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Discounting for Intergenerational Investments: Individual Discount Rate for Close and Remote Beneficiaries

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The paper aims to diagnose whether it is justified in investment appraisal to apply a separate treatment (in terms of the value of the discount rate) for close-in-time versus distant-in-time project effects as well as for effects applying to close-in-space versus distant-in-space beneficiaries. The analysis rests on a survey asking Polish citizens to state their indifference points between lives saved now and in the future (with delays from 10 to 150 years to capture temporal distance) for two separate projects: saving lives in Poland (geographically close) and in Latvia (geographically remote). The findings suggest that while time distance can be perceived as a rationale to apply separate (lower) DRs which increase the weight of time-distant impacts in project's NPV, outcomes distant in space should be treated as equally important to geographically close impacts, thus extending the analysis beyond national borders.

Keywords: discount rate, intergenerational decisions, other-regarding behaviour, contingent valuation.

Dyskontowanie inwestycji międzypokoleniowych: indywidualne stopy dyskontowe dla bliskich i odległych beneficjentów projektu

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Celem artykułu jest określenie czy w ocenie efektywności inwestycji uzasadnione jest odrębne traktowanie (wyrażające się doborem odmiennej wartości stopy dyskontowej) efektów bliskich oraz odległych w czasie, a także efektów dotyczących beneficjentów bliskich oraz odległych geograficznie. Analizę przeprowadzono na podstawie wyników badania ankietowego, gdzie respondentami byli obywatele Polski, pytani o zadeklarowanie liczby istnień ludzkich uratowanych w przyszłości (z opóźnieniami od 10 do 150 lat) równoważących zadaną liczbę osób uratowanych dzisiaj dla dwóch odrębnych projektów: ratującego osoby w Polsce (bliskie geograficznie respondentom) i ratującego osoby na Łotwie (odległe geograficznie). Wnioski z badań wskazują, że o ile uzasadnione jest stosowanie odrębnych (niższych) stóp dyskontowych ze względu na odległość czasową efektów, o tyle oddziaływania odległe w przestrzeni powinny być traktowane jako równie istotne jak te pojawiające się blisko pod względem geograficznym. Uzasadnia to rozszerzenie prowadzonych ocen efektywności poza granice poszczególnych krajów.

Słowa kluczowe: stopa dyskontowa, decyzje międzypokoleniowe, zachowania względem innych osób, wycena warunkowa.

JEL: H43, D61, D64

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1. Introduction

Sustainable development as development providing future generations with unchanged level of welfare and opportunities not worse than those experienced by people living at present (cf. Brundtland, 1987) is closely linked to investing activities. Long-term investments, with impacts 30, 50 or 100 and more years into the future, are examples of investments that serve sustainable development, as they involve a contemporary generation making sacrifice (voluntarily reducing its welfare by investing) for the benefit of forthcoming generations. The examples of such transfers are predominantly environmental investments, including biodiversity protection or climate change mitigation, where effects may occur in hundreds of years (cf. Stern, 2007; Anthoff et al., 2009; Chapman, 2001). A multigenerational time horizon may also emerge in case of other types of investments, i.e. renewable energy, highways or R&D (Reserach & Development) (cf. Jones et al. 2014; Brouwer & Kind, 2005; OXERA, 2002; Florio et al., 2016). Additionally, such long-term impacts, particularly in the environmental protection, spill over not only generational boundaries but also national ones, i.e. global warming prevention with outcomes mainly for undeveloped countries and the majority of outlays in developed ones (cf. Schelling, 1995). This gives rise to new challenges for investment appraisal methods due to an inevitable discrepancy between an investing generation in one region, as investment can be made in selected counties incurring majority of outlays, and at present (the beginning of the investment cycle), and beneficiaries, spread in time and space, who do not participate adequately in the investment burden. The traditional appraisal procedures could be then too myopic and local in their perspective to appropriately capture all project impacts.

The willingness to share today's welfare with future people can be described by a discounting function that determines the weight of a delayed effect in today's decision. However, such choices differ substantially from decisions with time frame of one generation since the effects will be enjoyed by remote beneficiaries, not by the individuals making the decision and incurring outlays today. Shelling (1995) as well as Chapman (2001) compare transfers to benefit future generations with transfers on behalf of geographically distant people.

The appraisal of a public project is made by the Cost-Benefit Analysis (CBA) used to measure welfare changes of project beneficiaries via the opportunity cost and the willingness to pay. CBA decision criteria, i.e. economic Net Present Value (NPV), use the social discount rate (SDR) to discount project impacts distant in time. The study relates to the identification of conditions and a justification for distinguishing between the intragenerational versus the intergenerational perspective along with geographical distance between investors and beneficiaries in terms of SDR applied for NPV criterion. Thus, the aim of this study is to diagnose whether it is

justified to apply a separate value of discount rate in investment appraisal for close-in-time versus distant-in-time project effects as well as for effects applying to close-in-space versus distant-in-space beneficiaries. Research questions investigated whether discount rate values and determinants differ in respect of delay and geographical location of effects. The research is based on survey results, eliciting individual discount rates of the general public in Poland.

The paper contributes to the methodology of long-term public investment appraisal in several ways:

1. The importance of the discount rate value in the long-term appraisal process. The discount rate is a crucial parameter in long-term project evaluation due to high sensitivity of the present value to remote-in-time effects: the further in time the impacts of the project are placed, the lower their present value is. Additionally, even modest changes in the value of the discount rate for effects emerging after several dozens of years lead to substantial changes in their present value (PV)[1]. The results presented in the paper support the time declining discount rate schedule that increases the significance of remote effects in project appraisal made by a contemporary generation.
2. The importance of ethical consideration in the intergenerational and transboundary decision-making process. Intergenerational investments, i.e. climate protection policies, are inevitably accompanied by transfers made on behalf of others, when the society must forgo some part of current consumption to benefit people distant in time or distant geographically. Such transfer evaluation could be better justified by observed bids of the society, represented by discount rates resulting from this study.
3. National recommendations on SDR. The discount rate value results that decline with time offer a potential to justify the change of the current practice in Poland which applies a constant discount rate irrespectively of the time frame of the project.

The paper starts with the state of the art part describing recent developments in estimating the social discount rate based on the predicted economic growth as well as survey valuations, including social discounting describing preferences toward close and distant people. Afterwards, the methodology of the research is described, followed by the results of the survey. The methods of statistical analysis of the results involved descriptive statistics, as well as testing the significance of differences in DR between delays and between close and remote beneficiaries and constructing a log-normal model for analysing differences in DR explanatory variables. The results are then discussed from the point of view of relevance for long-term project appraisal. Conclusions summarise the findings.

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2. Discounting in Intergenerational Investment Appraisal and Its Ethical Perspective

In the search for an appropriate social discount rate for long-term project appraisal, two broad streams of literature may be distinguished.

The prevailing approach is Ramsey (1928) formula, based on the pure time preference rate and the projected long-run annual growth of *per capita* real consumption weighted by elasticity of marginal utility of consumption (Frederick et al., 2002; Freeman & Groom, 2016). Considering the intergenerational perspective, researchers suggest using a time-declining discount rate, which is justified by eliminating the pure time preference rate to prevent decreasing utility of future generations (Weitzman, 2001; Arrow et al., 2012) or by uncertainty over the distribution of discount rates (Weitzman, 2010; Fisher, 2003; Arrow et al., 2012) or by uncertainty over the future consumption growth rate (Gollier & Weitzman, 2009).

The second stream rests on direct estimations of discount rates (Cropper et al., 1994; Frederick et al., 2002; Almansa & Martínez-Paz, 2011; Foltyn-Zarychta, 2014). Such studies deliver a discount rate based on the direct measurement of preferences (stated preferences: contingent valuation or contingent ranking, cf. Spash & Hanley, 1994; Garrod & Willis, 1999). Applying the stated preference method is one of the approaches used in CBA for public good valuation where markets fail to provide a fair price. It is also justified in case of long-term investments where financial rates of return are unobservable as well as on the basis of ethical rationale as the welfare of future generations may be perceived as a public good.

These studies also show that discount rates decline with time (Reinschmidt, 2002). Individual intertemporal choices for outcomes distant in time (future generations) are described by the phenomenon of hyperbolic discounting (Loewenstein & Prelec, 1992; Henderson & Langford, 1998; Frederick et al., 2002). The empirical results support the time-declining discount rate (DR) suggesting that future people are given some preferential treatment by the contemporaries in comparison with the time-constant DR (Cropper et al., 1994; Frederick, 2003; Chapman, 2001; Meerding et al., 2010).

Declining discount rates instead of constant SDRs are also used in practice in selected countries. In the UK, SDR declines from 3.5% to 1% for horizons of over 300 years (HM Treasury, 2011). France also applies DDR with respect to non-market investment effects starting from 4% and declining to 2% for the 300-year horizon (Cropper et al., 2014). However, in Poland the prevailing approach for the economic evaluation of public projects follows EU Commission (2014) requirements with a constant rate of 5%, irrespectively of the time horizon of the project cycle.

Additionally, a research gap can be identified relating to intergenerational DRs that individuals apply when long-term transfers are made on behalf of geographically close versus distant beneficiaries. Wade-Benzoni (2008) as well as Chapman (2001) suggest that distance in time is in some respect similar to distance in space due to psychological distance between decision makers and the consequences of their decisions if they emerge away in space or in time. When the intergenerational perspective is not taken into consideration, regarding people distant in space, the empirical findings show that the value of DR is negatively correlated with social distance, which means that an individual's willingness to forgo an outcome for the self in lieu of a larger outcome for someone else diminishes as social distance increases (Takahashi, 2007; Rachlin & Jones, 2008; Yi et al., 2010; Osiński et al., 2015). Loewenstein (1996) also highlights that when considering trade-offs between an agent's own well-being and the well-being of others, more weight is put on the decisions affecting the agent himself/herself. Yet, when the long-term perspective is considered, future benefits for people distant in space are treated equivalently with future outcomes for people living close to the agent. Chapman's findings (2001) demonstrate that there is no statistically significant difference between long-term discounting of close and distant beneficiaries, which seems to contradict "social distance" discounting. It seems to be also the only study so far which compares temporally and spatially close vs. distant beneficiaries[2]. Results of Yi et al. (2010) may partly explain this phenomenon, showing that discounting due to social distance decreases for longer delays; however, their study considers only a short-term, intergenerational temporal scale (up to 6 years).

3. The Method

The research applies the stated preference approach of direct estimation of social discount rates, creating a hypothetical market for intertemporal decisions for Polish citizens. The respondents were asked to indicate their indifference points between immediate and delayed effects for various time lags (intra- and intergenerational) for projects benefiting Polish citizens (spatially close beneficiaries) and for projects benefiting Latvian citizens (spatially distant beneficiaries).

Research questions were formulated in respect of the issues:

1. Whether discount rate values for close and distant beneficiaries in time and in space differ?
2. Whether discount rate determinants differ for close and distant beneficiaries for intra- and intergenerational time frames?

The research question format was used instead of research hypotheses due to the scarcity of papers related to the issues raised in the article. Although it is possible to assume that the discount rate should decline with

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time and social distance (the latter can serve as a proxy of geographical distance), the results available relate mainly to a short time frame. The intergenerational horizon combined with the geographical location has been represented only by Chapman (2001) study so far.

The respondents were Polish citizens living in Poland. The survey was designed as an Internet questionnaire. The invitation to take part in the survey was sent to a nation-wide representative sample of individuals according to the database belonging to the Centre of Research and Knowledge Transfer at University of Economics in Katowice in 2014. The respondents were accessed via emails and social portals. The stratified sampling method was used. The total number of individuals contacted can be estimated roughly from 3 500 to 5 000. Filled in questionnaires were returned by 502 respondents, out of which 470 were finally used in the analysis.

The questionnaire comprised three parts. The first part contained general attitude questions i.e. on the importance of the well-being of future generations, environmental protection or saving human lives and the frequency of charity activities. The second part consisted of valuation questions for four types of projects and various delays. The third part included questions about the socio-economic profile of respondents (sex, age, income, household size, education, presence of juvenile children in the family).

To investigate whether people distant in time are perceived differently than the contemporaries, the respondents were asked to choose a number of lives saved in the future (future effects, FE), which makes them indifferent in comparison with saving 10 people after one year (present effects, PE) (Figure 1).

Imagine that you are helping the government in the comparison and evaluation of two investment projects aimed to **save lives**. Outlays for both projects would be equal and borne this year. However, only one project can be executed.

PROJECT A will regulate a river in Poland to avoid the risk of flooding. In one year from now, due to the investment 10 PEOPLE will be saved.

PROJECT B is an investment to prevent climate change, which will influence the whole area of Poland reducing the risk of flooding, but in the future. PROJECT B will also save a number of people, but saving lives is deferred.

How many people should PROJECT B save after X* YEARS to be as good as PROJECT A?
After one year Project A will save the lives of 10 people, but after X years it will save 0 lives.
After one year Project B will save the lives of 0 people, but after X years it will save the lives (enter how many) ……. people.

* – the delay of effects (X) varied across questions from 10, 30, 90 to 150 years.

Fig. 1. Sample valuation question.

All valuation questions were open-ended to allow respondents an unrestricted choice of any value. The delays were set at: 10, 30, 90 and 150 years. The individual discount rate was estimated as the logarithmic rate of return (cf. Cropper et al., 1994; Hepburn et al., 2009; Loewenstein & Prelec, 1992):

$$IDR = \frac{\ln\left(\frac{FE}{PE}\right)}{n}$$

n – number of years of delay
PE – present effect produced by the number of lives saved by the contemporary investment (project A)
FE – future effect produced by the number of lives saved by the delayed investment (project B)

To analyse the differences in stated discount rates between geographically close and distant beneficiaries, the respondents were asked first to state their discount rates for the projects saving lives in Poland for each delay, and then to state their discount rates for a similar project, however, saving lives in Latvia, keeping all delays identical as for the "Polish life-saving" project. Latvia was chosen due to several reasons. First, it is a Baltic country, which makes it potentially sensitive to flooding due to climate change. Second, it is a country not far from Poland and a member state of the EU, which allowed for assuming that the respondents had some general knowledge about it. However, it does not have common border with Poland and is basically free from common clichés (positive or negative) from which close neighbour countries sometimes suffer and which could bias the results. Third, an average income in Poland and in Latvia is relatively similar.

The survey results were analysed with STATISTICA 12 software. The methods of statistical analysis of the results involved basic statistical measures (mean, median, dispersion, skewness). The central moment was assumed to be a better estimator due to the positive skewness of the results[3].

To test the significance of differences in DR between delays and between close and remote beneficiaries (Poland vs. Latvia), first normality of distribution of DR was tested for all effects with Kolmogorov-Smirnov and Shapiro-Wilk tests. To compare DR between different delays, ANOVA Friedman and Wilcoxon signed-rank tests were run at p-value of 0.05.

To analyse whether socio-economic determinants of DR for close and distant beneficiaries differ, the associations of the respondents' background characteristics with DRs were examined using Kruskal-Wallis (multiple options) or Mann-Whitney (for binary characteristics) tests. Then, the log-normal model (Generalized Linear and Nonlinear Models) was used for estimating the explanatory variables for DR models for spatially and temporally close and distant outcomes[4].

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4. The Results

Socio-economic characteristics of the survey respondents are comparable to the Polish social structure. 52% of the respondents are female, the average size of the household is 3.02 (Poland – 2.82), median age is 38.7 years (Poland – 37.8) (GUS, 2015). The results show that university degree holders are over-represented in the sample (44%), and so are high-income households[5]. This can be due to the Internet accessed survey.

Mean values of discount rates for Polish beneficiaries (close) decline from 13.67% (10-year delay) to 2.57% (150-year delay) and in general are slightly lower than for Latvians (distant), where average DR is 14.14% for the shortest delays, while for the longest: 2.45%. Median values decline with time as well (7.7% to 2.01%); however, they are similar between close and distant individuals for all delays.

	N	Mean	Median	Min	Max	25 – percentile	75 – percentile	SD
LSP10	469	13.67%	7.70%	–25.58%	102.34%	0.00%	25.58%	16.91%
LSP30	467	7.51%	5.55%	–7.94%	39.70%	1.40%	11.73%	7.44%
LSP90	468	3.47%	2.59%	–2.59%	18.11%	0.46%	5.06%	3.28%
LSP150	468	2.57%	2.01%	–1.55%	10.82%	0.35%	3.36%	2.38%
LSL10	469	14.14%	7.70%	–25.58%	102.34%	0.00%	25.58%	18.48%
LSL30	468	7.65%	5.55%	–7.94%	34.15%	2.39%	11.73%	7.19%
LSL90	468	3.43%	2.59%	–2.59%	15.52%	1.23%	5.06%	3.04%
LSL150	461	2.45%	2.01%	–1.55%	10.75%	0.74%	3.36%	2.17%

LSPX, LSLX – life-saving project in Poland or Latvia after X years

Tab. 1. Descriptive statistics of discount rates for close and distant beneficiaries

The results indicate that the stated discount rates decline with time and the differences between each delay are statistically significant (Chi^2 ANOVA Friedman test and Wilcoxon signed-rank, p-value <0.05) suggesting that the beneficiaries remote in time are treated differently than the contemporaries. The differences are significant not only between generations but also for 10 and 30 years, which means that time distance is a significant variable also intergenerationally.

Comparing the results for spatially close and distant beneficiaries, it must be noticed that although mean values are slightly higher for shorter delays (10 and 30 years), when the significance of differences between the value of the discount rate for Polish and Latvian beneficiaries is tested (Wilcoxon signed-rank test run separately for each time delay, $p>0.05$),

it shows negative results indicating no statistically significant differences between geographically close and remote beneficiaries.

Therefore, referring to the first research question, we argue that while the discount rates for the temporally close and distant beneficiaries differ significantly, the comparison of intertemporal choices of Polish respondents for the geographically close and distant beneficiaries does not show statistically significant differences, indicating equal treatment of Polish and Latvian beneficiaries.

The second research question referred to the differences in factors determining the value of the discount rate for the inter- and intragenerational time perspective as well as for the spatially close and remote beneficiaries. The list of variables and survey questions relating to them is given in Table 1 in the appendix at the end of this paper. To analyse the relationship, Generalized Linear and Nonlinear Models in Statistica (GZL) were used. The parameters were estimated based on all-effects statistic. The DR value in the model is explained by socioeconomic characteristics, delay and general-attitude questions. This relationship can be described as:

$$r = \mu = g^{-1}(X\beta) + e$$

where:

$r = \mu$ – expected value of discount rate,

$X\beta$ – linear predictor, defined as: $X\beta = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k$

g – link function, here defined as: $g(\mu) = \ln(\mu) = \ln(X\beta) \Rightarrow \mu = e^{X\beta}$

The goodness-of-fit was analysed via scaled deviance and scaled Pearson Chi-square as well as with Akaike information criterion (AIC) and Bayesian information criterion (BIC). Tables 2 and 3 contain results of model parameter estimates with standard errors and goodness-of-fit statistics.

The models were estimated for the total (10–150 years), intragenerational (10–30 years) and long, intergenerational (90–150 years) periods separately for the Polish and Latvian beneficiaries. The discount rate was explained by socioeconomic characteristics: binary variables: MALE, AGE≤45, education (NUD – no university degree), income lower than PLN 2000 (INC≤2000), family size smaller than 3 members (FS<3) and no children under the age of 18 (NU18) as well as a continuous variable (youngest child age, YCA) and introductory questions about the importance of future generations (IFG); environmental protection (IEP); life-saving issues (ISL), measured on the 5-point scale from "completely unimportant" to "very important"; and charity behaviour frequency (WA), measured on the 5-point scale from "never" to "more often than once a month"; and finally the delay of effects (D) (10, 30, 90 and 150 years). The results show that the models are reasonably well adjusted to raw data.

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	Poland			Latvia		
	Estimate	**st error**	**p value**	**Estimate**	**st error**	**p value**
Intercept	**–3.28**	**0.36**	**0.000**	**–2.81**	**0.41**	**0.000**
IFG	**0.10**	**0.04**	**0.020**	–0.02	0.05	0.697
IEP	**0.11**	**0.05**	**0.015**	0.02	0.05	0.744
ISL	**0.12**	**0.06**	**0.034**	**0.12**	**0.06**	**0.048**
WA	0.01	0.04	0.784	–0.05	0.04	0.195
YCA	–0.01	0.01	0.083	0.01	0.01	0.216
D	**–0.02**	**0.00**	**0.000**	**–0.02**	**0.00**	**0.000**
MALE	**0.12**	**0.04**	**0.001**	**0.14**	**0.04**	**0.000**
AGE≤45	–0.03	0.04	0.448	0.06	0.04	0.156
NUD	–0.02	0.04	0.509	0.08	0.04	0.067
INC≤2000	**–0.07**	**0.04**	**0.038**	**–0.08**	**0.04**	**0.033**
FS<3	**–0.31**	**0.14**	**0.024**	**–0.42**	**0.18**	**0.019**
NU18	**0.25**	**0.06**	**0.000**	0.03	0.06	0.642
Scale	0.09	0.00		0.10	0.00	
AIC	–2119.67			–1902.04		
BIC	–2049.95			–1832.21		

Variables found significant for p<0,05 are marked in bold.

Tab. 2. Model parameter estimates, standard errors and goodness-of-fit statistics for LSP and LSL for time horizons of 10–150 years

Comparing the models for all delays (Table 2) for close (Polish) and geographically distant (Latvian) beneficiaries, there are some differences in explanatory variables. Results demonstrate that the discount rate for 10–150 years for distant beneficiaries is explained by a lower number of variables: sex (higher for male respondents), income (lower for low-income households), family size (lower for small families), importance of saving lives (higher for people perceiving life-saving activities as more important) and delay (lower for higher delays), whereas close beneficiaries' discount rate is also dependent on the absence of juvenile children (higher), importance of future generations and environmental protection (positively correlated). It is worth noticing that the signs of variable estimates for both models are similar. Additional differences can be seen under the assumption that the p value will increase to 0.1. In that case, the model for close beneficiaries could be enlarged by the age of the youngest child ($p = 0.083$), which is not significant for geographically remote agents, while the discount rate for the Latvian project could be additionally explained by the lack of university degree (higher than for respondents graduating from university).

Looking closer at the reasons for such differences, the models were estimated separately for the intragenerational time frame (10–30 years)

and the intergenerational period (delays of 90 and 150 years) (Tables 3 and 4). Comparing short- vs. long-term as well close vs. distant in space beneficiaries, only 2 variables enter all models consecutively: delay and sex. Assuming a higher p value ($p<0.1$), the family size enters all models as well[6].

	Poland 10–30			Latvia 10–30			Poland 90–150			Latvia 90–150		
	Estimate	**st error**	**p value**	**Estimate**	**st error**	**p value**	**Estimate**	**st error**	**p value**	**Estimate**	**st error**	**p value**
Intercept	**–3.24**	**0.52**	**0.000**	**–2.70**	**0.59**	**0.000**	**–3.00**	**0.41**	**0.000**	**–3.06**	**0.41**	**0.000**
IFG	0.11	0.06	0.077	–0.02	0.07	0.762	0.00	0.05	0.970	–0.02	0.05	0.679
IEP	0.12	0.06	0.066	0.00	0.07	0.952	0.03	0.05	0.508	**0.10**	**0.05**	**0.038**
ISL	0.15	0.08	0.073	0.15	0.09	0.094	–0.03	0.06	0.665	–0.07	0.05	0.172
WA	0.02	0.05	0.755	–0.06	0.06	0.341	0.00	0.04	0.997	–0.03	0.04	0.441
YCA	–0.02	0.01	0.147	0.01	0.01	0.340	–0.01	0.01	0.500	0.00	0.01	0.906
D	**–0.03**	**0.01**	**0.000**	**–0.03**	**0.01**	**0.000**	**–0.01**	**0.00**	**0.000**	**–0.01**	**0.00**	**0.000**
MALE	**0.13**	**0.05**	**0.007**	**0.15**	**0.05**	**0.007**	0.07	0.04	0.061	**0.09**	**0.04**	**0.017**
AGE≤45	–0.04	0.05	0.497	0.06	0.06	0.308	0.03	0.04	0.506	0.07	0.04	0.089
NUD	–0.02	0.05	0.741	0.09	0.06	0.148	–0.06	0.04	0.130	0.00	0.04	0.955
INC ≤2000	–0.08	0.05	0.096	–0.09	0.05	0.091	0.01	0.04	0.833	0.03	0.04	0.482
FS<3	–0.32	0.20	0.099	–0.42	0.25	0.092	–0.23	0.13	0.081	**–0.37**	**0.16**	**0.024**
NU18	**0.27**	**0.08**	**0.001**	0.02	0.08	0.806	**0.18**	**0.06**	**0.006**	0.09	0.06	0.140
Scale	0.12	0.00		0.14	0.00		0.03	0.00		0.02	0.00	
AIC	–711.42			–591.22			–2345.62			–2432.39		
BIC	–651.39			–531.06			–2285.62			–2372.31		

Variables found significant for p<0,05 are marked in bold.

Tab. 3. Model parameter estimates, standard errors and goodness-of-fit statistics for LSP and LSL for time horizons 10–30 and 90–150 years

The comparison between Polish and Latvian beneficiaries for the intra-generational time frame (10–30 years) shows that importance of saving lives, delay, sex, income and family size explain the value of DR in both cases (close and distant outcomes) and the estimates of variables are of similar signs, indicating that discount rates change simultaneously. The only variable that differs between both models is the presence of children under 18 (at $p<0.05$). Two other variables that could enter the DR model for Polish beneficiaries (at $p<0.1$) are the importance of future generations and the importance of environmental protection; however, the comparison of the discount rates calculated for each level of importance separately indicates that the values do not grow or decline uniformly (Table 4), so it is dubious whether they should be included in the model anyway.

The comparison of Polish vs. Latvian beneficiaries' models for the long-term time frame (90–150) shows also a substantial level of similarities. Both models are explained by the delay (DR decline with time for both models), sex (DR higher for male for both models) and the family size (higher for larger families in both cases). The set of explanatory variables for Poland differs from the one for Latvia in respect of the absence of

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juvenile children and environmental protection (at $p<0.05$), coupled with age which is significant in case of Latvia (at $p<0.1$).

Variable	Poland 10–30	Latvia 10–30	Poland 90–150	Latvia 90–150
Importance of future generations (IFG)	**	NS	NS	NS
Completely unimportant	15.14%	–	–	–
Less important than the present generation	11.51%	–	–	–
Equally important	10.45%	–	–	–
More important than the present generation	9.30%	–	–	–
Very important	16.11%	–	–	–
Importance of environmental protection (IEP)	**	NS	NS	*
Completely unimportant	9.77%	–	–	1.91%
Of small importance	9.39%	–	–	2.44%
Of average importance	9.81%	–	–	2.76%
Quite important	10.46%	–	–	2.99%
Very important	12.92%	–	–	3.34%
Importance of saving human lives (ISL)	**	**	NS	NS
Completely unimportant	–	–	–	–
Of small importance	4.24%	5.09%	–	–
Of average importance	8.88%	10.51%	–	–
Quite important	10.23%	10.38%	–	–
Very important	11.18%	11.37%	–	–
Delay of investment effects (D)	*	*	*	*
10	13.68%	14.14%	–	–
30	7.52%	7.65%	–	–
90	–	–	3.48%	3.44%
150	–	–	2.57%	2.45%
Gender (M)	*	*	**	*
M	8.64%	7.65%	2.65%	2.19%
F	6.63%	5.70%	2.29%	1.84%
Age (AGE)	NS	NS	NS	**
≤45	–	–	–	2.15%
>45	–	–	–	1.87%
Average monthly HH income per capita (INC)	**	**	NS	NS
≤PLN 2000	6.97%	6.03%	–	–
>PLN 2000	8.22%	7.24%	–	–
Family size (FS)	**	**	**	*
<3	5.48%	4.32%	1.96%	1.39%
≥3	10.47%	10.09%	3.10%	2.90%
Children under 18-years-old (NU18)	*	NS	*	NS
absent	9.91%	–	2.94%	–
present	5.78%	–	2.07%	–

* – variables significant at $p<0.05$, ** – variables significant at $p<0.1$

Tab. 4. Comparison of sets of explanatory variables and their mean discount rates between beneficiaries close and distant geographically and in time[7]

Analysing the set of explanatory variables, more discrepancies can be observed between the short- and long-term perspective. Short- and long-term models for Poland are both explained by delay, sex, family size and presence of juvenile children with similar signs of DR change (Table 3 and 4). However, the long-term model for Poland excludes all 3 attitude questions (importance of life saving, environment and future generations) as well as income, significant for the intragenerational time frame. The latter variable is also found insignificant for the long-term Latvian model, while it enters the short-term one. The Latvian short- and long-term perspective models also differ in terms of importance of environmental protection and age (at $p<0.1$) variables. The summary of sets of variables with DR values is presented in Table 4.

It can be concluded that comparing the set of explanatory variables, more discrepancies can be observed between the short- and long-term perspective than for geographically close and distant beneficiaries.

5. Discussion

The values of DR are comparable with the results of other studies eliciting discount rates on the basis of surveys. Chapman's (2001) results show the decline of mean discount rates from over 30% for one-year delay, approx. 8% for 10 years, approx. 3% for 30 years and less than 1% for 300 years. Meerding et al. (2010) discount rates decline from over 10% for a 5-year delay to 3.5% for 10 years and 2.3% for 40 years. The mean values of discount rates (LSP) in this study climb down from 13.5% for 10 years to 2.5% for 150 years may be perceived as similar to the above results. It must be pointed that some other studies show slightly higher results, i.e. Cropper et al. (1991) study shows a decline from 8.6% for 25 years to 6.8% for 50 years and 3.4% for 100 years. The results support the time-declining discount rate (DR) suggesting that future people are given some preferential treatment by the contemporaries.

The differences between the value of DR for the life-saving project in Poland and the life-saving project in Latvia were found statistically insignificant (Wilcoxon signed-rank test run for each delay), supporting Chapman (2001) results that showed no statistically significant difference between New Jersey and Thailand live-saving projects with delays up to 300 years in the eyes of New Jersey respondents. However, referring to the similarities in DR values between close and distant beneficiaries, it is worth noticing that the results of short-term social distance discounting do follow a hyperbolic decline similar to temporal discounting. Such results can be found in Rachlin and Jones (2008) and Osiński at al. (2015).

The discrepancies between discount rates for temporal and spatial distance are also visible in model explanatory variables. Comparing the

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intragenerational vs. intergenerational models for Polish and Latvian beneficiaries, more similarities can be observed (one variable) for the models for close and distant individuals than for the intra vs. intergenerational time frame (two variables at $p<0.1$).

The dissimilarity between social discounting studies and results of Chapman's and this study could be explained by a number of reasons. First, it should be noticed that neither of them tests explicitly for the social discounting phenomenon, as they apply only one point of social distance (close vs. distant: New Jersey vs. Thailand and Poland vs. Latvia). Secondly, social distance studies are mainly static, meaning that they do not apply both social and temporal distance simultaneously. When both dimensions are joined (although tested for the intragenerational time-perspective), the importance of social distance shows less impact on the value of the discount rate for delayed impacts, irrespectively of how long the delay is (Yi et al., 2010). This may justify to some extent why geographically distant beneficiaries in Chapman's and this study were treated as equally important as spatially close receivers. However, a closer look at intergenerational and spatial social distance discounting could be one of future research directions.

An additional justification for separate discounting the effects differing in terms of temporal distance results from the fact that project outcomes acquire the features of public goods as the time distance grows. Such changes do not concern a situation where the social difference increases (in geographical terms). Carmi and Kimhi (2015) indicate that when results are not perceived as personal but apply to the general public, agents tend to see them as public responsibility. Therefore, delayed saving of lives in Poland could be perceived as a public good very close to the saving of future lives in Latvia, applying a similar valuation, irrespectively of spatial distance. Jones and Rachlin (2009) support the results as they indicate a positive correlation between the level of altruism and public good characteristics. This can explain both the similarities of models and values of discount rates between Latvian and Polish beneficiaries as well as lower rates for the intergenerational time frame that gives separate, preferential treatment to future generations.

6. Conclusions

The study shows that the value of the discount rate is sensitive to the delay and declines with time; however, spatial distance between the decision maker and the receiver is not significant for the choice of the discount rate. Additionally, analysing the variables that explain the value of the discount rate, more apparent discrepancies in explanatory variables can be observed when comparing intragenerational and intergenerational periods than spatially close and distant outcomes (Table 5).

	Poland 10–30	Latvia 10–30	Poland 90–150	Latvia 90–150
IFG	IFG			
IEP	IEP			IEP
ISL	ISL	ISL		
D	D	D	D	D
Male	MALE	MALE	MALE	MALE
AGE≤45				AGE
INC ≤2000	INC<2000	INC<2001		
FS<3	FS<3	FS<4	FS<5	FS<6
NU18	NU18		NU18	

Tab. 5. Comparison of sets of explanatory variables (for $p<0.1$) between beneficiaries close and distant geographically and in time

The results are relevant to the methodology of long-term public project appraisal. The Cost-Benefit Analysis is criticized on many grounds for its short-term perspective; however, it deserves an extremely careful treatment when the intergenerational time frame is involved (cf. Spash & Hanley, 1994; Mishan & Quah, 2007; Dasgupta et al., 1999). The reason is the high sensitivity of the Net Present Value to slight changes of the discount rate value that may change the evaluation outcome when distant-in-time effects are involved. Additionally, ethical issues must be taken into consideration due to the fact that investments will affect unborn people, unable to participate in decision making, as well as altruistic preferences of people living at present, visible in benefiting people in other countries, and future generations that will mainly enjoy benefits, while the present generation incurs the majority of outlays (cf. Zerbe, 2004).

The decline of discount rates with time found in the study suggests changing the constant social discount rate applied at present in Poland for public project appraisal, irrespectively of the investment time frame, into a time-declining discount rate schedule. It could be additionally supported by the experience of other countries (UK, France) (Freeman & Groom, 2016).

Although the decline of discount rates with time is generally of higher relevance for public investments, which usually face longer time horizons than in case of private projects, some attention could be also given to selected types of private investments, like pension schemes or real estates.

The study relates also to the international efforts to protect the environment. A few remarks could highlight the importance of the findings due to the fact that the results, although Polish citizens were investigated, could be useful in justifying climate change protection efforts. It should be noticed that climate change issues are both transgenerational and transnational.

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Intergenerational justice explains the nature and the scope of duties the present generation has towards the future. A vast number of philosophers analyse the concept, which is compared by Gardiner to "a perfect moral storm" i.e. due to the disproportionality between the decision-making power between the present and future generations. Those issues are raised i.e. by Parfit (1982), Page (2007), Birnbacher (2009), Gosseries & Meyer (2009). While philosophical theories put forward the concepts that we owe to our descendants as much as we have (based on reciprocity or a stewardship approach) or more than we have (justified by utilitarianism) or enough (sufficientarianism principles) (cf. Roser & Seidel, 2016), they are not widely backed by empirical findings. The results of the paper in part referring to the discount rate value and the time horizon support the intergenerational justice theories making the future generation count in the project evaluation.

Secondly, climate warming is a global issue and may affect multiple countries; the results that show stability of preferences irrespectively of the geographical distance between the investor and the receiver support the need to increase global efforts to reduce the temperature rise. Public bodies, including governments, are reluctant to take immediate actions to prevent climate change, supporting the status quo (cf. Kunreuther et al., 2014), which happens partly due to the temporal distance between societies incurring outlays and receiving benefits as well as impacting other non-investing countries. The substantial disparity of the climate change adverse effects generally replicates the division between developed and underdeveloped countries, with highest risks applied to African and Asian countries. The results, indicating equal importance of fellow citizens as well as geographically distant people (both in terms of values as well as mix of variables affecting them), could be used as a rationale for including effects spilling over national borders and perceiving them as equally important as within-country impacts. Additionally, the time-declining discount rate schedule increases the present value of far-off impacts, raising the importance of future unborn people in the investment appraisal process.

Endnotes

1 For example: If an investment project generates an effect of EUR 1 mln value after 50 years, discounting it by 5% gives the present value of approx. EUR 90 thousand. However, applying 4% produces the present value of EUR 140 thousand, which is over 60% higher than the initial PV outcome.

2 The literature investigation (cited references search in WoS, Scopus and Google Scholar) showed no similar research results.

3 Median value is also useful since it is not influenced by extreme bids (cf. Garrod & Willis, 1999).

4 The non-linear model assumption was based on the type of relationship between the delay and the discount rate (cf. Loewenstein & Prelec, 1992). The calculations

made in Statistica also confirmed that as the created linear models showed none or very few variables that were statistically significant in the model.

5 The average disposable income per person in Poland in 2014 was PLN 1340 (GUS, 2015), whereas the sample estimate is higher than PLN 2000.

6 In the latter case, the sex variable can be found statistically significant in case of the intergenerational time frame for Poland, due to the fact that the p value is slightly higher than 0.05 (0.061)

7 Table 4 omits education, charity frequency and youngest child age variables due to the fact that they were found statistically insignificant both in models as well as when analysed separately (Mann-Whitney and Anova tests).

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Appendix

Variable	Abbreviation	Survey question
Importance of future generations	IFG	"How important are future unborn generations to you in comparison with the generation you belong to? (Think of future generations' well-being, quality of life, environment degradation)" 5-point scale: 1 – completely unimportant, 5 – very important (continuous variable)
Importance of environmental protection	IEP	"How important is environmental protection to you?" 5-point scale: 1 – completely unimportant, 5 – very important (continuous variable)
Importance of saving human lives	ISL	"How important are issues relating to saving human lives to you?" 5-point scale: 1 – completely unimportant, 5 – very important (continuous variable)
Charity behaviour frequency (willingness to altruism)	WA	"Do you help other people, non-family members whom you do not know personally? (Consider charity, voluntary work or giving money to social entities, people suffering from natural catastrophes in other countries, etc.)" 5-point scale: 1 – never, 5 – more often than once a month (continuous variable)
Youngest child age	YCA	"How old is the youngest child in the family? (in years)" (Open-ended question, continuous variable)
Delay of investment effects	D	"How many people project B should save after X years to be as good as project A? After one year Project A will save the lives of 10 people, but after X years it will save 0 lives. After one year Project B will save the lives of 0 people, but after X years it will save lives (enter how many people)". Delays (X) varied across questions from 10 to 150 years (continuous variable)
Gender	MALE	"Gender": Female, Male (binary variable)
Age (lower than 45 years)	AGE≤45	"Age": from "up to 25" to "more than 65" with 10-year intervals (transformed into a binary variable)
Education (no university degree)	NUD	"Education": Primary school, Vocational school, High school, University degree (transformed into a binary variable)
Average monthly HH income per capita (lower than 2000)	INC ≤2000	"Average monthly income per capita in your household": from "Up to PLN 500" to "More than PLN 5000" with PLN 1000 intervals (transformed into a binary variable)
Family size (smaller than 3 members)	FS<3	"Number of household members": from "1" to "7 and more") (transformed into a binary variable)
Presence of children under 18 years old	NU18	"Number of children under 18 years old": from "0" to "5 and more" (transformed into a binary variable)

Tab. 1. The list of variables, abbreviations used in the model and survey questions