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Double Discounting for Intergenerational Economic Net Present Value

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Abstract

In economic policy-making, the broadly utilitarian framework of cost-benefit analysis (CBA) is used to measure welfare changes via opportunity cost and willingness to pay. For intergenerational valuation, CBA is usually supplemented with declining discount rates (DDR). At the same time, philosophical research that concentrates on intergenerational justice proceeds within framework of many approaches (cf. Tremmel (2006), Page (2006), Gosseries and Meyer (2009)). That raises the question of how ethical concepts on the one hand and decision criteria relate.

Intergenerational projects evaluation via CBA can be conducted by calculating the Economic Net Present Value (ENPV). When DDR are used in ENPV, a more favourable valuation of future benefits is achieved, in comparison with applying the constant social discount rate (SDR). However, such an approach still does not explicitly incorporate deontological considerations concerning, for instance, value one may attach to unborn generations, who are unable to participate in the decision process.

To rectify these shortcomings, the paper proposes a modified decision criterion for CBA that explicitly incorporates ethical judgements concerning future generation, called Intergenerational Economic Net Present Value (IENPV). While CBA generally assumes that utility depends on individual self-centred consumption, here the individual utility function depends also on consumption of other people and a deontological parameter. The former enables to include benefits and costs accruing to future generations on the basis of contemporary people preferences, while the latter depicts the importance of future persons, as judged by an individual in the current generation.

The modified decision criterion embodies double discounting, as it applies the social discount rate within a generation and the rate based on ethical attitudes towards future people between generations. I argue that this modification goes some way in overcoming the flaws of consequentialism, sum-ranking, and welfarism concerning intergenerational decision-making while still exploiting the usefulness of the utilitarian framework concerning the intragenerational perspective.

1. Introduction

The main aim of sustainable development is to ensure undeteriorated welfare for future generations. Intergenerational investment projects may serve that purpose, as contemporary generation makes sacrifice (voluntary reduces its welfare by investing) for the sake of forthcoming generations, whose welfare will increase as a result of the implemented project. The examples of such transfers are predominantly environmental investments, including biodiversity protection or climate change mitigation, where effects may reach hundreds of years.[1] Multigenerational time horizon may also emerge in case of infrastructure investments, i.e. in renewable energy sources or highways.[2]

The paper seeks to intertwine four issues:

First, Cost-Benefit Analysis (CBA) criteria, i.e. Economic Net Present Value (ENPV) rest on utilitarianistic principles. They are quite convenient to apply for project appraisal: summation of all costs and benefits across individuals and in time, delivering single monetary value easy to interpret (ENPV ≥ 0 – accept; ENPV < 0 – reject an investment). However, measuring economic efficiency based on utilitarian background when investment effects reach beyond life of people who make the decision, is unequivocal. Firstly, classical CBA restricts considerations to one, utilitarianistic concept of justice only. Secondly, this background serves insufficiently with respect to its three main dimensions: welfarism, sum-ranking and consequentialism (Sen and Williams, 1982, Berrens, Polasky, 1995).

The first aim is to modify utilitarianistic basis of ENPV to adjust them to intergenerational time frame.

Second, when unborn future generations unable to speak for themselves are at issue, deciding to accept or reject a project involves inevitably some normative approach. That approach is broadly discussed by philosophers. Frequently analysed is Rawls' original position where impartiality is achieved by locating all generations behind a veil of ignorance (Rawls, 1971, Dierksmeier 2001). However, the range of ethical approaches is much wider. Gosseries and Meyer in their introduction to "Intergenerational Justice" (2009) list other influential approaches: i.e. communitarianism, libertarianism, marxism, reciprocity rules and sufficientarianism.

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[1] The analysis made by Anthoff *et al.* (2009) or Chapman (2001) stretches the time frame to 1000 years.

[2] It is worth highlighting that the issue of intergenerational transfers can be arranged in the opposite direction, where contemporary investments may cause future welfare reductions: nuclear power plants, including radioactive waste disposal (Oxera, 2002) or non-renewable sources of energy extraction and usage.

CBA's development led to various proposals how to treat future generations more equally. Prevailing approach is a quite simple idea to use lower discount rate (DR), which impacts tremendously present value of very distant effects. However, even if applying lower estimates (i.e. declining discount rates, DDR) result in higher present value of intergenerational outputs, the relationship with intergenerational ethics is blurred.

Then, the second aim is to make this connection more explicit.

Third, intergenerational transfers meet an unavoidable issue of non-existence of future generations and, thus, inability to measure their preferences. In intergenerational discounting, there are two paths to deal with it. Prevailing number of studies refer to Ramsey approach. However, this approach needs estimates, which need certain assumption. Cline (1999) states that low discount for more distant future are the results of Social Time Preference Rate (STPR) parameters: growth rate and elasticity of marginal utility. That involves some level of subjectivity of the analyst. Another option is to estimate discount rate via stated preferences, asking individual about their intertemporal choices. Both approaches use preferences of contemporaries, however the connection of the latter is more direct.

Therefore, third aim is to create a ground to plainly include present generation preferences into decision criteria.

Forth, the last issue is related to stated preference studies. The results show that discount rates decline as the time passes. However, for distant intergenerational effects, some methods may produce too low estimates due to the fact that future value of small today input grows substantially and may produce values unimaginable for an average respondent. That may bias the results as for very long time discount rate may be lower than actually preferred.

The paper tries to shed some light on this issue as well.

The main aim can be formulated as: To develop an applicable decision criterion based on preferences of contemporary individuals and explicitly presenting ethical attitude toward future generations.

It is important to mention, that not all of the four issues are given equal attention in the paper. The major part of study is devoted to flaws of utilitarianism and establishing explicit connection between ENPV and normative approach.

The paper is organized as follows: Section 2 presents literature review in respect to CBA and intergenerational context, declining discount rates and other solutions allowing to include normative criteria. Section 3 discusses main sources of criticism of CBA both in intragenerational and intergenerational context on the basis on three utilitarian dimensions proposed by Sen and Williams (1982). Section 4 develops a modified approach to CBA decision criteria based on rejection of purely self-centered consumption and inclusion of deonthological elements into utility function. Section 5 depicts the modified model on an example, exploring the differences between traditional and modified approach. Section 6 provides a discussion of the results and the limitations of the approach. The paper ends with concluding remarks.

2. CBA, discounting and preference measurement in intergenerational context – literature review

CBA has been widely used as a method for project appraisal. CBA aims at achieving efficient allocation *via* overcoming market distortions in respect to present and future prices of goods and capital. Distortions are dealt by willingness to pay (WTP) as a measure of projects effects and opportunity cost (OC) for project's inputs. Intertemporal allocation is done *via* marginal rate of time preference (MRTP) and opportunity cost of capital (OCC). Starting from 1970's, where works by Dasgupta, Sen and Marglin (1972) and Little & Mirrlees (1974) were released, a substantial number of publications has been developing CBA assessment, although the beginnings date back to Pareto optimality (1896), Kaldor (1939) and Scitovsky (1941) works.

Although CBA is used in various types of projects, including climate change, it has been criticized as well. Zerbe and Bellas (2006), Pearce *et al.* (2006) or Mishan & Quah (2007) list a number of issues, including the absence of any "scientific" method of aggregating preferences (a socially "consensus" welfare function), reflecting in CBA outcome the existing patterns of welfare allocation, or the impossibility to measure utility, ignoring transaction costs, income distributions and Kaldor-Hicks (KH) criterion flaws.

When intergenerational perspective is analysed, the major share of debate is devoted to normative issues. The reason for this is depicted by Mishan & Quah (2007). They stress that defining rate of discount in terms of MRTP or OCC becomes difficult when some of gainers or losers from the project are not alive for the whole life cycle of the investment. Mishan & Quah (2007, p. 171-172.) describe the problem as follows:

"(…) suppose a benefit of $1000 is to be received by person X in year 100. The common rate of discount *r* (…) is such, we shall suppose, as to discount this $1000 to the sum of $2in year zero. But even though this *r* remains constant over his own lifetime, if person X is born in year 60, he cannot properly be said to be indifferent as between receiving $1000 in year 100 and receiving $2 in year zero when he is in fact not alive in year zero, this being 60 years before he was born."

Traditional ENPV assumes implicitly that each person affected by the project is alive during the entire investment period. Obviously it is not possible when effects are generated for a hundred or more years. Consequently, we arrive at an unsolvable issue: delivering economic appraisal when the preferences of people are unobtainable. It pushes decision making procedure away from economic and closes to normative dimension.

Page (2006) highlights that reciprocity in dealing between generations differs in quality and strength from transfers between contemporaries. Berrens & Polasky (1995) point out that since future generations are not yet present, they cannot negotiate any contracts or transfers with the current generation. Zerbe & Bellas (2006) write that KH neglects moral rights defined as the concern for other beings. Gardiner (2006) states that CBA for intergenerational context becomes controversial, as it tries to define the ends that ought to be achieved, and too narrow, as it takes into account only those items of costs and benefits that can be expressed in economic terms and tend to ignore longer-term values.

One of the crucial points of the debate is what discount rate should be used for the analysis. There are two reasons for that: 1) applying discount rates, even of low values, like 3% (compare EC Guidelines, 2014) would result in tremendous shrinkage in present value of future effects; 2) for time horizons longer than 30 years both MRTP or OCC are in practice unobservable on the market. The general tendency is to apply lower discount rates than within-generation time frame. Portney & Weyant (1999) relate it to the two opposing schools: descriptive (MRTP and OOC) and prescriptive (based on ethical principles, using lower rates than market provides). (See also Baumol, 1968, Arrow *et al.*, 1995, Manne, 1999, Cline 1999).

2.1. Ramsey equation and intergenerational perspective

The prevalent prescriptive approach is Ramsey equation (Ramsey, 1928). The classical interpretation of Ramsey equation $s = \rho + \eta g$ used for discounting consumption is that ρ refers to utility discount rate or pure time preference rate, η stands for elasticity of marginal utility of consumption and is multiplied by g – projected long-run annual growth of *per capita* real consumption and it reflects utilitarian assumption that achieving efficiency needs allocating resources where marginal utility of consumption is highest (Frederick *et al*, 2002, Freeman & Groom, 2015).

In intergenerational context ρ is usually assumed to be 0 to ensure equal treatment of future generations, because positive ρ would diminish future generations utility (Weitzman, 2010)., Arrow *et al.*, 2012, Lee & Ellingwood, 2015). Newell & Pizer (2001) cite Ramsey opinion that that it is ethically indefensible to discount the utility (i.e., well-being) of future generations. However, Arrow (1999) argue that it is not enough to explain the morality phenomenon toward future generations. Stern (2006) on the other hand interprets utility discount rate as annual risk of catastrophe eliminating society and therefore accepts positive value. Subsequently, η changes interpretation into inequity aversion or constant relative risk aversion (Anthoff *et al*, 2009, Dasgupta 2008, Smith, 2011). Arrow *et al.* (2012) argue that elasticity of marginal utility of consumption reflects the maximum sacrifice one generation should make to transfer income to another generation. Buchholz & Schumacher (2010) relate it to planner's degree of inequality aversion.

Another modification of Ramsey formula relates to uncertainty, either implicitly existing in DR, either relating to uncertainty of future growth. The former is justified due to placing much higher present value weights on scenarios with low discount rates, while scenarios with high discount rates are relatively less important. Then, certainty equivalent discount rates based on the distribution of possible rates at future time decline as the time grows (Weitzman, 1998, 1999, 2001; Fisher, 2003, Arrow *et al.*, 2012). The latter refers to inclusion of precautionary effect (Gollier *et al.*, 2008, Arrow *et al.* 2012, Pindyck & Wang, 2013). Lee & Ellingwood (2015) suggest to modify precautionary effect by adding an element based on increasing volatility of consumption growth rate in time. They also suggest that those parameters can be based on decision-maker preferences toward risk aversion.

Hampicke (2011) criticizes approaches based on Ramsey equation due to the fact that there is no consent between researches about the values of η and ρ, that are critical for the result of valuation.

It needs to be highlighted, that although applying lower values than market rates as well as DDR approach results in more equal treatment of future generations by increasing present value of future effects, those studies do not show explicitly the ethical attitude toward future generations. Furthermore, many studies on Ramsey approach imply that the parameters crucial for calculating STPR should be based on a vague idea of "decision-maker" or "planner" preferences. It is difficult to assess then if they truly depict real preferences of individuals.

2.2. Direct measurements of preferences in discount rate studies

Time-decline is also found in studies based on questionnaires investigating directly individual preferences (Cropper *et al*., 1994; Fredericks *et al.*, 2002, Almansa & Martínez-Paz, 2011; Foltyn-Zarychta, 2014b). Such studies deliver discount rate on the basis of direct measurement of preferences (stated preferences: contingent valuation or contingent ranking. Compare Spash & Hanley 1994, Garrod & Willis, 1999), it should be stressed that ethical attitude can be observed indirectly only: on the basis of the time-decline of the estimates.

The stated preference approach refers directly to individual preferences, where the market prices are unobservable (Whitehead & Blomquist, 2006). Due to the fact that it is based on declared preferences observed on hypothetical markets created via questionnaires, it can also capture deontological preferences of respondents and is a convenient tool for delivering the value of non-market goods, especially environmental goods. For applications one can refer to i.e. Mathews *et al*. (2006), Schwarz (1997), Carson *et al.* (2000), or works edited by Whitehead *et al.* (2011) and Champ et al. (2003).

Contingent valuations can be also applied for delivering the value of discount rate, both short term (Coller & Wiliams, 1999; Harrison *et al.* 2001), and long term (Frederick 2003; Luckert & Adamowicz 1993; Meerding et al. 2010). The questionnaires are designed to ask about indifference point between present and future benefits that is used to calculate DR (Cropper, 1994; Chapman 2001), or to ask respondents directly about discount rates (Weitzman, 2001, Drupp *et al.*, 2015). However the latter is more difficult to aswer by a respondent that do not specialize in the issue.

Even if calculating DR on the basis of an indifference point equalizing present and future benefit is more easy to be comprehended by a respondent, it is vulnerable to another kind of deficiency. Intergenerational valuation studies inevitably force to use extremely high values for long delays, even for estimating low DR which may trigger additional effect of time-decline of DR estimates.

Chapman highlights that higher rates obviously would require much higher numbers of future effect, which could lead to absurd answers.[3] Cropper *et al.* (1994) estimate the rate of 3,4% for 100-year-delay on the basis that one life saved today is equal to 44 lives saved after 100 years. Fredericks (2003) uses choice question where 100 lives saved this year are compared with 7000 lives in 100 years, which makes the rate equal to 4,3%. Chapman (2001)

[3] Chapman give the example of assuming 900 delay with 20% discount rate. The equivalent of saving 100 people now is 10^{72} lives saved in the future (Chapman, 2001).

uses live saved values ranging from 1 to 1000 for the delays from 1 to 900 years assuming immediate project saving 100 lives. That inevitably makes annual discount rate restricted to 0,26% (or less) for 900-year delay.

Researchers, constructing the survey, have to choose the amount on its own, or leave it open to the decision of the respondent, depending on the question format. In both circumstances, the responses are vulnerable to answers biased towards lower DR. That makes such decline of technical nature, not related to ethical attitude.

2.3. Morality and CBA decision criteria - some solutions

In the context of including moral principles into project evaluation procedure there are some approaches referring to deontological assumptions more explicitly.

Kopp & Portney (1999) propose a mock referendum as an alternative to CBA. The referendum follows contingent valuation approach, that „is based on individuals' own valuations of future benefit and costs, as well as their own views as to how future effects should be traded off against present ones". They indicate that CBA is „based on the preferences of all those around today". Kopp & Portney (1999) suggest using 3-dimension matrix: effects, time and individuals. The last one relates to the view presented by Mishan & Quah (2007), who underline that introducing politically determined parameters is against the economic view according to which the value of each good or bad is determined by a person herself. However, Mishan & Quah (2007) seek the solution in establishing a state agency, which would protect that any generation would not suffer a net loss, as the effect of some social consensus. This could be done by consequent applications of projects with positive ENPV in time. Fearnside (2002) put forward a unified index for time preference based on generation-weighted time preference instead of discount rate.

Kula (1981, 1997) presents a modified discounting or the sum of discounted consumption flows, applying social discount rate, but assigning benefits and costs to separate birth cohorts on a yearly basis. Discounting takes place only within each birth cohort life-time and the discount factor for longer horizons achieves minimum value for the life expectancy.

Bellinger (1991) expands Kula's model allowing subsequent generations to make decisions in their own time frames and distinguishing between public and private goods. He develops multigenerational value criterion on the basis of a private rate within generations and society discount rate for *per capita* utility of future generations. The former may depicts private or social discount rate, while the latter interpretation is derived from welfare function assuming an impartial observed with perfect information. Bellinger suggests it should be based on analyst's approach. Yaffey (1997) revisit Kula's approach adding some critique about equal STPR for future generations, and Bellinger's in regard to society discount rate for *per capita* utility.

Sumaila & Walters (2005) put forward similar solution by developing intergenerational weights based on two discount factors: conventional and for future generations. They justify altruism toward future generations by parental concern and Rawlsian veil of ignorance.

3. Decision criteria in CBA under utilitarianism – a closer look

3.1. Utilitarian dimensions for CBA

Utilitarianism is broadly defined as a view in which actions which increase welfare are right, and those decreasing welfare are wrong. Utility, therefore, is individual's pleasure or happiness, while welfare is defined as a social good being an aggregation of individual utilities. Sen defines utilitarianism in respect to three main dimensions (Sen, 1979; Sen & Williams, 1982):

1) Welfarism: a correct way to assess the state of affairs is welfare constituted by people's preference satisfaction. Sen (1979) defines welfarism as:

   "the judgment of the relative goodness of alternative states of affairs (that) must be based exclusively on, and taken as an increasing function of, the respective collections of individual utilities in these states".

   So a person is perceived as a sum of individual utilities. Hausman & McPherson (2009) or Spash & Hanley (1994, p. 139) add that the very concept of "utility" possess intrinsic value as the only one.

2) Consequentialism – the action is judged by its consequences, not its motives. Sen (1979) states:

   "in choosing one among various alternative acts, one should choose an act that yields at least as high a sum total of utilities as any other alternative act".

   An outcome of an action (a decision, a policy) is evaluated on the basis of the consequences for well-being (Hausman & McPherson, 2009).

3) Sum ranking – welfare is a sum of individual utilities:

   "One collection of individual utilities is at least as good as another if and only if it has at least as large a sum total" (Sen 1979).

   Adding up individual utilities provides the basis to judge the consequences.

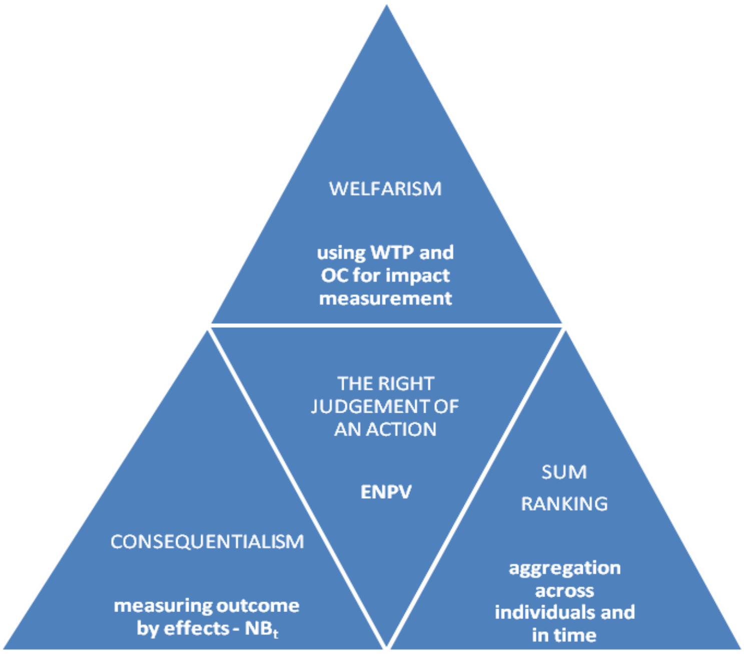

Fig. 1. Dimensions of utilitarianism and ENPV decision criterion.

Combining the dimensions creates a tool for making choices and valuing alternatives. A perfect exemplification is ENPV in CBA, where an investment is evaluated in terms of its impact on social welfare, the effects are aggregated both among individuals and in time. Net cash flows in ENPV represent changes in utility – net benefits, NB_t and are calculated on the basis of WTP and OC, and discounted with social discount rate. ENPV > 0 means that benefits (utility gains) exceed inputs (utility losses), so the gainers can compensate the losers and still remain better off in comparison with status quo, which satisfies KH criterion. The link between utilitarian dimensions and ENPV depicts the formula:[4]

$$\Delta W = ENPV = \sum_{t=0}^{T} \frac{NB_t}{(1+r)^t} > 0 \qquad (1)$$

where:

ΔW – change in social welfare triggered by investment implementation for the whole life cycle of the project,

$ENPV$ – economic net present value of the project,

NB_t – aggregated net benefits in period t,

r – social discount rate (SDR),

$t = 1,2,\ldots,T$.

Calculating NB_t in terms of WTP and OC reflects changes in social surplus and satisfies the welfarism dimension. Then concentrating solely on the project's effects and providing no information about the motives and how those effects are achieved depicts consequential

[4] The form of the criterion varies across literature, i.e. Pearce *et al.* (2006) calculate it as the difference between discounted sums of willingness to pay (or willingness to accept) for gainers and losers, however the basic idea is always to estimate changes in aggregate welfare.

approach. And finally, summing across individuals as well as across periods mirrors sum-ranking characteristic.

However, while for one-generation time frame, ENPV may serve its purpose, almost all its strength is lost when the project time frame stretches to multigenerational. The reasons for both – intra and intergenerational faults are being analysed in the next subsection.

3.2. Failures of CBA utilitarian dimensions for multiple generations perspective

This section is designed as a comparison of sources of criticism of welfarism, consequentialism and sum-ranking dimensions of CBA decision criteria both for intragenerational and intergenerational time frame. However, it is important to highlight that the intergenerational sources of critique are supplementary to intragenerational, nevertheless still present in long-term perspective.

Welfarism is criticized due to applying intrinsic value to the utility itself. Sen & Williams (1982) point out that this view tends to treat a person as a location of his or her respective utilities, not a person itself. Therefore, all choices and valuations are based on people’s preferences.

Intragenerational perspective critique includes distortions in preferences (i.e. free-riding, information bias) and blurring people’s true interests, when i.e. following one’s preferences lead to health deterioration (compare Harsanyi, 1955, Broome, 1998, Spash & Hanley, 1994). Those distortions are then included in the valuation of effects and final assessment of the project.

Nonetheless, the main problem for intergenerational time span are not the distortions, but measurement of preferences of people not yet present. Applying welfarism literally would require maximization of preference satisfaction of all generations, existing and the future ones, that the project influences, however ignoring the problem of unborn generations unable to express their preferences in neither market nor shadow prices. Preferences that could be satisfied, simply do not exist yet.

Proceeding to sum ranking, which allows summation of all inputs and outputs of the project in ENPV criterion, a number of sources of critique can be identified as well. The main flaw is seen in lost separateness of each person. Rawls (1971) points out that utilitarianism is not individualistic approach. While it joins all persons’ preferences systems, it also bases its choices on individual decision rules. Thus, aggregation of individual utilities may lead to unjust distribution of project benefits between groups or individuals.

Just distribution could be secured by Pareto (P) and KH rules. The former would require for those who incur costs to gain enough to level the sacrifice they have made. It is quite difficult to fulfil it in intragenerational time frame. Mishan & Quah (2007) underline that Pareto improvement is achievable only when „all persons affected are expected to remain alive all over the investment period". KH criterion is less challenging, since overall outcome counts and the compensation between gainers and losers do not have to take place (potential compensation). Still, even potentially, it must be feasible, so the requirement of staying alive for all parties affected by the project remains valid.

In intergenerational perspective, both criteria need some additional justification. Intergenerational project inevitably involves making sacrifices by one generation (investing generation), while future generations (benefiting generations) gain. Thus, the arrangement of transfers eliminates P criterion *a priori*, as one generation must inevitably reduce its welfare. Moreover, it excludes KH rule as well, because even under the assumption of "potential" compensation, the reparation is not possible: the simultaneous non-existence of present and future people makes such reciprocal behaviour non-feasible. Claiming "potentiality" under the circumstances where such transfer simply cannot be done, is ineligible. Both KH and P principles are no longer applicable – for non-overlapping generations, both potential and actual compensation toward deceased people cannot take place.[5]

A separate issue is dynamic sum ranking – aggregation of net benefits in time, which is dealt with by applying social discount rate. Dasgupta (2008) highlights that utilitarian summation over time treats differences between an individual's felicities in two periods of time in the same way as it treats differences between the felicities of two individuals in those same two periods of time. Hampicke (2011) criticizes discounted utilitarianism on the ground of infinitely lived agent which he terms as individuomorphic", and highlights again that it does not care about distinctions between persons.

[5] Both criteria are achievable only in case of overlapping generations, which in fact turns the evaluation model into intragenerational time frame. Under non-overlapping generations assumption, a compensation may appear under reciprocity rule, when the chain of generations compensation transfers is open. Then IG makes the investment due to the fact that it received a transfer from its predecessors, and BG „gives back" by investing again for the sake of its own successors (Gosseries and Meyer, 2009, Kolm, 2006, Foltyn-Zarychta, 2014a).

In intergenerational perspective another issue arises. DR no longer reflects the marginal productivity of capital in its alternative use. Since one generation reduces its consumption for the benefits of future people, the discount rate can no longer be defined as an alternative cost, but rather as a weight of importance of future people – a measure of altruism. However, this kind of concept is in vivid contradiction with the privileged position of utility itself. Moreover, a technical problem with discounting emerges: present value of future effects becomes extremely sensitive for discount rate changes as time delay rises. This very issue was noticed by a number of researchers, including Dasgupta (1978), Arrow (1995), Howarth (1996), Quiggin (1997) or Gollier (2002) and more recent works by Almansa, Martínez-Paz (2011), Moxnes (2014), or Foltyn-Zarychta (2014a). The time-declining discount rate discussed in the literature i.e. by Chapman (2001) or Weitzman (2001) secures lower pace of reduction in present value of future effects, however, I argue that the solution does not answer the problem of people trading their present sacrifices for benefits for not-yet-born and, furthermore, does not satisfy KH or P criteria.

The third utilitarian feature, consequentialism, concentrates on project's effects in comparison with the status quo (non-implementation of project). The consequential approach is criticised due to the fact that actions, rules and institutions are judged only by the goodness of the state of affairs, which concerns utility increases. Consequently, as Zboroń (2009) indicates, the value of the good is not universal, but relative. It is a value for a certain person. Goods that no-one desires are valueless: no intrinsic value can be given to rare-species unless they increase someone's utility.

For intergenerational investments the most important flaw of consequentialism resides also in the relativity of the value. It results in the impossibility of applying intrinsic value for future generations and, therefore, impossibility of assigning them rights. Moreover, concentrating on the effects increases their valuation importance for the final decision, omitting the possible difficulties, biases and uncertainties of that process.

CBA deals to some degree with those problems due to the concept of WTP – as long as people are willing to pay for the effect, it possesses some value in the analysis. So any good can be valued, however, the value depends on people's preferences, not because the good exists for itself. Therefore, some resources or goods (i.e. rare plants known only to some professionals) that could be worth investing in protection, but are not utility enhancing, will not get enough attention from consumers or society and will be omitted. For detailed discussion, refer to i.e. Hammond (1982). Spash & Hanley (1994) add that the concept of neo-classical utilitarianism influences the way of estimating the value of non-marketed goods in contingent valuation method, that uses the WTP and WTA categories. They argue that the teleological nature of the method, where the importance is placed on effects, i.e. values associated to the good by respondents, is in contradiction to deontological beliefs of respondents, that oppose compensations for loss in one good by increase in the other. Such people may declare extremely high bids, defined as protest bids.

To conclude, it should be stressed that as far as intragenerational time frame is analysed, utilitarianism in its three dimensions is not flawless but acceptable. Conversely, classical utilitarianism for intergenerational investment is not justified as the proper framework for the decision making process. Therefore, two options are feasible – rejection of utilitarianism or its modification. The former can be put under consideration, as other philosophical approaches are being developed, i.e. Rawls' egalitarianism. However, changing the basis brings on the need for elaboration of the whole new set of tools for investment decision making, including the issue of valuation of effects. The latter - the modification, does not violate the established methodology of investment evaluation and seeks a compromise between the theoretical correctness and the applicability. Section 4 aims at reaching such compromise.

4. The modified CBA criterion - Intergenerational Economic Net Present Value

ENPV criterion serves quite well as a foundation for investment decision making: homogeneous results given in money terms, easy to interpret by comparison to 0. Worth underlining is the fact that the biases analysed in section 3 emerge from the three dimensions that allow ENPV construction, so rejecting those dimensions would result in rejecting ENPV itself. Therefore, it seems justified to combine ENPV usefulness with intergenerational time frame requirements. Section 4 presents a modification to ENPV criterion, named here Intergenerational Economic Net Present Value (IENPV).

The enlargement of the model goes in concordance with the need, as Portney & Weyant (1999) put it, "(…) to confront how much we are willing to sacrifice today for benefits that will be enjoyed later in our lives or in the lives of succeeding generations." Therefore, IENPV strives for including in the decision frame of an individual both – "our lives" AND "the lives of succeeding generations"

The criterion revisits models developed by Kula (1981), Bellinger (1991) and Sumaila & Walters (2005) as it also applies two discounting regimes: intragenerational and intergenerational. In regard to these approaches my aims were 1) to analyse more closely the assumptions underlying the inclusion of intergenerational parameter, 2) to simplify the approach to overcome some difficulties of previous models.

4.1. Assumptions

Two main assumptions are based on Hahn (1982), who proposes a certain change in individual utility function. First, Hahn (1982) indicates that while utility in its classical form is perceived as a pleasure of self-regarding activities, it can be enhanced to the concept of deriving pleasure from other-regarding activities. Dasgupta *et al.* (1999) also put forward extended utility function assuming that each person's well-being depends on her own consumption level and on her offspring's well-being, however Hahn's formulation is less strict as it does not narrow interests to family line. Hahn's assumption can be illustrated by:

$$W_i = U_i(c_i, c_j) \tag{2}$$

where:
W_i, U_i – welfare and utility of individual i,
c_i – consumption of individual i,
c_j – consumption of individual j.

Utility of individual i depends not only on her own consumption but also on consumption of individual j. Individual i derives satisfaction from others' utility. It allows including preferences of future people into preferences of the contemporaries.

Second, consequentialism, prohibiting assigning rights to unborn generations, can be dealt with by inclusion of deontological aspect. Hahn (1982) proposes the utility function in the form of:

$$W_i = U_i(P, c_i(P)), \tag{3}$$

where:
P – policy affecting utility via consumption,
$c_i(P)$ – consumption of individual i being consequence of policy P.

Utility of an individual depends on his consumption (c_i) (as a consequence of policy P) and the policy P itself. Not only the consequences matter (consumption), but also the way they are achieved (P). Policy itself is the carrier of utility or disutility. Adjusting the assumption to intergenerational perspective, the inclusion of policy P allows to show preferences towards the well-being of other people explicitly. Therefore, policy can be seen as a reflection of people's actions on behalf of their heirs.

Two other assumptions supplement the former to deal with utilitarianistic dimensions.

Third, welfarism (bias of preferences and utilitarianistic self-centrism) as well as sum ranking (P and K-H criteria) are theoretically feasible under the assumption of existence of a kind members of investing generation who is able to unite the wishes of all generations and their own interests and makes a rational choice on all behalf.

Fourth, generations are non-overlapping. The fourth assumption is purely technical and serve to simplify the model.

4.2. Intergenerational Economic Net Present Value formulation

Under the assumptions listed above, future people's utility (consumption) and the policy applying a certain level of importance to the future, are included into utility function of contemporary generation.

Thus, for two-generation model individual welfare function becomes:

$$W_i = U_i(c_i, C_J, w_J) \tag{4}$$

where:
W_i – welfare function of individual i (belonging to present generation I) depending on his/her utility U_i,
C_J – consumption of future generation J,
w_J – weight of generation J.

Aggregating individual preferences gives:

$$W_I = \sum_{i=1}^{n} W_i = \sum_{i=1}^{n} U_i(c_i, C_J, w_J) \tag{5}$$

where:
W_I – welfare of generation I as a sum of individual utilities of individuals i (i=1,2,...,n),
w_J – the reflection of policy towards generation J given as a weight of generation J in utility function of individual i.

The social welfare function (SWF) given in (5) sums the utilities of one-generation individuals. What makes the difference with eq. 2 and 3 is the form of individual utility function concerning the welfare of generation J via its consumption and weight w_J. Since the model concentrates on reflecting the preferences of i towards future generation J, U_i implicitly incorporates the reciprocal, altruistic preferences towards other members of the same generation.

Expanding the model into multiple generations, the present generation is numbered 0, while all future generations as J = 1, 2, ..., M, and SWF becomes:

$$W_I = \sum_{i=1}^{n} W_i = \sum_{i=1}^{n} U_i \left(c_i, \frac{\sum_{J=1}^{M} C_J}{(1+\lambda_J)^J} \right) \tag{6}$$

where:
C_J – consumption of generation J, J = 1, 2, ..., M
λ_J – intergenerational discount rate (IDR) depending on weight of generation J, w_J .

The weight w_J is presented in (6) as the discount factor, that reflects individual preferences of members of generation I towards subsequent generations. [6] The importance of Jth generation is given by discount rate of i for Jth generation:

$$w_J = \frac{1}{(1+\lambda_J)^J} \tag{7}$$

where:
λ_J – individual discount rate of i for Jth generation consumption.

The weight w_J diminishes as a time distance between investing generation and future generation Jth grows. The measure of time distance is given in the Jth power in the denominator. Each subsequent generation makes the Jth power following $(1+\lambda_J)$ formula to rise by one. The more remote is the Jth generation, the lower is w_J in generation 0's SWF. The pace of the decrease depends on generation 0 preferences toward unborn people – whether they matter less or more in IG's utility function.

Therefore, the change in intergenerational welfare can be estimated by modified ENPV, named for the purpose of the paper: Intergenerational Economic Net Present Value (IENPV):

$$\Delta IW = IENPV = \sum_{t=0}^{T(0)} \frac{NB_{t(0)}}{(1+r_0)^{t(0)}} + \sum_{J=1}^{M} w_J \sum_{t=1(J)}^{T(J)} \frac{NB_{t(J)}}{(1+r_J)^{t(J)}} > 0 \tag{8}$$

or:

$$\Delta IW = IENPV = \sum_{t=0}^{T(0)} \frac{NB_{t(0)}}{(1+r_0)^{t(0)}} + \sum_{J=1}^{M} \frac{1}{(1+\lambda_J)^J} \sum_{t=1(J)}^{T(J)} \frac{NB_{t(J)}}{(1+r_J)^{t(J)}} > 0 \tag{9}$$

where:
ΔIW - intergenerational welfare change resulting from project implementation,
$IENPV$ – intergenerational economic net present value of the project,
$NB_{t(J)}$ – net benefits in period t for generation J,

[6] Both w_J and λ_J should reflect i's (of generation I) preferences toward generation J. Worth to emphasise is the identity between policy w_J and individual discount rate λ_J arising if this policy truly reflects individual preferences toward future people. If the policy is an exogenous factor, depending on government activities, then w_J and λ_J (the latter applied into the discount factor formula) may differ and w_J put into (6) will be undependable variable, not a reflection of individual preferences. In the paper, I assume that w_J and λ_J reflect i's intergenerational preferences and are equivalent.

r_J – intragenerational social discount rate for *J*th generation (SDR for *J*th generation),
w_J – weight of *J*th generation,
J=0,1,2,...,M,
t=0,1,2,…,T.

Total change in welfare resulting from the project's implementation is therefore calculated in two steps: firstly, at the intragenerational level, net benefits are discounted with DR identical to SDR for ENPV; secondly, the aggregated intragenerational welfare changes (or intragenerational ENPVs) are discounted again with λ_J reflecting the importance of subsequent generations in 0's generation preferences.

The time frame is following two schemes as well. The first is within one generation time span. *t(J)* value starts with 0 for the first year of project benefiting *J*th generation to the last year of *J*th generation time frame: the value of *T(J)*. The distance is arbitrary, but I suggest to employ the average age of mothers and fathers, which is about 30 years (compare also PWN, 1966, Cline 1999). The second scheme for time-aggregation is for generations (*J*th value): while one generation is gone, and the second one appears, and the *J*th value rises by one.

Equation (9) is following the assumptions given in (4), as long as both, social and intergenerational discount rates, reflect the preferences of investing generation. We can refer here again to the concepts of WTP and WTA as categories theoretically proper to mirror individual and social welfare.

Of crucial importance for calculating IENPV is the value of w_j. There is no upper or lower limits of w_j, so the value can be less than 1 (for smaller importance of forthcoming generations), equal to 1 (all generations treated equally) or more than 1 (when the future people are perceived more important than today's). The theoretical frames for values of *wj* can be searched for in ethical concept of intergenerational justice. Assuming i.e. egalitarian or libertarian ethics results in various approaches towards the importance of the unborn people. The considerations cannot be covered in this paper, however a vast literature sources may provide a deep insight, i.e. Tremmel (2006), Page (2007), Meyer & Gosseries (2009). Another source of w_j value can be contingent valuation techniques as weights should reflect preferences of investing generation towards its successors. It follows procedures in i.e. Cropper *et al.* (1994) or Chapman (2001), however the valuation question here concerns explicitly the comparison of importance of generations, not years of delay.

Worth underlining is the fact that the main difference between traditional ENPV and IENPV lies in two distinct discount rates: intragenerational (social discount rate); and intergenerational discount rate, reflecting weights of future generations.

IENPV model can be transformed into single-discount-rate to be easily compared with i.e. declining long-term discount rates. Assuming yearly compounding the joint discount rate, let's name it γ_τ, is:

$$\gamma_\tau = \left(\frac{NB_\tau}{NB_0}\right)^{\frac{1}{\tau}} - 1,\ \tau = 1,\dots\mathrm{T} \qquad (10)$$

where:

γ_τ - joint discount rate for intergenerational investment, combining the effect of SDR and IDR in eq. 9,

τ – subsequent years of investment life cycle, counted continuously from the beginning of the investment cycle, without generation time division.

NB_τ - net benefits in year τ,

NB_0 - present value of benefits in year τ, calculated with (9).

However, applying joint discount rate does not equal time-declining discount rates, as γ_τ does not follow constant value pattern. The details are given in the section 5.

The criterion given in (9) satisfies all three utilitarian dimensions and operates on intergenerational level as well. Inclusion of future generations' consumption and weight into contemporary individual utility function makes preferences and rights of non-existing people visible. Furthermore, Pareto and K-H criteria are ready for application as changes in utility and compensations that could take place inside the individual utility function: the individual decide on her own what the allocation between present and future should be. Once the decision is taken (assuming rational individual maximizing her well-being), any allocation satisfies both P and KH criteria due to the fact that any reduction in *i*'s consumption is compensated by *i*'s altruistic preferences reflected in pleasure derived from giving and assigning moral rights to others.

5. Comparison of IENPV with ENPV - a hypothetical example

Let us assume that a government considers an investment aiming at reduction of GHG, which estimated effects will last 300 years. The time frame corresponds to 10 non-overlapping generations. Every generation benefits from the project for 30 years. Generation numbering starts with 0 for investing generation and finish at 9.

Investment outlays are borne one time only, in year 0 and are excluded from the following analysis, as they remain undiscounted and their impact is equal for both ENPV and IENPV. The difference in results arises from effects treatment (allocation in time and discounting). The effects are delivered every year and NB_t equals 100 units, except for year 0, where only outlays appear, then $NB_0 = 0$. SDR is 3%, which follows European Commission (2014) guidelines for CBA and is constant for the whole time of the analysis.

IDR takes multiple alternative values (Table 1). The aim of this assumption is to analyse the impact of the change to the final outcome of IENPV depending on λ.

Table 1. Values of intergenerational discount rate λ

λ	0%	10%	25%	50%	75%	100%

The values of λ reflect the importance of forthcoming generations, an element of modified individual utility function given by eq. 4. λ equals to 0% means that all generations possess the same weight. The higher λ becomes, the less important future people are in project's appraisal (eq. 7). For instance, IDR of 25% means that the importance of direct heirs falls by 20%, and of 4th generation (numbered with 3) shrink almost by half in comparison to IG. Figure 2 presents the values of weights depending on generation's number.

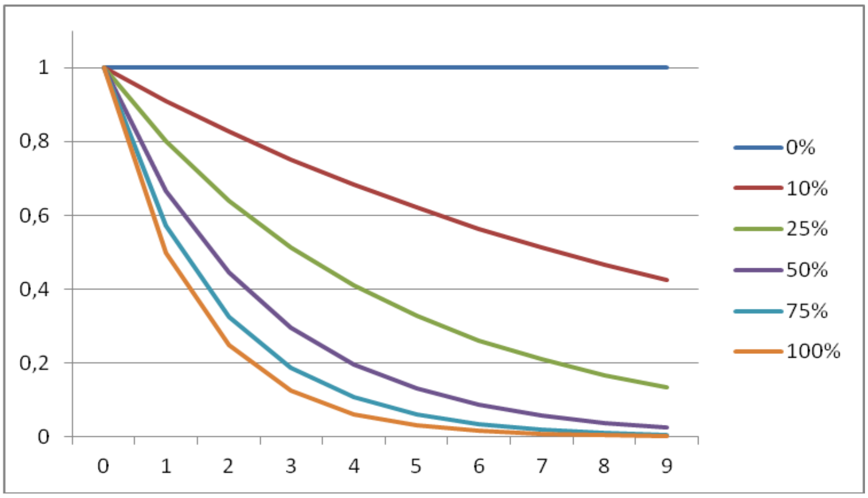

Fig.2. Weight of generations depending on intergenerational discount rate and the time distance.

Present value of stream of benefits under ENPV with constant exponential discounting with 5% SDR equals:

$$ENPV = \sum_{t=0}^{300} \frac{100}{(1+3\%)^t} = 3333 \quad (11)$$

Following modified approach, IENPV, the first stage was the calculation of ENPV for every generation benefiting from the project. In the example, due to equal values of NB for periods in the project cycle, IntraENPV values are the same for all generations involved:

$$IntraENPV = \sum_{t=0}^{30} \frac{100}{(1+3\%)^t} = 1960 \text{ for every } J,\ \ J=0,1,2,\ldots,9 \tag{12}$$

Figure 3 depicts the undiscounted benefits and discounted values of NB_t for both approaches. It is vital to bear in mind that benefits discounted for modified criterion are not the final outcome and the calculations are continued on the next stage, where intraENPV is discounted with IDR.

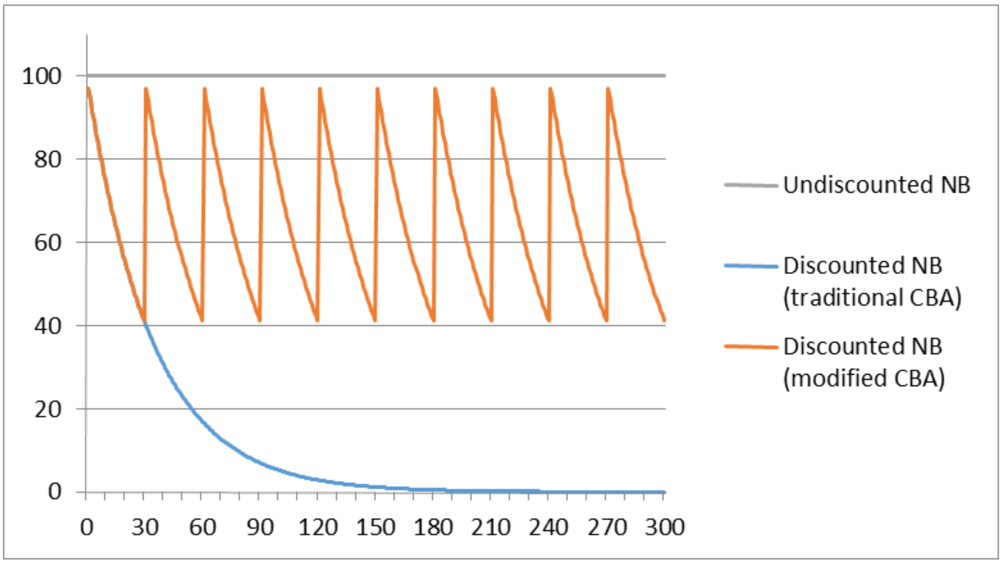

Fig. 3. Comparison of undiscounted stream of net benefits, and discounted stream of net benefits under classical and modified CBA criterion with 5% intragenerational consumption discount rate.

Present value of future NB_t discounted in traditional way decreases rapidly to almost 0. It is the effect of exponential, compound discounting which makes present value extremely sensitive for SDR value as time distance grows. More detailed analysis can be found in Foltyn-Zarychta (2014a). Comparing the values of NB for traditional and modified approach one can notice that the profile of PV is the same for the first generation (years 0-30). The profile changes once the modified approach reaches second generation due to the fact that the discounting procedure for intraENPV starts again from $t(1) = 1$ (years 31-60) and is repeated for consecutive generations.

Second stage for modified criterion consist of discounting with IDR and summing up IntraENPV values for all generations:

$$IENPV = 1960 + \sum_{J=1}^{9} \frac{1960}{(1+\lambda_J)^J} \tag{13}$$

Depending on the value of λ the final results vary. Figure 5 presents IENPVs for each IDR value and – for comparison - traditional ENPV calculated with 5% discount rate.

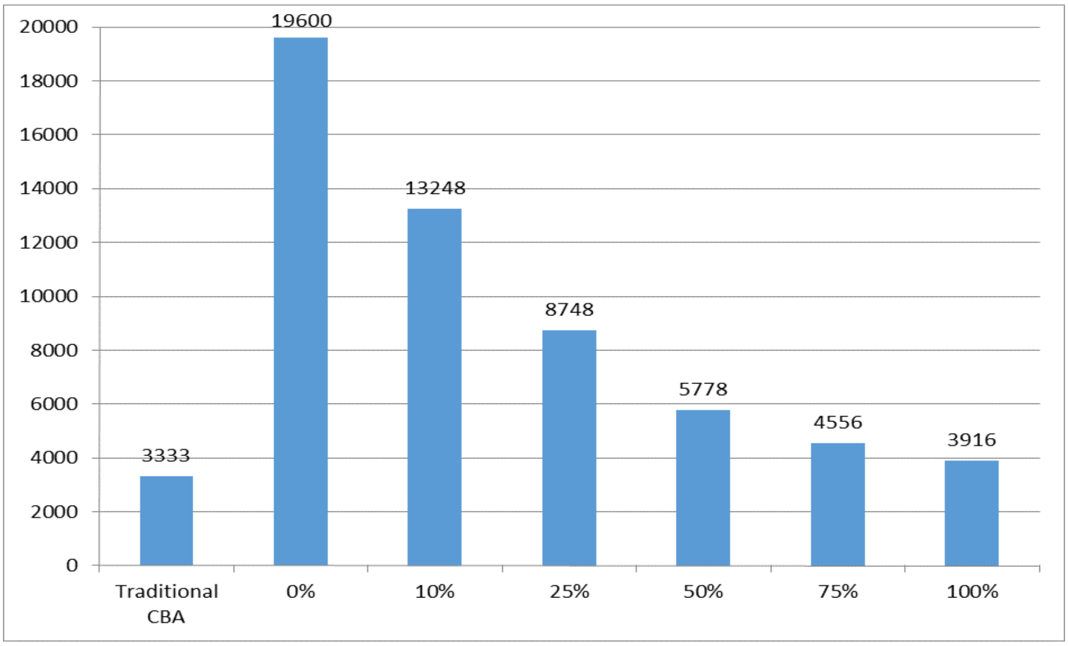

Fig. 4. Comparison of ENPV (traditional approach) and IENPV (modified approach) under various assumptions of intergenerational discount rate.

The highest present value of benefits (19 600 units) are found for λ=0% (equal importance of all generations), while the lowest – for λ=100%, where the weight of each subsequent generation is reduced by half. It is essential to add, that even for IDR reaching 100%, the final result is still higher than in case of traditional ENPV (3916 vs. 3333 units). Moreover, it is worth noting that the highest absolute changes in IENPV values are observed for changes in range of low values of λ: the change of IDR from 10% to 25% results in decrease in IENPV of 4500 units, while increase λ from 75% to 100% (almost two times higher) changes IENPV by merely 600 units.

Supplementing the results, a total discount rate γ (eq. 10) was calculated for each IDR value (Fig 5). Under ENPV the discount rate is constant for the whole life cycle of the project, while for modified approach, the value of γ changes. γ decreases and the pace of the shrinkage is higher for lower values of IDR, however, the decline is irregular. For generation 0 the value of γ equals SDR due to the fact that generation 0 does not undergo importance weighting process w_j. Discount rate profiles start to differ from year 30, which is the border between IG and the future people. A substantial drop in γ value is observed here, of more significance for lower IDRs. Then, within one-generation frame, the discount rate starts to regain its value.

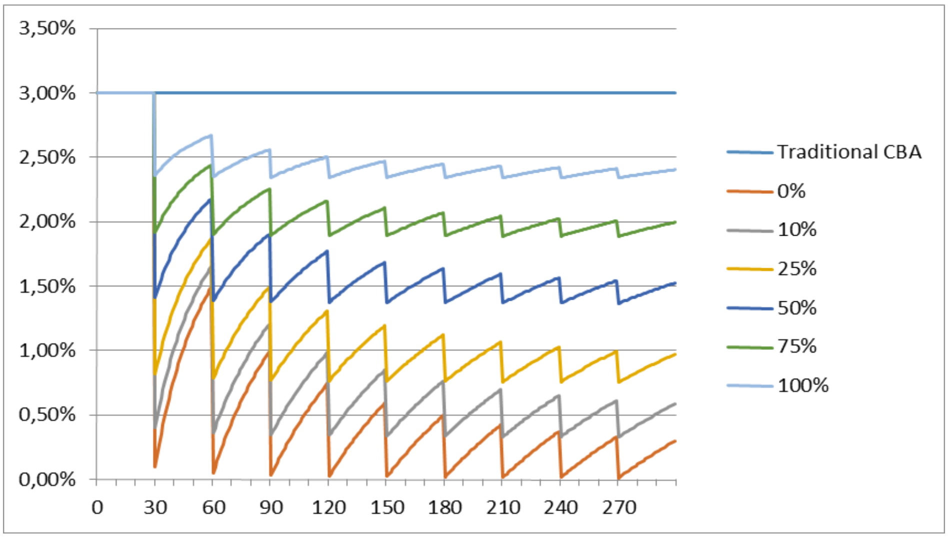

Fig. 5 Time profile of SDR for traditional ENPV and total discount rate for modified IENPV.

To sum up, γ shows three tendencies: 1) the value of γ is substantially lower for all generations following investing generation; 2) the value of γ generally decreases in time, however γ rises within the time span of each future generation and then drops again at the beginning of the subsequent future generation; 3) the variability of γ value decreases with time and it is generally lower for lower importance of future generations.

6. Discussion

6.1. Relationship with Kula's, Bellinger's and Sumaila & Walters's approaches

Modified criterion offers a simplification in comparison to the aforementioned approaches. The core of the simplification lies in generational time frame of 30 years instead of dividing project life cycle into yearly birth cohorts. The extension of the model is feasible, however it would require additional data on size and age structure of population of present and future generations to calculate *per capita* benefits as in Kula's and two other models. While it is possible for present generation, it must follow simplifying assumptions for the future people. Therefore, IENPV offers a possibility to omit this difficulty.

Bellinger (1991) argues that his criterion may accommodate a wide range of generational weights, however he implies they are given by an analyst. IENPV creates closer relationship with individual preferences, as it is based on individual utility function that incorporates future generations consumption and attitude toward future generations. The responsibility for the decision explicitly stays in the hand of present generation.

Furthermore, Kula's modified discounting (Kula, 1997) implicitly assumes equal treatment of all generations which goes with concordance with Ralwsian original position. IENPV approach do let introduce other ethical approaches.

Equation 6 follows quite closely Bellinger (1991) formulation of social welfare function assuming impartial observer with perfect information, where generational utilities are weighted *via* society's discount rate for the *per capita* utility of future generations. Equation 6 assumes that intergenerational discount rate refers to future generation consumption discounting and constitutes one of SWF variables. Furthermore, Bellinger assumes discounting utility in multigenerational value, while IEPNV refers directly to net benefits as in Kula's approach. It can be also perceived controversial to discount utility with STPR within generation time frame that he proposes.

Furthermore, Kula and Bellinger as well as Sumaila & Walters (2005) assume that all individuals will have equal tastes with the usual properties, and that follow constant rates of discount. IENPV allow for applying rates specific to each generation.

Sumaila & Walters (2005) also attribute altruistic preferences to parental responsibilities, whereas IEPNV underlying assumptions are formulated less strictly (section 4.1-4.2).

6.2. Ethical consequences of separating time schedules and discount rates

The most important implication of distinguishing intra- and intergenerational time schedules lies in explicitly defining individual preferences toward future generations. The consequence is the application of two separate discount rates.

Dasgupta (2008) highlights that for intergenerational perspective there should be two issues defined separately: 1) the trade-offs between present and future generations utility (utility discount rate, pure time preference), and 2) the trade-offs between the consumptions people enjoy, regardless of the date at which they appear on the scene. Cropper & Portney (1990) also assume separate treatment of intra- and intergenerational time frames.

Cline (1999) presents quite similar "a workable compromise". First, he distinguishes between intragenerational and intergenerational time frame. The intragenerational benefits can be discounted by cost of capital (up to 30 years), but after the generational break (that appears also due to time horizon of financial markets) all consecutive investment effects are discounted according to STPR approach, which is much lower. The example presented by Cline under this approach also shows the discontinuity in the moment of switching between the fist and the following generations.

Lee & Ellingwood (2015) as well as Fearnside (2002) mention 30-year-horizon, since for shorter periods, market discount rates can be applied or STPR based on financial behaviour. Separating longer periods is justified by market failures: government and individuals' attitudes to future generations which are not revealed on current markets. Rabl (1996) is less specific and describe simply two time frames as short and long.

Manne (1999) argues the separation of equity and efficiency issues, where the former relates to the descriptive framework, whereas the latter to efficiency seeking. That would make intragenerational rate descriptive, while intergenerational rate – prescriptive.

IENPV allow for applying rates specific to each generation. Holding intragenerational rate constant across all generations would satisfy egalitarian view, making all generations short-term decision equally important. Intergenerational weights may follow different ethical view. Under sufficientarian principles, where everyone should possess the well-being above a certain threshold (Meyer, Roser, 2009) the weights may benefit generations below the threshold; under reciprocity-based principles the weights are delivered from benefits that the present generation acquired from its predecessors (Gosseries, 2009).[7] If intergenerational rate reduces the welfare according to diminishing marginal utility of consumption rule, it would depict utilitarian framework.

6.3. Implications of the model for delivering DR value via stated preference approach

The formulation of SWF given in equations (5) and (6) has also consequences on deriving the value of discount rate from stated preferences. Inclusion of consumption and weights of future generations resembles capturing existence value in contingent valuation. That may serve as an alternative to undefined "analysts" or "decision makers" deciding upon those weights.

[7] The reciprocity rule can be also based on the ascending model that explains the obligations of present generation on the basis of what later generation transferred to the earlier one, however this model could be related to pension systems rather not investments. Gosseries proposes also model, where transfers are done in both directions. For further discussion, see Gosseries (2009) p. 119-146 and Page (2006), pp. 99-131.

Inclusion into utility function (eq. 4) of preferences towards policy may be perceived justified on empirical ground. The survey study done by Moxnes (2014) indicates that people are able to choose among policies: by analysing developments in time of policy consequences people seem to be able to make consistent choices.

In addition, introducing separate discount rate for intergenerational comparisons eliminates underestimation biases in contingent valuation questionnaires designed to derive the value of the discount rate. The proposal to establish separate discount rate for intergenerational present value will facilitate the answer for respondent as she can state directly her weight for, let's say, 4^{th} generations, which is more than a hundred year distant.

However, applying stated preference approach, we have to consider other difficulties. Questionnaire-based methods are sensitive to a number of issues: hypothetical bias, strategic bias, payment vehicle, differences between WTP and WTA or protest bids (Whitehead & Bloomquist, 2006, Foltyn-Zarychta, 2012 Mathews *et al.*, 2006). There are also some distortions that relate solely to intertemporal choice: framing effect, the effects of prior expectations, “delay- speedup" asymmetry, etc. (Loewenstein, Prelec, 1992, Garrod & Willis, 1999, Frederick *et al.*, 2002). A tricky issue may be a “warm glow” effect, where respondents declare bids due to moral satisfaction they achieve from supporting a problem that is perceived by society as important and fair.

6.4. Declining discount rates

It should be stressed that λ differs from the declining discount rate (hyperbolic discounting), raised i.e. by Ainslie & Haslam (1992), Henderson & Bateman (1995), and Portney & Weyant (1999), where the decrease follows some non-linear but continuous function pattern, without dividing the investment cycle into separate generations. There are multiple reasons for justifying the decline: Weitzman (2010) underline the importance of risk adjustments, Li & Löfgren (2000) explain it by differences in social preferences toward environmental protection. Total discount rate γ_τ (eq. 10) is the closest to the concept of this single declining discount rate, however, the decrease is non-continuous, at least for non-overlapping generation model. Furthermore, the IEPNV model assumes discount rate dependency on people's preferences by its inclusion into utility function. This methodology creates a bond with social choice approach (Li & Löfgren, 2000) and contingent valuation, due to the fact that intergenerational preferences are not observable on the market.

It is important to add that time-declining discount rate does not make any distinction between intragenerational allocation (justified by opportunity cost and impatience, and future reward benefiting the same individual), and intergenerational allocation (where investing individual do not accrue the benefits from sacrificing his consumption). Double discounting helps to treat those two issues separately on the ground that they are driven by different motives.

7. Conclusions

IENPV does not answer all the problems emerging at intergenerational project evaluation stage. All the issues raised at the intragenerational level, i.e. biases of preferences and unequal distribution, are still present at the intergenerational level. This criterion rather offers a kind of reasonable compromise.

Referring to the first aim stated in the introduction to the paper, the modification of the criterion arises from the shortcomings of utilitarian background in intergenerational perspective. IEPNV is not designed as a complete rejection of utilitarianism, but a form of extension. The model stays rooted in utilitarianistic framework within generation time frame, but allow to change the principles for longer time schedules.

Moving on to second and third aim, extending individual utility function by other-regarding consumption and attitude toward future generations has two effects: IEPNV reflects normative judgement (λ), that is missing in classical form of ENPV and allow to explicitly base the decision on contemporary people preferences (because future generations preferences are unobservable).

Additionally, splitting the time frame into intra- and intergenerational eliminated low discount rate bias in stated-preference studies, because rates for distant effect can be estimated by asking about comparing transfers for second, third or fourth generation instead of 60, 90 or more years.

Criticising the construction of IENPV, following issues must be raised:

- Non-overlapping generations: alternative assumption of overlapping generations is feasible as well. One of solutions can be, i.e. that every individual discounts her benefits and all forthcoming generations from her actual age at the moment when investment begins. This would have streamlined the total discount rate γ_τ profile.

- Future generations as an element of present generation utility: it makes forthcoming generations of somehow secondary importance, because they do not possess the intrinsic value of their own. They appear only as an element in utility function of those living today.
- Relying on present generation preferences: the issue is probably inevitable, due to non-existence of future people, however requires further assumptions, like non-myopic attitude of contemporary generation, a willingness for altruistic behaviour and environmental sensitivity.
- Uncertainty: the issue of dealing with uncertainty seems one of crucial importance for intergenerational investments. Due to its complexity, it needs separate analysis and was put aside in this paper. The uncertainty problem is approached by a number of authors, including Howarth (1995), Woodward (2000), Ekeli (2004), Gollier (2008) and Weitzman (2011, 2010).
- IENPV sensitivity to λ: IENPV changes significantly for small changes in low values of λ. This implies the importance for estimating preferences of contemporary people toward unborn generations, i.e. if the weights of future people are close to one.
- Stability of λ across generations: In section 5 example IDR value was stable for all generations affected by the investment. However, λ may change for generations more distant in time.
- Time inconsistency – project evaluation may change due to unequal discount rates (prolonging the benefits to achieve higher PV after reaching generational time limit).

The issue of sustainability can be raised either. The basic idea of sustainability is that social welfare (defined as the sum of individual utilities) is non-declining through time (Gowdy, 2005). Thus, implementing projects with positive IENPV supports sustainable development, however, in its weaker form, where substitution is allowed, which makes it closer to KH criterion. However, in the approach presented in the paper, it is important to highlight that KH test is done “inside” individual utility function, not between individuals or generations. It is individual’s decision on how much resources or consumption he is willing to sacrifice to compensate satisfaction from his own and others future consumption. However, the “intrinsic” compensation relates to intergenerational transfers only – when considering allocation between contemporaries, P and KH rules take again “external” forms for separate treatment of individual gains and losses.

Concluding, it should be stressed that intergenerational decision making is permanently intertwined with a certain degree of failure due to the inevitable non-existence of future generations and extreme uncertainty of future physical impacts of the project. Any approach is just an attempt to make the results a little closer to unreachable, perfect methodology.

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