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EXPLORING DIFFERENCES IN EMPIRICAL TIME PREFERENCE RATES: AN APPLICATION OF META-REGRESSION

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ABSTRACT

Introduction: Despite the existence of empirical estimates of time preference rates, 'standard' rates such as the UK treasury rate are used for discounting. This may be because estimated time preference rates are as varied as the studies that have been conducted, with many rates being extremely high. Reviewing empirical studies without quantitative synthesis of their findings is largely unhelpful in determining how rates vary according to different factors. This study therefore explores the use of meta-regression techniques to combine the available evidence and thus draw reliable conclusions about empirical time preference rates and the factors influencing them.

Methods: Papers reporting empirically derived time preference rates related to health and health care programmes were selected. Included were papers presenting all of: a mean time preference rate; information allowing derivation of standard errors; and one or more covariates. Meta-regression was used to analyse the data, using Stata.

Results: Appropriate data were derived from only eight of the 16 papers reporting empirical time preference rates. Meta-regression indicated that there were statistically significant relationships between mean time preference rates and: (a) delay period on a log scale; (b) whether the outcome question related to a gain or a loss.

Discussion: Is this a useful method for looking at these sorts of data? Problems in this exercise included: obtaining the required data from studies and/or authors; the resultant small number of data points for analysis; and the limitations of standard packages in dealing with the complex statistical model including various sources/levels of variation. Nonetheless, the process and analysis does appear to represent an advance on previous approaches, both in terms of the results themselves and the potential of the methodology.

INTRODUCTION

Economic evaluations generally incorporate the notion that benefits and costs that are deferred have lower value than those that are realised immediately. This is achieved through discounting, itself derived from the notion of positive time preference: that people prefer to receive a benefit today rather than in the future, and likewise to incur a cost later rather than sooner.

Although discounting is based on the notion of preferences, much less effort has been devoted to the development of preferences for allocating resources over time than to preferences for health outcomes (for example, vast amounts of effort in health economics have been consumed in developing quality-adjusted life-years, [1]; [2]; [3]; [4] through contingent valuation,[5]; [6]; [7] and even in determining appropriate objectives for societal decisions[8]; [9]; [10]). Further, whilst the use of preference based health outcome data is currently *de rigeur* in economic evaluation, the use of publicly determined time preferences is almost non-existent in the empirical economic evaluation literature. Indeed, the use of empirically based time preference rates in health care economic evaluation is seldom even ***advocated*** (exceptions being for example, Chapman *et al*,[11] [12]). Instead the use of "standard rates" such as the UK Treasury rate is accepted practice. These constant official rates do not, however, appear to reflect societal preferences[13] as evidenced by those studies that have empirically estimated implied discount rates for life saving, health improvement and financial/monetary gains (losses). These have found rates as high as a median rate of 206% for a 2-year delay in Ukraine [14] and as low as 0.14% for a 19-year delay in the UK.[15]

Reasons for avoiding the use of empirically derived time preference rates in economic evaluation are potentially threefold: (1) the time preference rates that have been estimated are as varied as the studies that have been conducted; (2) in many cases these rates are so high that their use would result in an extremely strong emphasis on immediate life saving (curative) treatments at the expense of preventive health services (and even research into future treatments) and; (3) although empirical studies agree that discount rates decrease with increases in time delay, none has yet been able to determine what rate should be used for which number of years and when to change the rate.

Empirical studies have considered a number of potential sources of variation within their individual studies. Factors identified as influencing the empirical time preference rates include: different settings, age, income and educational levels of individuals;[16] sequences of events;[17];

[18] [19] whether outcomes are expressed as gains or losses;[20] the magnitude of gains and the type of risk;[21] the severity of health state;[22]; [23] and the time delay.[24]

There are three problems with interpreting these findings, however. First, methodological difficulties make interpretation difficult. For instance, evidence seems to suggest that time preference rates decrease as time delay increases[25]; [26] but this has been described as an artefact associated with the particular methods used, specifically the use of restricted response sets that vary according to time delay.[27] If this is the case, it would be expected that the results from different studies would vary by data collection method. Similarly, where studies do not allow for expression of negative time preference, no such evidence is found, but when respondents are allowed to freely express their time preference, significant numbers of the same respondents demonstrate negative and zero time preference.[23]; [28] Again, study design appears to affect responses.

Second, the relatively small number of studies and the large variations across a number of factors associated with their designs make it difficult to draw accurate conclusions from review of the literature alone about which factors are the main influences upon the rates obtained. For example if one study finds a high time preference rate with a short delay period for a life saving intervention and another finds a low time preference rate with a long delay period and a health improving (but not life saving) intervention, is it the long delay period or the type of intervention, or both, which are causing the changes in time preference?

Third, there are questions about the extent to which context is important in influencing time preference rates. At the broadest level there is evidence of a distinction (referred to as domain independence) between time preference rates for money and health.[11]; [29] There is also evidence that time preference rates depend on the context in terms of the sample making judgements[30] and the type of health setting.[31]

These problems make it difficult to draw robust conclusions about the extent to which different factors influence mean time preference rates across populations. To ameliorate the difficulties of comparing across different studies, this paper explores the use of statistical techniques to determine the relative importance of different factors in influencing time preference.

The particular statistical technique used here to estimate the impact of different factors on time preference rates is meta-regression, a variant of meta-analysis. The latter combines results from different studies to produce a single, more precise, estimate of outcome;[32] [33] this technique has been used in education[34] and health services research.[35] Meta-regression also combines studies, but addresses questions about how the findings from different studies have been

influenced by their different characteristics, including study context and participants.[36] Like meta-analysis, meta-regression effectively uses multi-level models to allow appropriately for within and between study variance. It is thus a potentially powerful method for answering questions about the extent to which context and study design influence observed time preference rates. As far as the authors are aware, it has not previously been used to study time preference and discounting, or indeed in other areas of preference elicitation. This study therefore explores the use of meta-regression techniques available in Stata[37] to combine empirical evidence about time preference, with the aim of drawing reliable conclusions about the factors that influence these time preference rates.

METHODS

Literature Search And Data Sources

Studies containing empirical reports of time preference rates/discount rates in health care were identified using multiple sources. IBSS and EMBASE databases were searched for the years 1980 to 2003. Search terms included 'time preference' and 'discounting', combined with terms to identify health and health care. World Wide Web search engines (Alta Vista, Excite and Google) were also used in an attempt to obtain grey literature sources of empirical rates. The contents of issues available online were searched for the following journals: Health Economics; Social Science and Medicine; Journal of Health Economics; the International Journal of Health Planning and Management; and Journal of Public Economics. Citation tracking was also used to identify studies.

Study selection

Studies were included if they reported empirical time preference or discount rates related to health care, and provided sufficient information to perform the meta-regressions. A minimum requirement for inclusion was the availability of a mean time preference rate, its standard error (either presented, calculable from other data presented or subsequently obtained from the authors) and one or more relevant covariates: delay period; framing (whether the outcome decision related to a gain or a loss); context (life-saving or health improving); data collection

method (interview or postal); sample type (professional or public); response sets restricted; and perspective (private or societal).

Studies reporting only a median time preference rate were excluded. Where studies did not report standard error (SE) values but provided other measures of precision, standard errors were calculated from the available information such as the confidence interval or standard deviation. Where no measures of precision were available in, or calculable from, the published study, efforts were made to contact authors (using email addresses published in the paper) to obtain the additional data required to calculate standard errors. Where such data were not provided or where authors were uncontactable/did not reply, studies were excluded.

Data extraction

All relevant data were extracted using a standardized form onto an Excel spreadsheet. The meta-regression procedure in Stata only accounts for two levels of variation, and the following two sources of variation were the focus of the present investigation: variation attributable to the study sample and variation across individuals within the given study sample. However, the nature of the published literature meant that there were potentially two further sources of variation – namely, the journal article involved, and in some cases a given study sample was subjected to repeated time preference elicitation exercises (especially by altering the delay period or perspective involved).

The first of these was interpreted as reflecting fundamental aspects of the research approach used by the authors, and for the meta-regression models employed here was therefore considered secondary to the specific characteristics of the research design included in the regression models. Regarding repeated exercises, two different solutions were adopted. For delay period, to avoid issues of correlations between repeated exercises on the same study sample, one delay period was selected at random for each study sample within a given analysis. Preferably a parallel sampling procedure would have been employed for perspective, but the limited number of data points available led to an initial decision to conduct separate analyses for private and societal perspectives.

Data analysis

Scatter diagrams and univariable meta-regressions investigated the nature of the relationship between mean time preference rates and delay period, in particular to determine whether or not the latter should be transformed. The ‘metareg’ command in Stata was then employed to

conduct univariable meta-regressions between the mean time preference rates and each of the study characteristics (delay period, framing, context, data collection method, sample type, and restriction of response set). In deciding whether or not to take characteristics on to the next stage of modeling a liberal significance level of 10% was used. Multivariable meta-regression models were then employed to ascertain the factors independently associated with mean time preference rate.

RESULTS

Identification of papers

The literature search yielded a total of 73 papers that reported on time preference/discounting relating to health care and health care programmes. From these, only 16 papers reported empirical estimates of health care related time preference/discount rates (table 1). Other papers dealt with issues such as whether or not future health benefits should be discounted, whether or not to use the same discount rate(s) to discount cost and health benefits, the methodological development of estimating health preference rates (whether to use the discounted utility model or hyperbolic models), evidence of the existence of negative time preference and determinants of time preference rates.

Not all papers reporting empirical time preference rates presented ***mean*** rates and their standard errors (or information from which standard errors could be calculated). Even after contacting authors for additional information, information was obtained about mean time preference rates and standard errors for only eight papers. Figure 1 shows the route by which data were obtained. Of the eight papers, only one involved unrestricted response sets and so this factor was not considered further in the analyses reported here.

In total, these studies provided 50 data points, with studies using as many as six different delay periods, different groups of respondents and, in some cases obtaining both private and societal time preference rates from the same sample group (see appendix A). Of these 50 data points, 12 were for private rates and 38 for societal. Following random selection of a unique data point for each sample (within each perspective), there was a total of 18 data points, four of which were for private time preference rates and 14 of which were for societal. At this point it was decided that there was little point in pursuing the meta-regression for private rates given the paucity of data. The meta-regression therefore considered only societal time preference rates.

Determining the underlying relationship between delay period and mean time preference rate

Scatter plots showed that the association between mean time preference rates and delay period (for all data points and those randomly selected for inclusion) was closer to a linear relationship when delay period was considered on a log scale (see figure 2). This was confirmed by there being no evidence of curvature in the relationship between mean time preference rates and delay period using meta-regression (p=0.92 for the quadratic term for delay period on a log scale).

Univariable meta-regression models

Table 2 shows the results of the univariable meta-regression analyses. From this table, there was no evidence of an association for three of the variables: sample type, context and method of data collection. There were, however, two relationships with p-values lower than the 10% threshold. These were between mean time preference rates and logged delay period (p=0.012) and framing (in terms of whether the outcome decision question related to a gain or loss) (p=0.094).

Multivariable meta-regression models

Preliminary models

As a first step, the two variables that reached the threshold for inclusion in multivariable modelling were adjusted for each other. From this model, the weak association for expressing the outcomes decision question as a gain or loss became much stronger (p<0.001). This shows that log of delay period acts as an augmenting confounder to the framing in terms of gain or loss. Similarly, delay period was augmented by adjusting for the framing variable. There was no evidence of an interaction between them (p=0.86). Context, data collection method and sample type were then each reconsidered after adjusting for these two variables, and no further augmentation effects were observed.

Final model

Table 3 therefore contains the results of the final multivariable meta-regression model, which included log delay period and framing. For delay period, a ten-fold increase in the number of years by which outcomes are delayed resulted in a 14 percentage point decrease in societal time preference rate (p<001). Framing of the exercise in terms of gain was associated with on

average a 12 percentage point increase in societal time preference rate compared with framing the exercise in terms of loss.

DISCUSSION

The above results provide further strong evidence to support the finding that time preference rates decrease as (log) time delay increases, following a negatively sloped, convex pattern.[38]; [39]; [40]; [15] This implies that the practice of using constant discount rates in economic evaluation does not reflect societal preferences about the allocation of resources over time.[13] Future studies should therefore consider using hyperbolic functions [41] instead of the discounted utility (constant rate) method when estimating empirical time preference rates.

Previous evidence has shown that time preference rates for outcomes expressed as gain are different from those expressed as loss.[20] [30] The present study has confirmed this, but also suggests that this association is independent of delay period; moreover it indicates both the direction and the magnitude of the effect of framing as a gain or loss through the use of suitable regression models. Specifically, the results suggest that respondents tend to have higher time preference rates for outcomes expressed as gains than those expressed as losses suggesting the possibility of a low willingness to undertake actions that would improve future health.[30] However, two caveats should be borne in mind. First, only two studies covered by the present analyses had their outcome decision questions being related to loss.[42] [43] Both studies were from the same country, used general public as their sample, postal questionnaire to collect data and used health improvement as their main context. Hence the association observed here could be due to the research teams, their methods, or the country within which the studies were conducted. Insufficient data were available to investigate this further. The second limitation relates to the first, in that the limited data available meant that not all combinations of the two variables in the final model were covered by the data – for instance, there were no sampled data points that employed long delay periods (at least 50 years) within a framing in terms of loss.

Other limitations relate to the problems with the original data sets and a lack of consistency of reporting empirical findings across time preference studies. For these reasons, it was not possible to obtain the required information from half of the studies that were otherwise eligible for inclusion in the study. It is therefore recommended that journals should encourage more standardised reporting of the results of empirical time preference studies, following the format

used by Olsen,[39] and presenting the two appropriate measures of central tendency (mean and median) and their standard errors. Such improvements in presentation would facilitate both qualitative and quantitative comparisons across studies.

Despite only having a small number of data points available for inclusion in the analyses, meta-regression is a promising way forward in the area of time preference studies. As well as being the only approach that enables investigation of the impact of factors that can only vary across studies, the advantages of meta-regression relate to the benefits of a regression approach in general – specifically, being able to investigate confounding and interaction, and to obtain estimates and confidence intervals. Moreover, meta-regression in particular enables the analyst to achieve greater precision by combining evidence across what are often small individual study sample sizes.

However, future studies could explore the use of more sophisticated statistical packages. For instance, more specialised multi-level modelling software could in principle be employed to avoid having to sample data points within a study sample, as was necessary in the present study. Without a much larger number of studies available for analysis, though, it is for example unlikely that the effects of changing the delay period within a study would be identifiable with any precision, especially given the strong correlation between responses across different delays for the same group of people asked in the same way in the same study.

Despite these limitations, the study has shown that meta-regression analysis is a promising technique that could be used to provide useful information about time preferences. In addition, it may be helpful in other areas of preference elicitation such as health state valuation, and willingness to pay for relatively similar health care interventions/programmes.

In this study, data collection method did not appear to influence time preference rates, but it was notable that neither of the methods observed in the empirical studies offered participants an opportunity to reflect and deliberate on the questions being asked before responding (as recommended in other areas of preference elicitations[44]). It is likely that, in an area as unfamiliar to most people as making decisions about the temporal allocation of health care resources (often for decisions involving life and death), such an opportunity is important. Such studies are needed to investigate the reasons for any variation in individuals' time preference rates in relation to influences such as those considered in this paper.

Issues for discussion include:

- What are the advantages and disadvantages of the approach as a whole?

- How reasonable was the use of random sampling to obtain one data point for each study sample? Are there any other approaches that could be used?
- How much potential for multi-level modelling in the context of a meta-regression, especially with the limited number of studies available?
- Any other variables that could have been included?
- How plausible are the findings?

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Table 1. Empirical time preference studies meeting selection criteria

Study	**Delay Period**	**Framing**	**Context**	**Data collection method**	**Sample type**	**Perspective**	**Included or excluded**
van der Pol et al (2001)	5 – 13 years	Loss	Health improvements	Postal questionnaire	Public	Private & societal	Included
Cairns et al (1997)	2 – 19 years	Not stated	Life saving	Postal questionnaire	Public	Societal	Excluded
Johannesson et al (1996)	20 – 100 years	Gain	Life saving	Telephone interview	Public	Societal	Excluded
Olsen (1993)	5 –20 years	Gain	Health improvement & life saving	Postal questionnaire	Public & health planners	Societal	Included
Cairns et al (2000)	5 – 13 years	Loss	Health improvement	Postal questionnaire	Public	Private & societal	Included
Lazaro et al (2001)	2 –15 years	Gain	Health improvement	Questionnaire	Students	Societal	Included
Hojgard et al (2002)	10 years	Gain	Life saving	Personal interview	Gps, internists, vascular surgeons, 60-year old men, aaa-patients	Societal	Included
Cairns (1994)	4 – 19 years		Life saving	Postal questionnaire	Public	Private	Excluded
Dolan et al (1995)	10 years		Health improvement	Personal interview	Public	Private	Excluded
Poulos et al (2000)	2 – 10 years	Gain	Life saving	Personal interview	Household heads/ spouse	Societal	Excluded
Cropper et al (1991)	25 – 100 years	Gain	Life saving	Interview	Public	Societal	Included
Cropper et al (1992)	5 – 100 years	Gain	Life saving	Interview	Public	Societal	Included
Cropper et al (1994)	5 – 100 years	Gain	Life saving	Interview	Public	Societal	Included
Horowitz et al (1990)	5 years		Life saving		Students	Societal	Excluded
Olsen (1991)	5 – 20 years				Public	Societal	Excluded
Chapman (2001a)	1 –100 years	Gain	Life saving, health improvement and financial benefits	Questionnaire	Students	Societal	Excluded

Table 2 Results of univariable meta-regression analyses of empirical time preference rates

Variable	***Category***	***Difference in mean time preference rate***	***Standard Error***	***95% Confidence interval***	***p-value***
Delay period	-	-11.7[a]	4.0	-20.3 to -3.0	0.012
Framing	Loss (reference)	-			0.094
	Gain	8.6	4.7	-1.7 to 18.9	
Context	Health Improvement (reference)	-			0.53
	Life saving	2.7	4.2	-6.5 to 12	
Data collection method	Questionnaire[b] (reference)	-			0.69
	Interview[c]	1.6	3.9	-6.8 to 10.0	
Sample type	Public (reference)	-			0.54
	Professionals	2.5	3.9	-6.1 to 11	

a delay period on log scale; here coefficient is the difference in mean time preference rate for a ten-fold increase in the delay period
b refers to postal questionnaires
c includes face-to-face and telephone interviews

Table 3 Results of multivariable meta-regression of empirical time preference rates

Mean rate	***Coefficient***	***Standard error***	***P-value***	***95% confidence interval***
Delay period[a]	-14.1	2.3	< 0.001	-19.2 to -8.9
Framing[b]	11.5	2.4	< 0.001	6.3 to 16.7
Constant	18.8	3.0	< 0.001	12.2 to 25.3

a delay period on log scale
b decision related to gain or loss, with loss being the reference choice

Figure 1. Selection of papers for meta-regression

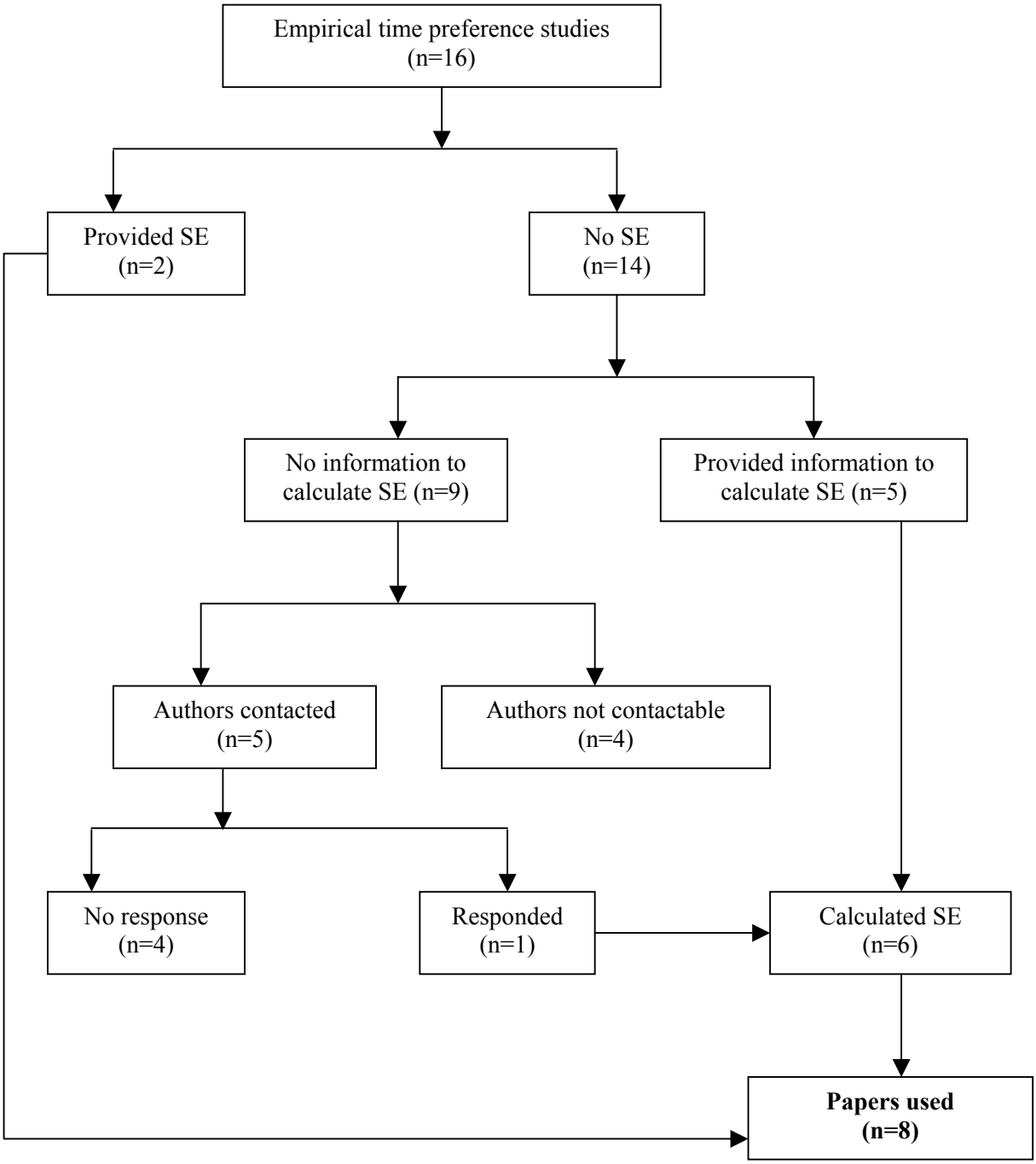
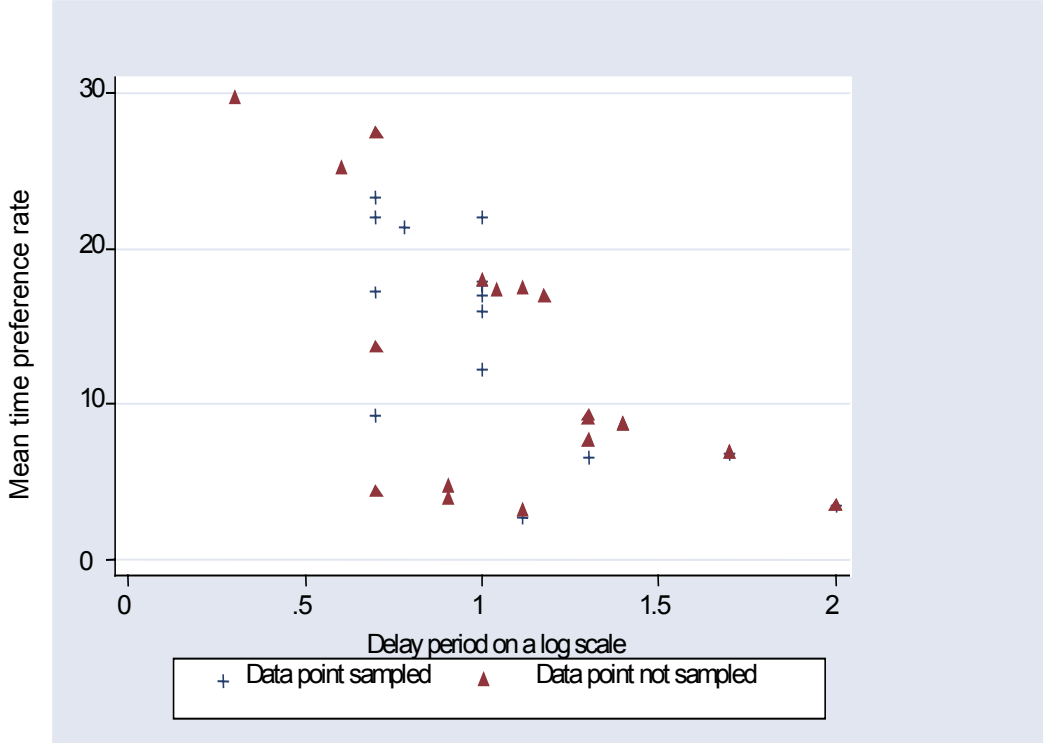


Figure 2: Scatter plot showing mean societal time preference rate and delay period across all studies.



Appendix A. Data points for societal time preference rates from included studies

Author(s)	Sample group	n	Sample type	Main context	Data collection method	Outcome decision	Delay period	Mean time preference rate	Standard error
Hojgard et al (2002) [+]	GPs	21	Professional	Life saving	Interview	gain	10	17	1.75
Hojgard et al (2002) [+]	Internists	20	Professional	Life saving	Interview	gain	10	22	1.53
Hojgard et al (2002) [+]	Vascular Surgeons	25	Professional	Life saving	Interview	gain	10	12.2	0.82
Hojgard et al (2002) [+]	60-year old men	22	Public	Life saving	Interview	gain	10	17.7	1.95
Hojgard et al (2002) [+]	AAA-patients	21	Public	Life saving	Interview	gain	10	16	2.1
Olsen (1993) [+]	Public	209	Public	Life saving	Questionnaire	gain	5	22.1	1.3
Olsen (1993) [▲]	Public	206	Public	Life saving	Questionnaire	gain	20	8.9	0.4
Olsen (1993) [+]	Public	206	Public	Health improvement	Questionnaire	gain	5	23.3	1.2
Olsen (1993) [▲]	Public	206	Public	Health improvement	Questionnaire	gain	20	9.2	0.4
Olsen (1993) [▲]	Health Planners	69	Professional	Life saving	Questionnaire	gain	5	13.6	1.9
Olsen (1993) [+]	Health Planners	66	Professional	Life saving	Questionnaire	gain	20	6.6	0.7
Olsen (1993) [+]	Health Planners	68	Professional	Health improvement	Questionnaire	gain	5	17.2	2.1
Olsen (1993) [▲]	Health Planners	65	Professional	Health improvement	Questionnaire	gain	20	7.6	0.7
Cairns & Pol (2000) [▲]	Public	158	Public	Health improvement	Questionnaire	loss	5	4.3	0.74
Cairns & Pol (2000) [▲]	Public	158	Public	Health improvement	Questionnaire	loss	8	4.6	0.41
Cairns & Pol (2000) [+]	Public	158	Public	Health improvement	Questionnaire	loss	13	2.7	0.38
Cropper et al (1991) [▲]	Public Maryland	462	Public	Life saving	Interview	gain	25	8.6	0.08
Cropper et al (1991) [▲]	Public Washington	528	Public	Life saving	Interview	gain	50	6.8	0.09
Cropper et al (1991) [+]	Public Maryland	442	Public	Life saving	Interview	gain	100	3.4	0.03
Cropper et al (1992) [▲]	Public National	475	Public	Life saving	Interview	gain	5	27.4	0.31
Cropper et al (1992) [+]	Public National	480	Public	Life saving	Interview	gain	10	17.9	0.18
Cropper et al (1992) [▲]	Public Maryland	462	Public	Life saving	Interview	gain	25	8.9	0.08
Cropper et al (1992) [▲]	Public Washington	528	Public	Life saving	Interview	gain	50	6.8	0.09
Cropper et al (1992) [▲]	Public Maryland	442	Public	Life saving	Interview	gain	100	3.4	0.03
Lazaro et al (2001) [▲]	Students	69	Public	Health improvement	Questionnaire	gain	2	29.7	12.95
Lazaro et al (2001) [▲]	Students	64	Public	Health improvement	Questionnaire	gain	4	25.1	8.5
Lazaro et al (2001) [+]	Students	68	Public	Health improvement	Questionnaire	gain	6	21.4	6.5
Lazaro et al (2001) [▲]	Students	69	Public	Health improvement	Questionnaire	gain	11	17.3	4.25
Lazaro et al (2001) [▲]	Students	64	Public	Health improvement	Questionnaire	gain	13	17.4	3.45
Lazaro et al (2001) [▲]	Students	68	Public	Health improvement	Questionnaire	gain	15	16.9	3.75
Cropper et al (1994) [▲]	Public National	475	Public	Life saving	Interview	gain	5	27.4	0.31
Cropper et al (1994) [▲]	Public National	480	Public	Life saving	Interview	gain	10	17.9	0.18
Cropper et al (1994) [▲]	Public Maryland	462	Public	Life saving	Interview	gain	25	8.6	0.08
Cropper et al (1994) [+]	Public Washington	528	Public	Life saving	Interview	gain	50	6.8	0.09
Cropper et al (1994) [▲]	Public Maryland	442	Public	Life saving	Interview	gain	100	3.4	0.03
Van der Pol et al (2001) [+]	Public	185	Public	Health improvement	Questionnaire	loss	5	9.31	0.028
Van der Pol et al (2001) [▲]	Public	185	Public	Health improvement	Questionnaire	loss	8	3.84	0.023
Van der Pol et al (2001) [▲]	Public	185	Public	Health improvement	Questionnaire	loss	13	3.08	0.01

+ Data point sampled
▲ Data point not sampled