Adjusting time trade-off scores for individuals' time preferences

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Abstract

Quality weights derived from time-trade-off (TTO) responses are likely to be a representation of individuals' preferences for health as well as time. The aim of this paper to examine the influence of adjusting TTO scores for individuals' time preferences. These preferences are elicited alongside a TTO exercise using a convenience sample of 111 university students. The results show that the mean adjustment factor is around 0.03 and depends on the duration of the health state, the size and sign of the time preference rate and the time preference model used. The second aim of the paper is to test whether the adjusted scores are more consistent with individuals' preferences. This is done through testing the constant proportional trade-off assumption. Unadjusted and adjusted TTO scores are compared for two different durations (20 and 50 years). The results show that this assumption holds with respect to both unadjusted and adjusted scores. It can be concluded that the adjustment factor appears to be non-trivial but it is unclear whether the adjusted scores are more valid. Further refinement of the elicitation of time preferences alongside a TTO exercise and further exploration of the validity of adjusted TTO scores are both important areas of future research.

I. INTRODUCTION

The time trade-off (TTO) is a widely used technique to elicit quality weights of health states. Although it is generally accepted as being a valid health state valuation technique several sources of potential bias in TTO responses have been identified in the literature (Nord, 1992). One particular bias that has been discussed quite extensively is the influence of individuals' time preferences (Dolan and Jones-Lee, 1997, Loomes and MacKenzie, 1989). TTO scores (quality weights) are generally estimated assuming that the marginal utility of life-years is constant and not a function of when they occur in time. However, evidence suggests that individuals exhibit time preferences for health (Cairns and van der Pol, 2000) and that most individuals value future life-years at a lower rate than current life-years. Quality weights derived from TTO responses are therefore likely to be a representation of health state preferences **and** time preferences. Since health effects are discounted in economic evaluations the problem of double discounting may occur.

Sox *et al.* (1989) proposed an adjustment procedure for TTO scores. By eliciting certainty equivalents for gambles between a short life expectancy and longer life expectancy using different probabilities a utility function for life-years can be identified. This method has been applied in a few studies, mainly in an attempt to explain differences between TTO scores and standard gamble scores (Stiggelbout *et al.*, 1994 and Martin *et al.*, 2000). This procedure adjusts TTO scores for a time preference effect **and** a gambling effect. The latter effect reflects an individuals' attitude towards gambling where a risk averse individual would require a risk premium to compensate the act of gambling (Gafni and Torrance, 1984). The limitation of the procedure is that the gambling and time effect cannot be disentangled. This is especially problematic since these effects can operate in opposite directions (Gafni and Torrance, 1984). It is therefore important to examine the influence of a gambling and a time preference effect separately. Moreover it is unclear whether quality weights which incorporate a gambling effect are better proxies for utility (Dolan *et al.*, 1996) and it may therefore not be desirable to adjust TTO scores for this effect.

This paper examines the influence of adjusting TTO scores for individuals' time preferences. It is relatively straightforward to adjust the TTO scores for the time preference effect only. In this case quality weights are estimated by dividing the **discounted** life-years in full health by the **discounted** life-years in the health state. Although the adjustment procedure is straightforward the choice of rate at which the life-years are discounted is not. This rate

should reflect individuals' time preference rates under conditions of certainty (to avoid a gambling effect). There is a growing literature on the elicitation of time preferences for health and a variety of approaches have been used. Evidence suggests that time preference rates for health vary widely across individuals (Cairns and van der Pol, 2000). It is therefore essential that time preference rates are elicited alongside the TTO exercise in order to obtain an individual specific rate.

Evidence suggests that time preferences vary across health outcomes (Ganiats *et al.*, 2000, Redelmeier and Heller, 1993, Chapman *et al.*, 1999) which has implications for the framing of the intertemporal choices. Eliciting time preferences for life-years under certainty would involve presenting individuals with two different life expectancies and ask them to trade-off life-years between these two scenarios. These choices are very complex and this has never been attempted before. Moreover, these choices have to be framed in the context of full health and of the health state to be valued in the TTO exercise. It is unclear whether individuals would be able to answer these complex questions in a meaningful way that would represent their preferences. In this paper time preferences rates are therefore elicited for a health profile in which individuals are asked to trade-off life-years in the health state at different points in their life. The difference is that they are asked to consider non-fatal changes rather than fatal changes. Although, this is not an ideal measure of time preference in the TTO context it is likely to reflect individuals' time preference for life-years in the health state.

Although the elicitation of time preference rates alongside a TTO exercise has been suggested before (Stiggelbout *et al*., 1994) it has not been applied. This paper reports the results of a pilot study using a sample of university students. As noted above the aim of the paper is to examine the influence of adjusting TTO scores for time preference. It has been suggested that a failure to allow for discounting results in a downward bias (Nord, 1992). However, a substantial proportion of individuals have negative or zero time preferences for health (van der Pol and Cairns, 2000). The direction of the bias is therefore unclear and needs to be tested empirically. This paper also examines the influence of the time preference model used to discount the future life-years. Future outcomes are generally discounted assuming the discounted utility (DU) model. There is a substantial body of evidence that the DU model does not accurately describe individuals' time preferences (Cairns and van der Pol, 2000). Hyperbolic models tend to describe individuals' preferences better and these are now

standard models in the psychology literature (Loewenstein and Elster, 1992). The main difference between these models is that hyperbolic models allow for non-stationary preferences. In this paper the TTO scores are therefore also adjusted assuming a hyperbolic model.

The second aim of this paper is to test whether the adjusted TTO scores are more consistent with individuals' preferences. This is done through testing whether the constant proportional trade-off assumption holds with respect to unadjusted and/or adjusted TTO scores as suggested by Johannesson *et al.* (1994). They conclude that if the constant proportional trade-off assumption holds with respect to discounted TTO scores only then discounted scores should be used in order for QALYs to be consistent with individuals' preferences.

The constant proportional trade-off assumption is tested by comparing TTO scores for two different durations. There is mixed evidence with respect to whether the assumption holds for unadjusted TTO scores. Several studies have found that individuals are willing to sacrifice relatively more life years when the number of life years in the health state is greater (Sackett and Torrance, 1984, McNeill *et al.*, 1981, Kirsch and McGuire, 2000). However, other studies have shown that the condition does hold (Bleichrodt and Johannesson, 1997). In these studies any differences in TTO scores for different durations are hypothesized to be a result of individuals exhibiting positive time preference. Some authors have even estimated implied rates from the differences between TTO for different durations (Olsen, 1994). However, this is problematic since other factors may influence the difference in TTO scores and the DU model needs to be assumed in order to estimate an implied time preference rate. In our view it is therefore a better approach to elicit the individuals' time preference rate separately and test whether this explains any difference between TTO scores for different durations.

II. ADJUSTMENT PROCEDURE

It is assumed that the health profile is of constant quality and that the health state is more attractive than death. If an individual is indifferent between X years in health state Q and Y years in full health the quality weight ($W(Q)$) is equal to:

$$W(Q) = \frac{X}{Y} \qquad (1)$$

To adjust the quality weight for time preferences the X and Y years are first discounted to present values using the individuals' time preference rate (ρ). Discounting future life-years assuming the DU model results in the following adjusted quality weight:

$$W(Q) = \frac{\sum_{x=1}^{X}(1+\rho)^{-x}}{\sum_{y=1}^{Y}(1+\rho)^{-y}} \qquad (2)$$

Equation 2 is equal to equation 1 if ρ=0. Discounting future life-years assuming the hyperbolic model proposed by Harvey (1986) results in the following adjusted quality weight:

$$W(Q) = \frac{\sum_{x=1}^{X}(1+x)^{-h}}{\sum_{y=1}^{Y}(1+y)^{-h}} \qquad (3)$$

where h is the individuals' time preference parameter in the hyperbolic model.

Table 1 illustrates the effect of adjusting TTO scores for time preferences. The TTO scores are shown for three different quality weights and for two different durations in health state Q. The adjusted scores are estimated assuming three different time preference rates including a negative rate. Since the time preference parameters in the two models cannot be interpreted in the same way different rates are chosen for the hyperbolic model. The rates reflect the same discount factors for a 20-year delay in both models. In other words, assuming a rate of 0.05 in the DU model results in the same discount factor for the 20-year delay as assuming a parameter (h) of 0.32 in the hyperbolic model.

The adjustment factors are reported in parantheses. The table shows that the impact of adjusting the scores depends on the size of the unadjusted TTO score, the duration in health state Q, and the size and the sign of the time preference rate. Note that the impact of the size of the unadjusted TTO on the adjustment factors is non-linear. The adjustment factors tend to be larger if a hyperbolic model is used to discount future life-years.

Table 1. Adjustment factors

Unadjusted	DU adjusted			Hyperbolic adjusted		
	0.05	0.10	-0.02	0.32	0.63	-0.13
10-year duration						
0.30	0.35 (0.05)	0.40 (0.10)	0.28 (-0.02)	0.40 (0.10)	0.50 (0.20)	0.27 (-0.03)
0.50	0.56 (0.06)	0.62 (0.12)	0.47 (-0.03)	0.59 (0.09)	0.68 (0.18)	0.46 (-0.04)
0.70	0.75 (0.05)	0.79 (0.09)	0.68 (-0.02)	0.77 (0.07)	0.82 (0.12)	0.82 (-0.03)
30-year duration						
0.30	0.46 (0.16)	0.61 (0.31)	0.24 (-0.06)	0.42 (0.12)	0.55 (0.25)	0.26 (-0.04)
0.50	0.68 (0.18)	0.81 (0.31)	0.42 (-0.08)	0.61 (0.11)	0.71 (0.21)	0.46 (-0.04)
0.70	0.83 (0.13)	0.92 (0.22)	0.63 (-0.07)	0.77 (0.07)	0.84 (0.14)	0.67 (-0.03)

III. STUDY DESIGN

Previous study

The current study is a follow-up from a study which elicited TTO scores for weight loss in obese individuals (Roux, 2002). In the sample used in this study most individuals are not obese and the questions are therefore framed in terms of weight gain rather than weight loss.

Preamble

In the preamble of the questionnaire respondents are informed that the study is trying to find out students' feelings towards weight and its impact on quality of life, so as to better understand individual perceptions when designing weight loss programs. They are first offered two practice questions in which they are asked to trade-off life-years with current vision against life-years with blindness. Respondents are then asked to fill in their current weight and to calculate what they would weigh if it increases by 20%. They are then given a description of how they would be influenced by this weight increase: your clothes fit more snug; you may have to go up a dress size or go up a belt notch; you feel less energetic and find that it takes more effort to get things done; you feel less in control of your body and less satisfied with your appearance; you feel more conscientious of how other people perceive you; and you generally feel worse.

TTO questions

An example of the TTO question is:

Option A: live 20 more years weighing 20% more or ……lbs, then die

Option B: live 15 more years weighing just what I do today, then die

Respondents are asked to fill in their increased weight on the dotted line since it may be hard to consider what a 20% increase would imply. Respondents are asked which option they prefer or whether they are indifferent between the two options. Due to resource and time constraints it was not possible to use computer-based questionnaires or face-to-face interviews. The use of paper questionnaires does restrict the elicitation process. The following procedure is chosen in this study. Respondents are presented with eleven TTO questions in total with quality weights ranging from 0.0 to 1.0. The first TTO question represents a quality weight of 1.0. The subsequent TTO questions reduce the quality weight by 0.1 until it equals 0.0. The limitation of this procedure is that it may introduce an upward bias since a starting point of 1.0 is used. However, this may not be problematic since the interest of the study is not in the TTO scores per se but rather in the impact of time preferences on TTO scores.

The impact of duration on the quality weights is tested using a split sample design. As a result comparisons of the TTO scores are between samples rather than within samples. Half the sample receives a questionnaire eliciting TTO scores for a 20-year duration and the other half is presented with a 50-year duration.

Time preference question

As noted in the introduction time preference rates are elicited for a health profile. The respondent is presented with two scenarios. In the first scenario it is specified when and for how long the weight increase occurs. In the second scenario it is only specified when the weight increase occurs. The respondent is then asked to specify the number of years of weight increase in the second scenario would make the two scenarios equally bad. The question is as follows:

Option A: a 20% weight increase for 5 years starting 15 years from now

Option B: a 20% weight increase for ___ years starting 45 years from now

Assuming the DU model the implied time preference rate is equal to:

$$\rho = \left(\frac{5}{x}\right)^{\frac{1}{30}} - 1 \qquad (4)$$

Assuming the hyperbolic model the implied time preference parameter is equal to:

$$h = \frac{\log 10(x/5)}{\log 10(1/31)} \qquad (5)$$

Other questions

Information is also obtained on the respondents' socio(economic) characteristics as well as lifestyle behaviors which may have an impact on the quality weight attached to the weight increase.

Method of analysis

Regression analysis is used to test the impact of duration on the TTO scores and to determine the relationship between individuals' characteristics and TTO scores. Tobit regression analysis is used which allows for the fact that the scores are censored (between zero and one). The following individuals' characteristics are included: their gender (dummy variable: Male); their diet (dummy variable: Very healthy); their perceived weight (dummy variable: Overweight); whether their health status is good/fair (dummy variable: Health); whether they exercise less than 3 times a week (dummy variable: Exercise); and whether they drink alcohol more than 3 times a month (dummy variable: Alcohol). To test the impact of duration a dummy variable for 50-year duration is included.

IV. DATA

A convenience sample of university students is used. Undergraduate Kinesiology students at the University of Calgary were approached in a lecture to participate in the study. In an attempt to increase the response rate a prize draw was held among participants. In total 111 students filled out the questionnaire. One of the authors was available to explain the questionnaire and to respond to any questions. The two versions of the questionnaire were randomly assigned to the participants. Appendix 1 shows the descriptive statistics of the two samples. For an accurate comparison of the TTO scores for the two durations it is essential that the two samples are similar. The null hypothesis that distribution of respondents across categories for each of the individual's characteristics is independent of whether the questions concerned a 20-year or a 50-year duration is accepted for all characteristics.

V RESULTS

The majority of respondents (63%) expressed positive time preference for health. Twenty-six percent expressed zero time preference and the remaining 11% expressed negative time preference. These numbers are not evenly distributed across the two samples. A higher percentage of respondents in the 50-year duration sample expressed zero and negative time preference. Table 1 reports the implied time preference rates for the full sample and for the two samples separately. The mean time preference rates are substantially lower for the 50-year duration sample. The range of implied time preference rates is similar for the two samples. There is no apparent reason why the mean time preference rates for the 50-year sample are smaller.

Table 1. Implied time preference rates

	Mean	N	Minimum	Maximum
Discounted utility model				
20-years	0.024	53	-0.052	0.062
50 years	0.009	52	-0.052	0.076
Total	0.016	105*	-0.052	0.076
Hyperbolic model				
20-years	0.200	53	-0.469	0.522
50 years	0.075	52	-0.469	0.640
Total	0.138	105*	-0.469	0.640

* 6 missing values

Table 2 reports the unadjusted and the adjusted TTO scores. As suggested in the literature adjusting the scores for time preferences results in higher scores. The mean adjustment factor is 0.039 for the 20-year duration and 0.028 for the 50-year duration assuming the DU model and 0.041 for the 20-year duration and 0.017 for the 50-year duration assuming the hyperbolic model. The adjustment factor for the 50-year duration is lower mainly because a larger proportion of respondents expressed negative time preference. The table also shows that the TTO scores for the 50-year duration are lower than for the 20-year duration which indicates that individuals are willing to trade relatively more life-years at longer durations. This difference increases when the scores are adjusted for time preference. This is again the

result of a larger proportion of respondents expressing negative time preference in the 50-year duration sample.

Table 2. Mean TTO scores

	Unadjusted	DU adjusted	Hyperbolic adjusted
20-years	0.677	0.717	0.719
50 years	0.658	0.686	0.674
Total	0.668	0.702	0.697

Table 3 shows the preliminary Tobit regression results. The dummy variable is not statistically significant in any of the regression equations indicating that the constant proportional trade off assumption holds with respect to unadjusted as well as adjusted TTO scores.

Table 3. Regression results

	Unadjusted		DU adjusted		Hyperbolic adjusted	
	b	p-value	b	p-value	b	p-value
Intercept	0.682	0.000	0.718	0.000	0.709	0.000
50-year duration	-0.014	0.739	-0.021	-0.114	-0.035	0.425
Male	0.080	0.081	0.070	0.179	0.074	0.124
Weight	-0.052	0.338	-0.112	0.075	-0.081	0.161
Diet	0.003	0.944	-0.008	0.888	0.007	0.899
Health	-0.104	0.051	-0.075	0.218	-0.087	0.119
Exercise	0.067	0.160	0.096	0.083	0.092	0.071
Alcohol	-0.028	0.520	-0.020	0.686	-0.016	0.731
N	105		105		105	

Most individuals' characteristics are not statistically significant. Self-rated health and gender are significant at a 10% level in case of unadjusted scores. The signs indicate that individuals who rate their health as good or fair as opposed to very good or excellent perceive the health state as more severe. Males perceive the weight increase as less severe. Exercise is statistically significant at a 10% level in case of the adjusted scores indicating that individuals who exercise less than 3 times a week perceive the weight increase as less severe. It could be hypothesized that these individuals are less concerned with their weight and therefore attach a

higher value to the health state. Perceived weight is significant at a 10% level in case of adjusted TTO scores assuming the DU model. Individuals who see themselves as overweight perceive the weight increase as more severe.

VI Discussion

This study elicited individuals' time preference rates alongside a TTO exercise. The first aim of the paper was to assess the influence of adjusting the TTO scores for individuals' time preferences. The results showed that the majority of respondents expressed positive time preference and as a result the adjusted TTO scores were higher than the unadjusted scores. The mean adjustment factor was around 0.03. A proportion of respondents expressed negative time preference. This proportion was larger in the 50-year duration sample and the adjustment factor for the 50-year duration was therefore lower than for the 20-year duration. It should be noted that if all respondents had expressed positive time preference the opposite finding would have been found since the longer the duration the larger the adjustment factor. The size of the adjustment factors varied across the time preference model used to discount future life-years. The adjustment factor was smaller for the 20-year duration assuming the DU model whilst it was larger for the 50-year duration. The second aim of the study was to test the constant proportional trade-off assumption with respect to unadjusted and adjusted TTO scores. The results showed that this assumption holds with respect to both scores. No conclusions can be drawn with respect to whether unadjusted or adjusted TTO scores are more consistent with individuals' preferences. The difference between adjusted TTO scores were larger than between unadjusted scores but this was mainly a result of a larger proportion of respondents expressing negative time preference in the 50-year duration sample. The regression results also indicated that self-rated health was a determinant of the unadjusted TTO score but not of the adjusted scores. This may indicate that the unadjusted scores are more valid. However, it should be noted that these results are based on a pilot study using a sample of university students and the findings can therefore not be generalized. It should be considered as a first exploration of the validity of unadjusted versus adjusted scores only

The adjustment factors reported in this study appear to be non-trivial. However, the adjustment factor is a direct function of the individuals' time preference rate and it raises the question whether individuals' time preferences can be captured by hypothetical intertemporal choices. A substantial number of studies have elicited time preferences for health but the

validity of such methods still need to be assessed. Intertemporal choices are complex. Thinking about the future is not easy especially in the context of health. Even if respondents understood the exercise it is uncertain whether time preferences for the health profile are similar to time preferences for life-years. Intertemporal choices concerning fatal changes in health under certainty are very complex and future research should explore the feasibility of such choices.

Related to the previous issue is the presence of negative time preferences. It is unclear whether these preferences are true preferences. However, Loewenstein (1987) hypothesized that individuals may exhibit negative time preference in some instances because of the anticipation of future unpleasant consequences (dread). This is likely to influence time preferences for health. If these preferences are true preferences, they do need to be taken into account when adjusting TTO scores for individuals' time preferences. Although the DU model does not restrict the time preference rate to be positive it is unclear whether the model is appropriate in case of negative time preferences. Not enough is known about these preferences and further research should gain an understanding of these preferences and explore what time preference model best describes these preferences.

Besides a further refinement of the elicitation of time preferences alongside a TTO exercise a number of areas of future research can be identified. An essential area of research is to test whether adjusted TTO scores are better proxies for utility. A first attempt was made in this study by testing the constant proportional trade-off assumption for adjusted TTO scores. Further validity tests using larger samples and members of the general public are obviously required before any conclusions can be drawn regarding the use of adjusted TTO scores in economic evaluations.

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Appendix 1. Descriptive statistics

		20-year duration		50-year duration			
		N	%	N	%	χ^2	p-value
Gender	Female	38	69.1	37	66.1	1.051	0.591
	Male	17	30.9	19	33.9		
Weight	About right/underweight*	43	78.2	42	75.0	3.348	0.187
	Overweight	12	21.8	14	25.0		
Diet	Quite healthy/unhealthy*	40	72.7	43	76.8	0.244	0.885
	Very healthy	15	27.3	13	23.2		
Health	Excellent/ very good	44	80.0	39	69.6	1.582	0.453
	Good/fair	11	20.0	17	30.4		
Exercise	> 3 times per week	36	65.5	40	71.4	1.670	0.434
	≤ 3 times per week	19	34.5	16	28.6		
Alcohol	< 3 times per month	19	34.5	28	50.0	3.246	0.197
	≥ 3 times per month	36	65.5	28	50.0		

* because of small numbers these two categories have been aggregated