier 2010).

b) The declining discount rates (DDR) use a hyperbolic rather than an exponential discount factor[1]. A hyperbolic discount function tends to improve the viability of projects, in which the costs occur in the early years and the benefits do not appear until the end, while tending to reduce the estimated viability of projects with costs to be met at the end of the period. Hyperbolic discounting causes the penalty in the future to tend asymptotically towards zero over time, thus offering great promise as an option in the projects that stretch over centuries (Sterner 1994; Scrieciu et al. 2013).

c) The use of constant discount rates (CDR) adjusted to the time horizon of the impact generated by the project. Apart from the hyperbolic discount rate or DDR, discussed in the point above, other decreasing functions have been explored by, among others, Weitzman (2001), who finds that, in a climate of uncertainty about the economic future, the discount rate follows a Gamma distribution (giving rise to the term 'Gamma-discounting'). Newell and Pizer (2003) is an attempt to operationalise the findings of Weitzman (2001), which was subsequently furthered by Groom et al. (2004)[2].

d) Maintain the standard SDR but varying the value of the cost or/and the benefits over the time, in line with the approach proposed by Krutilla and Fischer (1975); a method developed in studies such Tol (1994) by using damage cost functions that are increasing over the time.

e) The use of different discount rates for tangible and intangible goods, in the same CBA application—the dual discounting approach—given the differences in their characteristics (Gollier 2010; Martínez-Paz et al. 2013)[3].

f) The design of different mechanisms, to include future generations in the analysis, is known as 'Intergenerational CBA'. The central argument is that, rather than value benefits and cost using the current generation's time perspective thought discounting, it needs to use time perspective of both, the current and the future generation. A variety of approaches, albeit with the same general objectives, can be found in Nijkamp and Rouwendal (1988), Sumaila and Walters (2005), and Morrissey et al. (2013), among others.

Parallel to ongoing developments and debate among the scientific community, public institutions are also starting to appropriate and adopt some of these new approaches to discounting. See, for example, the guidelines for CBA published by the European Commission (2008, 2013), which promote the monetary valuation of environmental quality improvements (externalities) and recommends standard social discount rates (SDR) of around 3.5% to 5% (2008) and 3% to 5.5% (2013). Also presented are the indicative social discount rates (SDR) for some EU countries based on the social time preference rate (STPR)[4].

A step forward can indeed be seen in the UK government's proposal (HM Treasury 2003), which is to use DDR based on the time horizon used in public policy evaluation (described under the heading "declining discount' in point b above). As Table 1 shows, the proposed discount rates are considerably lower than in relatively recent practice (Souto 2003). In fact, as far back as 1997, the Government of UK (HM Treasury) already recommended an SDR of 6%, despite empirical studies recommending it between 2% and 3% (Kula, 1988).

To resolve some of the uncertainty about discount rate, Weitzman (1998) surveyed a group of 1,700 US economists and subsequently a hand-picked group of 15 well-known experts using a brief questionnaire to collect their views on discounting. The initial survey was later extended in Weitzman (2001) to a total of 2,160 economists by questionnaire, and 50 experts via interview. The main outcome was the development of the so-called 'Gamma-Weitzman' approach that applies different discount rates for different time horizons. Subsequently, it also appears to have inspired the proposal described in the above-mentioned 'Green Book' published by the Government of UK, which is an indication of the extent of its impact and hence, of its significance.

Table 1
"Green Book" discount rate proposal

Discount rate (%)	*Project time horizon (years)*
3.5	0-30
3	31-75
2.5	76-125
2	126-200
1.5	201-300
1	>300

Source: HM Treasury (2003)

Due to uncertainty regarding the appropriate discount rate to use for the distant future, Weitzman (2001) suggested calculating it from a weighted mean of probable discount rates. In his view, we should establish a distribution of discount rates, setting a suitable time profile of discount factors for each discount rate and then find economic risk and uncertainty-adjusted average of these discount factors. Thus, Weitzmann suggests the schedule of time-declining discount rates as shown in Table 2, which divides the future or time horizon into five major periods, giving the corresponding marginal SDR.

The deduction from the preceding section is that the scientific debate is yielding accepted results, starting to permeate the practical level of application, and influence institutional guidelines. In the elapsed time between the Weitzman survey and the one reported in this paper, the scientific literature has begun to show signs of growing and increasingly unanimous support for the adjustment of discount rates in the light of new sustainability criteria.

Hence, the primary goals for this study are methodological. We wish to investigate, using a Delphi survey, the views of specialists from around the world on the main approaches to environmental discounting listed earlier, first and foremost in qualitative terms (the suitability of both environmental CBA and the various discounting approaches proposed for the intergenerational context) and secondly, and less in crucially, in quantitative terms, with a view to deriving concrete numerical discount rate values (or intervals) for different time horizons. The Delphi survey results are later applied to a real case study to enable a sensitivity analysis of the most strongly supported discounting approaches according to the average scores given by the experts.

The structure of the paper is as follows. Part 2 describes the general characteristics of the Delphi method and the specific methodology used in this exercise. Part 3 contains the presentation and the analysis of the survey results, from which we derive the implied certainty equivalent discount rate for the sample. Part 4 describes the practical application using the results from the survey. The paper ends with an outline of the main conclusions.

METHODOLOGY AND APPLICATION

The Delphi method: a description

The Delphi method is one of a number of forecasting techniques that draw on expert opinions. It is aimed at developing a framework for individual specialists from different disciplines to contribute their own opinions about the problem under discussion (Rowe and Wright 2011). Linstone and Turoff (1975) defined it as "a method for structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem." The method consists of consulting a panel of experts on a given topic by asking them, individually and anonymously, about their predictions for future events. Using a series of questionnaires, it creates channels of communication, allowing participants to give their opinions and later receive feedback on the views of the rest of the panel on the same issues and, finally, offers them an opportunity to review their original responses (Dalkey and Helmer 1963).

There are two basic principles underlying the Delphi method (Landeta and Barrutia 2011): 1) the subjective judgement of experts helps to reach a forecast in situations of uncertainty; and 2) group consultation leads to a better outcome than individual consultation and thus, facilitates decision-making. Some studies show that it is possible to predict more accurately through consultation with experts than by means of alternative econometric methods (Witt and Witt 1995). The Delphi method is particularly recommendable for use in areas where ethics or morals override economic and technological questions (Linstone and Turoff 1975). There is no question of the high level of uncertainty surrounding long-term environmental issues and the difficulty for the determination of the appropriate SDR for their evaluation. At the same time, they also carry direct or indirect ethical implications, specifically, intergenerational ethics, in the case in hand. This provides the main justification for the use of this methodology in this study, particularly in view of the limited number of experts in environmental discounting.

The quality of the results depends primarily on the attentive and careful preparation of the questionnaire and the selection of experts. It is also important that the survey designers are experts or thoroughly informed about the issue under investigation. It is not necessary to consult a very large number of experts. Dalkey (1969) conducted an extensive set of experiments concerned with evaluating the effectiveness of the Delphi procedures for formulating group judgements. This study shows that there is a significant increase in the reliability of the group of responses with increasing group size to about 17 experts. Adler and Ziglio (1996) reported that an expert sample of between 17 and 50 individuals produced good results. As pointed out by Somerville (2008) "the size of Delphi panels can vary widely and there is disagreement about what constitutes an appropriate panel size."

The main features of the Delphi method are (Okoli and Pawlowski 2004): 1) anonymity (no individual expert is aware of the identity of the other members of the debating panel); 2) iteration (there is no upper limit on the number of rounds, the minimum is two); 3) controlled feedback (each participant receives the results of the previous round and thus learns the different points of view put forward by the rest and

Table 2

The "Gamma-discounting" proposal

Discount rate (%)	*Project time horizon (years)*
4	0-5
3	6-25
2	26-75
1	76-300
0	>300

Source: Weitzman (1998, 2001)

is able to modify his/her own); 4) statistical results (the group response in each successive round can be represented by means of various descriptive statistics including means, modes and frequencies, among others); and 5) a heterogeneous sample (experts from various branches of activity contribute from their own perspectives).

There are now numerous applications of the Delphi method to the management of environmental issues. The future potential of this method for environmental uses was hailed by Amant (1970) in his comparative study of Delphi forecasts. It was also included among the methods for the economic valuation of the environment mentioned by Hufschmidt et al. (1983), and its application has grown steadily, very often in conjunction with other techniques, as shown in recent studies, such as Dios-Palomares and Martínez-Paz (2011), García-Melón et al. (2012), Krueger et al. (2012), Scolozzi and Geneletti (2012), Carson el at (2013), Navrud and Strand (2013), Benitez-Capistros et al. (2014), Strand el al (2014), and López et al. (2016) among others.

Application of the Delphi technique: implementation and characteristics

The survey was conducted by e-mail. The primary criterion for the selection of the Delphi panel was that the panellists should have had researched on the specific topic of environmental discounting and the overall theme of the evaluation of public projects with environmental impact published in international scientific journals. The search drew on the Web of Knowledge (WoK), using all available databases, performing a search using key words in the topics: social discount, environmental discounting, discounting, discount rates, rates of time preference, and environmental investment. The initial search resulted in an initial base of 379 potential panellists that was screened in two steps: 1) authors who were cited only once and in a job before year 2000 were discarded; and 2) twenty authors whose current contact information could not be found were eliminated. Finally, 280 experts were contacted, from which 118 declined the invitation to join the initial panel, in most cases because they considered their knowledge of the subject inadequate. Another 12 experts, invited on the recommendation of existing panel members, agreed to participate. This process enabled the construction of a final pre-selected panel of 174 experts, not based on any a priori geographic distribution.

The two rounds were predetermined, and the questionnaires for both rounds contained fourteen closed questions. Prior to each round, panel members received a letter of presentation and an information pack about the topics by e-mail. In the second round, each expert received a personalised questionnaire, with indications to remind participants of their own responses and inform them of the average response across the whole panel to the questions in the first round (Alcon et al. 2014). Finally, an internet link to a document with the end results was sent to all panellists, including those who did not answer the second round. Most of them responded by thanking such information and requesting some additional information or clarifications that were provided to them.

Table 3 shows the technical details of the survey and the distribution of experts by country group. Despite the fact that participation was purely voluntary and altruistic, the suitability of the panel members and their knowledge of the subject is evident in the final participation rate, which at 56%, is well over the 35% threshold considered acceptable in Delphi surveys (Adler and Ziglio 1996).

Two further points are worth noting regarding the final size of the panel, which comprised 98 experts: 1) this figure

Table 3
Technical details of the Delphi process

Process details	**Interview format**		E-mail	
	Interview material		Letter of presentation, information pack and the questionnaire. Panellists are encouraged to add their own comments, as well as answering the closed questions in the questionnaire.	
	Number of rounds		Two	
	Number of questionnaires distributed (pre-selected panel)		174	
	Number of experts participating in the 1st round		112	
	Participation in the 1st round		64.37%	
	Number of replies received in the 2nd round		98	
	Participation in the 2nd round		87.50%	
Expert details	**Distribution of experts by country group**	**Pre-selected***	**1st round***	**2nd round***
	North America (EEUU and Canada)	28.2	26.8	29.6
	Central and South America	12.0	14.3	16.3
	European Union (EU)	35.6	35.7	34.6
	Europe, non-EU	9.8	9.8	8.2
	Africa	5.2	5.4	3.1
	Asia	9.2	8.0	8.2

Source: Elaborated by authors. *All numbers in per cent (%)

is nearly twice the highest recommended maximum of 50 experts already mentioned in the methodology section; and 2) although the Delphi survey is a prospecting technique and thus, not designed to draw statistical inferences (Dalkey 1969), it is worth estimating the representativeness of the sample in the worst-case scenario of a population tending towards infinity (a very large lumber of experts).

This section, therefore, describes the validation of the feedback process, which is to determine whether the second round achieves its basic objective. That is, whether the replies given by the experts show greater consensus and thus, less variability. The results about consensus (Table of the appendix) show that 12 of the 14 items show lower dispersion in the second round, and only two show a bit higher. Levene's test of homogeneity of variances (Glass and Hopkins 1996) was performed on each item in each round to test the significance of these variations in dispersion, the results revealing a statistically significant (at the 5% level) reduction in variance in six items, thus confirming a higher level of consensus among panel members in the second round. The next issue to be examined is response stability, which, to demonstrate the impact of the feedback between the rounds and/or experts (the cornerstone of this data collection process), should preferably be not too high. The result in this respect shows that only 10 of the 98 experts, who participated in the second round, failed to modify any of their replies. This gives a low response stability index (9.8%), suggesting that panel members gave great consideration to the overall results of the first round. Analysis of stability per item shows an average modification frequency of 29.9 across the panel, versus a theoretical maximum of 98 (which would be the score if all panel members were to modify all the items). All of the above leads to the conclusion that response stability is low overall. In short, the second round yields two desirable outcomes: a higher degree of consensus and a lower level of stability, both of which provide justification for the use of the Delphi method.

RESULTS AND DISCUSSION

In what follows, we present the main results for the various items included in the questionnaire. Table 4 gives the basic statistics for each question. Panel members were asked to indicate their level of agreement with the various statements using a standard Likert-type scale (from -2 to 2), where -2 indicates 'complete disagreement', 2 indicates 'complete agreement', and 0 indicates indifference.

Table 4
Basic statistics for the survey items

	1st round		2nd round	
Questions*	**Median**	**Mode**	**Median**	**Mode**
Cost-Benefit Analysis is the appropriate method to use for the economic appraisal of public investment projects, including those with intergenerational impact.	1	2	1	2
The Social Discount Rate (SDR) should be reconsidered in intergenerational settings with time horizons spanning centuries, because the standard SDR is only appropriate in the case of projects with time horizons of a few decades.	2	2	2	2
A lower SDR should be used in intergenerational contexts, in order to assign more weight to long- and very long-term benefits and costs (sustainability).	2	2	2	2
The only valid SDR in intergenerational contexts is 0%.	-1	-2	-2	-2
The value of the SDR should be linked to the project time horizon (a "Weitzman" or "Green book" scheme, or similar).	1	2	1	2
The value of the SDR should be linked to the characteristics and type of natural resource affected.	0	1	1	1
In time horizons spanning centuries, it is better to use a time variable discount factor (such as hyperbolic discounting) rather than a constant factor (exponential).	1	2	1	2
One option to bear in mind is the simultaneous use of different discount rates for tangible and intangible effects in the same CBA.	0	0	1	2
If you agree that the time horizon for the project is a variable that that should be considered when selecting the SDR please indicate the discount rates you consider reasonable in projects with different time horizons (score or interval):	**Mean**	**Stand Deviation**	**Mean**	**Stand Deviation**
0-30 years	3.80	1.41	3.47	1.46
31-75 years	3.02	1.03	2.84	1.04
76-125 years	2.02	1.08	1.88	1.05
126-200 years	1.68	1.04	1.55	1.04
201-300 years	1.11	0.92	1.05	0.82
>300 years	0.93	0.93	0.87	0.79

Source: Authors' own calculations based on survey results. *In question 1 to 8, the scale is from -2 (total disagreement) to 2 (total agreement), with 0 indicating a neutral position

In what follows, we present and discuss the frequencies obtained in the experts' replies to the survey questions. Unless otherwise specified, the data refers to the second (final) round:

1) Four fifths of the experts (79.2%, scores of +1 and +2) agree with the statement that CBA is appropriate for the evaluation of public investment projects, including those with an intergenerational impact.

2) Three quarters of the experts (75%) are in complete agreement with the need to reconsider the approach to discounting in the intergenerational context, with 100% of the panel members agreeing to it on some level (scores of +1 and +2).

3) Practically the entire panel of experts (97.8%) agree that reconsideration of the discounting issue should lead to lower[5] discount rates, in order to give more importance to the long-term costs and benefits.

4) Just over two thirds (68.8%) manifest disagreement with the application of a unique discount rate of 0% for projects with intergenerational impacts, which means that only 18.7% agree with the proposed statement. This suggests that experts consider the discount mechanism to be a consistent and valid instrument for the monetary appraisal of future investment proposals, despite some voices expressing support for a single zero-discount rate as the only valid option for environmental issues. In fact, however, this no-discounting view is more closely associated with disagreement over the use of CBA in the intergenerational context.

5) A large majority (85.5%) agrees that the SDR in the intergenerational context should be determined as a function of the projected time profile. In other words, only 3.8% manifest complete disagreement (scores of -2). As noted in the introduction to this paper, the Government of UK has already adopted this type of discount schedule. The results of this survey clearly support this approach.

6) Close to two thirds (62.5%) of those surveyed agree that the discount rate should take into account the natural resource affected by the project under appraisal, while the remainder express disagreement (29.1%) or indifference. The percentage of agreement is higher than in the first round, where less than half the panel (47.8%) supports the idea.

7) Again, a large majority of the panel members (84.5%) agree with the statement that for time horizons of centuries, a variable (hyperbolic) discount factor is more appropriate than a constant factor. The period of reflection between the first and second rounds increases the percentage of agreement. Only 8.9 % of the experts (second round) manifest disagreement with this discounting approach. Thus, it can be concluded that hyperbolic discounting (or other variants of the so-called DDR[6]), which decreases over time, thereby reducing the burden on generations in the distant future, is an option that the relevant authorities should consider when evaluating projects whose environmental impact may last for hundreds of years.

8) The results for the suitability of the dual discounting (DD) approach for use in the appraisal of projects with tangible and intangible impacts on future generations show that just over half the experts (52.1%) expressed agreement with the simultaneous use of different discount rates for tangible and intangible goods, in the same CBA. The percentage of agreement in the first round is slightly lower (41.9%). Just over a quarter of the experts (26.7%), that is, fewer than in the first round, manifest disapproval to this approach. In both the rounds, the percentage of don't know (DK) and no answer (NA) responses to this question, compared with the rest, is relatively higher at 20.4% in the second round and 36.7% in the first. This is a reasonable outcome, taking into account the novelty of this approach in the research literature, as advanced earlier in this paper. When the sample is re-proportioned in order to focus only on those experts who answer this question, nearly two thirds (64.1%) of those expressing an opinion on the DD approach are found to be in favour of it.

9) Table 5 gives the basic statistics for the results of the Delphi survey regarding what discount rates (in real terms) should be used per time horizon, in projects with long-term impacts. As the table shows, the average discount rates are: a) visibly lower than standard SDR, and b) slightly lower in the second round, suggesting that the feedback causes the experts to adjust their recommended discount rate downwards. The representative discount rates of the group will be provided by the mean, which best represents the opinion of the group, given the high level of consensus reached at the second round. (Pill 1971).

As already noted in the introduction, the Delphi findings represent expert opinion, rather than indisputable fact (Muller 2003), and the choices based on the strengths and weaknesses of alternative approaches to discounting are difficult to decide solely on the votes of experts. Nonetheless comparison of the modes reveals that the experts prefer three intervals—up to 75 years; 75 to 200 years and over 200 years—instead of the six originally proposed. The median values are the same for the last two intervals, which could be combined as > 200 years.

The mean discount rates proposed by the experts in the second round of the Delphi survey are slightly lower than those proposed by Weitzman (see Table 2) or the Government of UK (see Table 1). The immediate conclusion, therefore, is that the academic community represented by the panel is in favour of reducing these discount rates even further. On the other hand, the value obtained by the panel is also very similar to the 1.5% discount rate for the evaluation of changes in biodiversity recently proposed by Gollier (2010), which was derived from an extension of the Ramsey rule for economic and environmental goods.

Lastly, we compared the final results of the second round by broad geographical areas, finding no significant differences in the first eight questions, which required qualitative answers or, indeed, in the discount rates for the last four time horizons, although the proposed discount rates of the US and the European experts for the first two time horizons were 5% to 10% lower than those of the experts from other areas of the world. This is consistent with the existing link between the SDR in STPR (see endnote 4) terms and the economic parameters on which it is based. Economies with higher levels of development at the time of the study have lower STPR rates, as noted in the European Commission (2008, 2013) documents

Table 5
Delphi estimates of discount rates (%) by project time horizon

Time Horizon in years	Mean		Median		Mode	
	1st round	2nd round	1st round	2nd round	1st round	2nd round
0-30	3.80	**3.47**	3.5	**3.5**	3.0	**3.0**
31-75	3.02	**2.84**	3.0	**3.0**	3.0	**3.0**
76-125	2.02	**1.88**	2.0	**2.0**	2.0	**2.0**
126-200	1.68	**1.55**	1.5	**1.5**	2.0	**2.0**
201-300	1.11	**1.05**	1.0	**1.0**	1.0	**1.0**
>300	0.93	**0.87**	1.0	**1.0**	1.0	**1.0**

Source: Authors' own calculations based on survey results

cited above. This is because the consumption discount rate (the term *ce* at footnote 1) is expected to vary. Typically, it is higher in lower-income countries (Heal 2005).

In practical terms, these results show that, in projects with less environmental impact, where shorter time horizons can be used, 'the environmental discount rate' (understood as a revised version of the traditional discounting model) will be closer to the SDR of the country in question. Importantly, however, when it comes to projects with more far-reaching consequences, which require consideration of a longer time horizon because they pose a greater threat to the welfare of future generations, we find no significant disparity of opinion across different areas of the world. This—beyond its relevance to the practical aims of this paper—is potentially of the key importance when it comes to addressing major environmental issues, which are inherently global in nature.

CASE STUDY: ECONOMIC ASSESSMENT OF THE SEGURA RIVER ENVIRONMENTAL ENHANCEMENT PROJECT

As advanced earlier, in order to illustrate the importance of the selection of the correct the correct discount rate for use in the economic appraisal of projects with environmental impacts, this section of the paper briefly describes a practical application to a real case. Another recent cases study can be found at Almansa and Martínez-Paz (2011b), using a probabilistic approach to CBA, and Martín-Ortega et al. (2015) witch develop an integrated approach to the economic analysis of the Water Framework Directive (WFD). Towards the end of the year 2000, the European Union (EU) adopted the WFD as a means to fully address water consumption and water quality issues across EU waterways (Perni and Martínez-Paz 2013). The application of WFD principles in Spain has resulted in the so-called "Actions for the Management and Use of Water" programme, which includes environmental measures aimed at the recuperation of river basins.

The Segura River, located in southeast Spain, is one of the most highly regulated rivers of the Mediterranean basin (Grindlay et al. 2011). It is known for the irregularity of its flow due to long periods of drought and for problems with water pollution, particularly along the final stretch of its 325-km long course (Pellicer and Martínez-Paz 2016). Several projects have been and are currently being undertaken in this respect along the river Segura (Perni et al. 2012). The latest, still in its initial stages, is the restoration and recovery of the part of the river that stretches through the main city, Murcia (400,000 inhabitants, i.e., 50% of the riverside population) for a distance of more than 2 km, over most of which (1.9 km) it has no natural banks and is artificially contained. Not only is this stretch of the river severely degraded and its ecosystem anthropogenically affected, but also the average flow is currently so low that public use of the riverbanks or waters is virtually impossible. The restoration of this urban section of the river involves two projects, one to restore hydraulic depth by partially purifying the waters and reinstating the banks, the other to increase the mean flow (CHS 2009). The same technical project plan also includes the cost estimates for these actions, shown in Table 6.

Both, the dredging and partial purification of the waters, and restoration of the riverbanks are planned during the first year of the project and involve only a single payment, since there are no exploitation or maintenance costs attached. As well as the initial investment for year 2 of the project, an additional investment will be required every 10 years to keep the installations and pumping stations in good working order. The overall annual exploitation and maintenance costs, once the system is in operation, will amount to EUR 435,393 per year. Minor works required for total project completion in the third year will also entail some expenditure.

The environmental services recovered by the project are non-market benefits and, therefore, have no direct price, but their value is estimable by indirect methods drawn from environmental economics. For the case in hand, we use the avoided cost method, which values the impact (benefit) of intervention in terms of the cost of the cheapest available alternative (Perni et al. 2012) A technically viable alternative treatment to prevent muddy build-up and the deterioration of the riverbank consists of an annual campaign to clean up the river, maintain the riverbank, and physically and chemically treat the waters to prevent unpleasant odours, maintain water quality, etc. This precise case, which is discussed in Sánchez-García (2011), enables us to estimate the environmental benefit of the restoration project, in monetary terms, at EUR 1,230,869 per year.

Thus, using net present value (NPV) as the project profitability indicator, evaluations are made under two different discounting approaches (exponential and hyperbolic) and time scales (from 30 to 200 years), using the values obtained from the Delphi survey. Table 7 shows the results of the 28 evaluations thus performed.

Discussion of these results raises two types of issues, some specific to the case study, and others of a more general nature relating to the capabilities of the different discounting approaches. Thus, it is found that non-inclusion of environmental externalities (standard CBA) with standard SDR (5.5%) gives a negative NPV for all time horizons and discount strategies, given that market flows are always negative. The obvious conclusion, therefore, is that, it is not a suitable method for the appraisal of projects of these characteristics, unless the analysis is designed to include non-financial criteria. The inclusion of environmental benefits as a monetary value, discounting all flows at standard SDR (5%), leads, inevitably, to an improvement in the project profitability outcome. It can be seen, however, that both discount strategy also yields negative indicators. For environmental CBA using DDR, the case study signals the importance of selecting a correct discount rate to suit the length of the time horizon considered (as indicated by the experts consulted in the Delphi survey and in the preceding bibliography). Reducing the penalty on future environmental benefit flows by using a DDR gives favourable project profitability ratios, irrespective of the adopted discount strategy (exponential or hyperbolic). Table 7 shows internal rates of return (IRR) slightly below the 2.6% level (exponential discount) and 3.9% (hyperbolic discount) in the intergenerational context (200 years). These results, which are in line of those obtained by Martínez-Paz et al. (2014), are a clear illustration of the importance not only of the applied discount rate but also of the adopted discount strategy.

Table 6
Construction and operating costs

Chapter	Time in years	Cost in EUR at 2010 prices
Dredging and purification	1	4,285,241
Restoration of riverbanks	1	3,456,694
Flow recirculation works	2	15,139,455
Minor works	3	167,566
Renewal of installations	11+(10)	928,823
Renewal of pumping stations	12+(10)	1,199,224
Operating and maintenance (EUR/year)	≥3	435,393

Source: Authors' own calculations based on CHS (2009)

CONCLUSIONS

The primary result is that this panel of expert's survey reveals a consensus over the need to reconsider the approach to discounting in the intergenerational context. Almost all (98%) recommend the reduction of discount rates. A large majority (87%) are in favour of adjusting the discount rate to the time horizon considered. Most of the experts (86%) support the use of a DDR (hyperbolic) for the very long term; a somewhat smaller majority (52%) are in favour of the DD approach; and only 17% of the panel members are in favour of non-discounting (or 0% discount rate). The specific discount rates given by the experts for different time horizons follow the lines of the Government of UK proposal (HM Treasury 2003), but with a slight downwards tendency, especially for time horizons between 76 and 300 years.

As an overall conclusion we can say that, the results of this study provide empirical confirmation of the view put forward by Pearce et al. (2003) in a review of advances in discounting: "the use of declining discounting approaches (the hyperbolic scheme and declining discount rates based on time intervals) is a practical option that may contribute in the debate on discounting toward consensus between those who want to continue discounting the future at traditional discount rates, and those who reject the standard SDR in an intergenerational context.'

Finally, the application presented in this article reveals some conclusions that go beyond the exemplification of the opinions shared by the panel. First, we might highlight the fact that the appraisal of projects, whose benefits are largely in the form of environmental restoration, should not be based on classic CBA but on the environmental CBA option, that is, DDR linked to the project time horizon, or a DD approach, to include

Table 7
Net present value by evaluation scenario in EUR in 2010

		Standard CBA*	Extended CBA#	Environmental CBA *Declining Discount Rate (by time horizon)^*		Environmental CBA *with Dual Discount approach†*		
Discounting Strategy	Period (years)	NPV (EUR 10^3)	NPV (EUR 10^3)	DDR (%)	NPV (EUR 10^3)	DDR (%)	NPV (EUR 10^3)	IRR (%)
Exponential	30	−28,424	−12,807	3.47	−11,055	3.47	−8,040	1.59
	75	−30,752	−11,049	2.84	−4,357	2.84	4,921	1.98
	125	−30,945	−10,866	1.88	5,281	1.88	25,750	2.47
	200	−30,959	−10,853	1.55	13,111	1.55	42,381	2.58
Hyperbolic	125	−33,362	−5,928	1.88	4,656	1.88	20,779	2.78
	200	−35,920	−3,530	1.55	14,717	1.55	39,582	3.89
	300	−38,230	−1,475	0.87	38,376	0.87	88,151	4.83

Source: Authors' own calculations.

Notes: *CBA without including environmental externalities, standard SDR (5.5%) #CBA including environmental externalities, standard SDR (5.5%) ^CBA including environmental externalities, time horizon adjusted discount rate (DDR). †CBA including environmental externalities, with Dual Discount (DD) approach (DDR for intangibles effects and SDR for tangible effects) environmental benefits extending beyond the present generation. The application also shows that the choice of discounting strategy (exponential or hyperbolic) used in project appraisal is just as important in as the choice of discount rate per se.

It is worth noting that, although expert opinion can be considered a key component of discounting decisions, it is also important to bear in mind the repercussions of a chosen discount rate—or discounting approach—in any practical application of CBA, since intergenerational discounting involves not only technical but ethical issues.

Finally, we point out that the monetary valuation of environmental goods and services, as in CBA, is only one perspective to guide decision-making process, and in some cases it is controversial or even counterproductive, as it undermines the objectives of conservation (Rodríguez-Labajos and Martínez-Alier 2013). Therefore, it may be necessary to apply other methods to improve the results and acceptability of decisions. In this sense, interaction with local stakeholders, cost-effectiveness analysis and/or multi criteria approaches (Munda 2008; Perni and Martínez-Paz 2013) are crucial.

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NOTES

1. The hyperbolic (f_H) and the exponential (f_E) discount factors have the general form: $f_H = \frac{1}{1+SDR*t}$; $f_E = \frac{1}{(1+SDR)^t}$ where SDR is the discount rate choose and t the time.
2. According to Groom et al. (2004), the Weitzman discount factor (f_W) can be expressed as $f_W = \frac{\alpha}{1+(t\frac{\beta^2}{\alpha})}$ where α and β denote the mean and standard deviation of the Gamma distribution. Weitzman proposes two rounded off average values as parameters for the gamma distribution: *α-value*=0.04 per annum and *β-value*=0.03 per annum.
3. For a description and justification of the Dual Discount (DD) approach, see Almansa and Calatrava (2007). Under this approach, Net Present Value is given by the following equation: $NPV = \sum_{t=1}^{t}\left(\frac{F_t}{(1+SDR)^t}\right) + \sum_{t=1}^{t}\left(\frac{N_t}{(1+EDR)^t}\right)$ where F_t denotes the annual net financial cost or benefit (usually the shadow price of the tangible effects), and N_t is the annual net environmental cost or benefit (usually of the intangible effects) as assessed by the current generation in year 0. The discount rate varies, using the appropriate SDR for the economic effects and a lower Environmental Discount Rate (EDR) for the environmental effects.
4. In practice, the STPR formula works as follows (Pearce and Turner 1990): STPR = c e + p where *c-value*=the real per capita consumption rate; *e-value*=the elasticity of the consumption function's marginal utility; and *p-value*=the type of interest of pure time preference. The component *ce*, hence, represents the idea that, since it is likely that future societies will be richer, we allot a smaller weight to their earnings, and should therefore discount those future earnings. This is what is called the decreasing consumption marginal utility principle.
5. Numerous authors defend the reduction of discount rates for environmental reasons, conventionally determined as a rational adjustment in standard discount rates (Rabl 1996).
6. Thus, there is increasing academic support for calculating time-varying discount rates using a decreasing hyperbolic function, with a value between zero and the SDR (Sterner 1994).

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Appendix

Consensus test

Questions	Standard Deviation		Difference
	1st Round (σ1)	2nd Round (σ2)	(σ1)-(σ2)
1	0.44	1.25	0.19*
2	0.64	0.43	0.21*
3	0.67	0.54	0.14
4	1.54	1.36	0.18*
5	1.15	0.92	0.23*
6	1.35	1.28	0.07
7	1.15	1.02	0.12
8	1.37	1.17	0.20*
9a	1.41	1.46	-0.05
9b	1.03	1.04	-0.01
9c	1.08	1.05	0.03
9d	1.04	1.04	0.00
9e	0.92	0.82	0.10
9f	0.93	0.79	0.14*
Mean	1.11	1.03	0.08

Source: Authors' own calculations based on survey results. * 5% Levene's test significance