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A note on the estimation of the equity-efficiency trade-off for QALYs

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Abstract

In this note the veil of ignorance approach is tested as a basis for empirically determining the shape of the social welfare function for QALYs. An experiment is carried out where the participants choose between different societies that differ with respect to per capita QALYs and the distribution of QALYs. The answers are analyzed using logistic regression analysis. According to the results the respondents are willing to give up 1 QALY in the group with more QALYs to gain 0.45 QALYs in the group with fewer QALYs, but this trade-off is independent of the size of the difference in QALYs between the groups.

JEL classification: I18; D63; D71

Keywords: Social welfare functions; Equity; Efficiency; QALYs

1. Introduction

It has been argued by Wagstaff (1991) that the use of cost-effectiveness analysis is based on health maximization, with health ideally defined in terms of quality-adjusted life-years (QALYs) or some other measure that incorporates both quality and quantity of life. A problem with this approach according to Wagstaff is that it ignores the distribution of health. Wagstaff, however, argued that by using a social welfare function that weights QALYs gained for different individuals

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depending on their endowment of QALYs, it may be possible to incorporate both efficiency and equity in the cost-effectiveness approach (e.g., a QALY increase from 9 QALYs to 10 QALYs is given a greater weight than a QALY increase from 10 QALYs to 11 QALYs). It is, however, unclear how to determine the shape of the social welfare function.

Rawls (1971) argued that in principle social decisions should be made behind a "veil of ignorance" where each individual does not know which position in society he/she will eventually be in. Harsanyi (1953, Harsanyi (1955) had also previously expressed similar ideas. The aim of this note is to test the feasibility of using the veil of ignorance approach as a basis for empirically determining the equity-efficiency trade-off for QALYs, i.e., to determine the shape of the social welfare function. The approach was tested in an experiment among 80 students. In the next section the design of the experiment and the methods used to estimate the equity-efficiency trade-off are outlined. The results of the experiment are then presented and the note ends with some concluding remarks.

2. Methods

2.1. Design of the experiment

To test the feasibility of the veil of ignorance approach as a way to determine the shape of the social welfare function for QALYs an experiment was carried out on 80 students at the Stockholm School of Economics in Sweden. Before the experiment the question was also pretested in two groups of students and revised in accordance with the comments received.

The experiment was carried out in 8 sessions with 10 individuals in each session. In each session the approach of making decisions before the individual knows which position he/she will occupy in society was explained and the individual was then confronted with a hypothetical choice between two different organizations of society (for wording of this question see Appendix A). The individual was told to assume that there are two different groups in society (group 1 and group 2) that differ only with respect to the remaining life-expectancy and that the probability is 50% that the individual will belong to group 1 and 50% that the individual will belong to group 2. The individual was also told that the difference in life-expectancy between the two groups was due to hereditary factors and that the life-years were in full health in both groups. The individual was then asked to make a choice between two societies (society A and society B) that differed with respect to the life-years in groups 1 and 2 and told to make the choice before it was revealed which group the individual would eventually belong to.

Since the number of life-years were in full health, they can be interpreted as the number of QALYs. The respondents were randomly divided into two groups that differed with respect to the difference in the number of QALYs between group 1 and 2 in Society A. For half the respondents the number of QALYs in society A were 20 in group 1 and 10 in group 2. For the other half the number of QALYs were 16 in group 1 and 10 in group 2.

The aim of the question was to elicit the marginal trade-off of QALYs between the group with more QALYs and the group with fewer QALYs. For society B the number of QALYs was therefore decreased by 3 for group 1, and this was compensated by an increase in the number of QALYs in group 2. [1] The increase was randomly varied between 0, 1, 2 and 3 QALYs. It was hypothesized that for a 0 increase most individuals would choose society A, since this society would have more QALYs for group 1 and the same number of QALYs for group 2. For an increase of 3 QALYs it was hypothesized that most individuals would choose society B since this society would have the same total number of QALYs as society A and a more even distribution of QALYs. The four different increases in QALYs for group 2 (0, 1, 2, and 3 QALYs) corresponds to trade-offs of QALYs between group 1 and 2 of 0.00, 0.33, 0.67 and 1.00. These trade-offs were interpreted as marginal trade-offs in the analysis of the data.

The framing of the question means that the individual is making a trade-off between equity (the distribution of QALYs between the two groups in a society) and efficiency (the total number of QALYs in a society). The individuals were assumed to have preferences both about the distribution of QALYs and the total number of QALYs in a society, and the aim of the question was to elicit these individual preferences concerning the equity-efficiency trade-off. It should be noted that to view the trade-off between equity and efficiency as one of individual preferences as done here is not obvious. Some authors for instance view equity as something extrinsic to preferences (e.g., Culyer, 1980).

2.2. Estimation of the equity-efficiency trade-off for QALYs

To analyze the data logistic regression analysis was used. The probability of choosing society A was used as the dependent variable. The marginal trade-off of QALYs between group 1 and group 2 was entered as an explanatory variable (i.e., the difference in QALYs in group 2 between the two societies, divided by the difference in QALYs in group 1 between the two societies). The hypothesis to test was that an increased marginal trade-off would decrease the probability of choosing society A, since an increased marginal trade-off makes society B more attractive. The relative difference in QALYs between group 1 and 2 in society A

[1] The decrease of 3 QALYs in group 1 was chosen to be able to use increases of whole life-years in group 2. When the question was pretested among two groups of students with a smaller decrease in group 1, the students expressed that it was difficult to differ between changes of less than 1 year in group 1.

was also entered as an explanatory variable (i.e., the percentage more QALYs in group 1 compared to group 2 in society A). The hypothesis to test by including this variable was that for a given marginal trade-off between QALYs in group 1 and 2 the probability of choosing society A would decrease for a higher relative difference in QALYs, i.e., that for a higher relative difference in QALYs individuals would be willing to give up more QALYs in group 2 to gain 1 QALY in group 1 than with a lower relative difference.

The logistic regression analysis can also be used to derive the mean marginal trade-off between QALYs in groups 1 and 2 for a specific relative difference in QALYs between the two groups. With the logistic function the log of the odds ratio is equal to the regression equation:

$$\ln[P/(1-P)] = a + b_1\text{marginal trade} - \text{off} + b_2\text{relative difference.} \quad (1)$$

In Eq. (1) P is the probability of choosing society A, marginal trade-off is the marginal trade-off of QALYs between groups 1 and 2, relative difference is the relative difference in QALYs between the two groups and a, b_1 and b_2 are the coefficients to be estimated. In accordance with the hypotheses stated above the regression coefficients, b_1 and b_2, were hypothesized to have negative signs. The median marginal trade-off is equal to the marginal trade-off where the probability of acceptance is 0.5 (i.e., 50% of the individuals would choose society A and 50% would choose society B at that trade-off). As long as the marginal trade-off variable is entered as a linear variable, the median marginal trade-off will also equal the mean marginal trade-off (Johansson et al., 1989). By setting the probability of acceptance to 0.5 in Eq. (1) it is possible to solve the equation for the mean marginal trade-off for different levels of the variable relative difference:

$$\text{Mean marginal trade} - \text{off} = (-a - b_2\text{relative difference})/b_1. \quad (2)$$

In terms of a social welfare function the marginal trade-off shows the slope of the social welfare indifference curves for different relative differences in QALYs between group 1 and 2. [2] The relative difference in QALYs variable on the other hand determines the convexity of the social welfare indifference curves. [3]

Eqs. (1) and (2) were therefore also used to estimate social welfare indifference curves. The estimated social welfare indifference curves were based on the assumption that the marginal trade-off of QALYs between groups 1 and 2 for a

[2] The marginal trade-off shows the slope of the social welfare indifference curves below the 45° line and the inverse of the slope of the social welfare indifference curves above the 45° line.

[3] That the relative difference determines the convexity of the social welfare indifference curves can be seen by noting that b_2/b_1 in Eq. (2) gives the unit of change in the mean marginal trade-off for a one unit change in the relative difference variable. With the hypothesized negative signs of b_1 and b_2 the welfare indifference curves will be convex since the mean marginal trade-off will decrease with a greater relative difference. With a greater absolute size of b_2 the convexity will thus increase.

Table 1
The percentage of individuals choosing society A for the four different marginal trade-offs of QALYs between group 1 and 2 and the two relative differences in QALYs between group 1 and 2

Relative difference	Marginal trade-off			
	0.00	0.33	0.67	1.00
60%	70	80	20	10
100%	100	60	30	0
Full sample	85	70	25	5

specific relative difference in QALYs is the same irrespective of the total social welfare level.

The logistic regressions were estimated by the maximum likelihood method. Two goodness-of-fit measures are reported: individual prediction and the likelihood ratio index (Amemiya, 1981). Individual prediction is the percentage of binary responses correctly predicted by the equation. LRI = 1 − (L(general)/L(restricted)), where L(general) is the maximum likelihood value of the log-likelihood function, and L(restricted) is the maximum likelihood value of this function under the constraint that $b_i = 0$. LRI is between 0 and 1, and a better fit gives a value closer to 1. The likelihood ratio test (LR-test) was used to test the hypothesis that the X_i variables were unrelated to the probability of acceptance.

Table 2
Coefficients of the logistic regression analysis of the probability of choosing society A. No discounting of QALYs.

Regressor variable	LOGIT-general		LOGIT-restricted	
	Coefficients	t-values	Coefficients	t-values
Intercept	1.781	1.40	2.122	3.90 [a]
Marginal trade-off of QALYs	−4.764	−4.77 [a]	−4.758	−4.77 [a]
Relative difference in QALYs	0.004	0.29	Excluded	
n	80		80	
Goodness of fit:				
Correct prediction (%)	0.81		0.81	
Log-likelihood	−36.286		−36.329	
LR-index	0.34		0.34	
Slope restriction:				
LR-test; general → slopes = 0	37.88 [a]		37.80 [a]	
LR-test; general → restricted	–		0.09	

LR-test = Likelihood ratio test. LR-test; general → slopes = 0, tests the null-hypothesis that all slopes in the general model is zero against the general model. LR-test; general → restricted, tests the restricted model as the null hypothesis against the general model.
[a] = significant on the 1% level.

The likelihood ratio test was also used to compare the general model with all the explanatory variables with a restricted model only including statistically significant variables. The test statistic for this asymptotic test is $-2[\mathrm{L(general)} - \mathrm{L(restricted)}] \sim \chi^2$.

Since QALYs are often discounted when they are used in cost-effectiveness analysis the logistic regressions were estimated both for no discounting of QALYs and with a 5% discounting of QALYs. To be able to discount QALYs the life-years were assumed to be life-years with certainty rather than life-expectancy. Otherwise it would have been necessary to make an assumption of the distribution of survival probabilities to discount QALYs. As a sensitivity analysis the logistic regressions were also estimated with outliers excluded. An outlier was defined as an observation with a standardized residual ($u_i = e_i/\mathrm{var}(e_i)^{0.5}$) in excess of 2. Four outliers were identified.

3. Results

The percentage of individuals choosing society A for the four different marginal trade-offs used in the veil of ignorance question is shown in Table 1. The percentage is shown for the two relative differences in QALYs between groups 1 and 2 used in the question. The table shows that as can be expected the percentage

Table 3
Coefficients of the logistic regression analysis of the probability of choosing society A. 5% discounting of QALYs.

Regressor variable	LOGIT-general		LOGIT-restricted	
	Coefficients	*t*-values	Coefficients	*t*-values
Intercept	0.875	0.62	2.177	3.90 [a]
Marginal trade-off of QALYs	−3.848	−4.80 [a]	−3.765	−4.76 [a]
Relative difference in QALYs	0.027	0.98	Excluded	
n	80		80	
Goodness of fit:				
Correct prediction (%)	0.81		0.81	
Log-likelihood	−35.630		−36.122	
LR-index	0.35		0.35	
Slope restriction:				
LR-test; model → slopes = 0	39.19 [a]		38.21 [a]	
LR-test; general → restricted	–		0.49	

LR-test = Likelihood ratio test. LR-test; model → slopes = 0, tests the null-hypothesis that all slopes in the model is zero against the general model. LR-test; general → restricted, tests the restricted model as the null hypothesis against the general model.

[a] Significant on the 1% level.

of individuals choosing society A decreases when the trade-off increases. There is no clear pattern between the relative differences of 60% and 100% in the table.

The result of the logistic regression analysis for the case of no discounting of QALYs is shown in Table 2. The marginal trade-off of QALYs variable is highly significant with the expected negative sign in the regression analysis. The relative difference in QALYs variable is not statistically significant, and has the wrong sign. The likelihood ratio test shows that the general model with both explanatory variables is not statistically different from the restricted model with only the marginal trade-off variable included. The percentage of correctly predicted responses is 81% for the restricted model and the likelihood ratio index is 0.34. The regression results with 5% discounting of QALYs is shown in Table 3. The results are similar to the results with no discounting. The deletion of the four outliers does not significantly alter the results.

According to the regression results the marginal trade-off does not vary with the relative difference in QALYs, which implies social welfare indifference curves with a constant slope above and below the 45° line. The mean marginal trade-off based on the restricted logistic regression equation is 0.45 for no discounting and 0.58 with 5% discounting. [4] In Fig. 1 the implied social welfare indifference curves are shown for the case with no discounting.

4. Concluding remarks

It is important to stress the pilot nature of this study. The aim of the study was to carry out a first test of the veil of ignorance approach as a basis for empirically estimating a social welfare function for QALYs. The study is based on a relatively small sample of students and it is important to interpret the results with great caution.

The results are somewhat mixed. The responses were clearly affected by the size of the trade-off in QALYs between group 1 and 2 in the expected way, and overall the results suggest a rather strong aversion towards inequality in health. According to the results the respondents are willing to give up 1 QALY in the

[4] The interpretation of the mean marginal trade-off of 0.45 is that the respondents are willing to give up 1 QALY in the group with more QALYs to gain 0.45 QALYs in the group with fewer QALYs. It should be noted that this mean marginal trade-off of 0.45 cannot be interpreted as the inequality aversion parameter in the iso-elastic social welfare function used by Wagstaff (1991) to exemplify the social welfare function approach. In the iso-elastic social welfare function the trade-off in QALYs between the two groups will vary depending on the difference in QALYs between the groups unless the mean trade-off is either 0 or 1. In the iso-elastic social welfare function the elasticity of substitution of a social welfare indifference curve is assumed to be constant (Boadway and Bruce, 1984). The result of our study is not consistent with the shape of the iso-elastic social welfare function. More research is needed to determine the appropriate functional form of the social welfare function and how to derive the inequality aversion parameter of the iso-elastic social welfare function with the present approach.

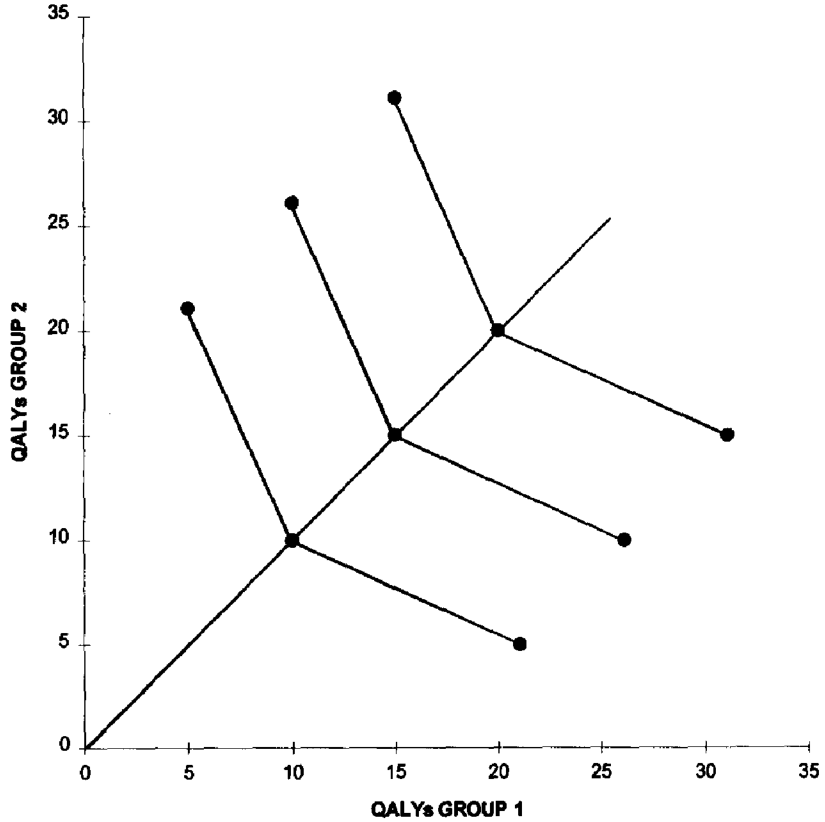

Fig. 1. Estimated social welfare indifference curves for QALYs in group 1 and group 2. No discounting of QALYs.

group with more QALYs to gain 0.45 QALYs in the group with fewer QALYs. With 5% discounting of QALYs the respondents are willing to give up 1 discounted QALY in the group with more QALYs to gain 0.58 discounted QALYs in the group with fewer QALYs. An unexpected finding was, however, that the trade-off was not affected by the size of the difference in QALYs between the two groups. It was thus as if the respondents focused on inequality as such rather than the size of the inequality. It may, however, also be the case that a larger sample size is needed to detect an impact of the size of the inequality on the marginal trade-off of QALYs. The sample consisted of only 80 individuals and since a binary choice question was used relatively little information is obtained from each respondent.

The veil of ignorance approach is in theory appealing as a principle for social choice. As far as we know it has, however, not previously been used as a basis for empirical research. This pilot study shows that it may be possible to use the veil of ignorance approach as a basis for empirically estimating a social welfare function and in our view more research about the usefulness of the approach as a basis for empirical research is warranted.

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Appendix A. Wording of the question used in the experiment

Assume that the society consists of two groups (groups 1 and 2) of the same size that differ with respect to the remaining life-expectancy due to hereditary factors. Assume further that you can choose between two alternative ways of organizing the society (society A and B) that differ with respect to the remaining life-expectancy in the two groups. Assume that you have to make the choice between these two societies before you know which group you will belong to, and that the group that you will eventually belong to is determined by a random draw where the probability of each group is 50%. Assume that the annual income is the same in both groups and that the life-years are in full health in both groups.

Which society would you choose given that the remaining life-expectancy in group 1 and 2 is as shown in the matrix below? Take into account both efficiency (i.e., the average life-expectancy in the society) and distribution (i.e., the difference in life-expectancy between the two groups in the society) when you make your choice. Circle the society that you prefer below.

	Society A	*Society B*
Group 1	20 years*	17 years*
Group 2	10 years	11 years**
Average	15 years	14 years

* The life expectancy for group 1 was varied randomly between 20 years in society A (17 years in society B) and 16 years in society A (13 years in society B).

** The life-expectancy in group 2 in society B was varied randomly between 10 years, 11 years, 12 years, and 13 years.

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