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An experimental test of the concentration index

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ABSTRACT

The concentration index is widely used to measure income-related inequality in health. No insight exists, however, whether the concentration index connects with people's preferences about distributions of income and health and whether a reduction in the concentration index reflects an increase in social welfare. We explored this question by testing the central assumption underlying the concentration index and found that it was systematically violated. We also tested the validity of alternative health inequality measures that have been proposed in the literature. Our data showed that decreases in the spread of income and health were considered socially desirable, but decreases in the correlation between income and health not necessarily. Support for a condition implying that the inequality in the distribution of income and in the distribution of health can be considered separately was mixed.

1. Introduction

Reducing inequalities in well-being is an important aim of economic and social policy. Both the World Health Organisation (2000) and the World Bank (2006) explicitly mention it as a major objective. There exists a vast literature on the measurement of inequality. The common approach in this literature is to focus on inequality in one dimension, typically income or health. Well-being is, however, determined by several dimensions simultaneously, two of which are income and health. Focusing only on one dimension may give a misleading impression of the degree of inequality. Properly assessing the degree of inequality in well-being requires measures of inequality that account for the multifaceted nature of well-being.

Early contributions to measure multidimensional inequality were made by Kolm (1977) and Atkinson and Bourguignon (1982, 1987). Atkinson and Bourguignon used dominance criteria to assess whether one distribution was more equal than another. A drawback of using dominance criteria is that they only lead to a partial ordering, which means that the number of distributions that can be compared is limited. This is undesirable for social policy, where we would like to assess the distributional effects of any policy proposal.

An alternative is to start from a (complete) social preference relation, to derive a social welfare function that represents this preference relation, and to use the resulting social welfare function to derive an inequality index. This *normative approach* to inequality measurement was pioneered for one-dimensional distributions by Kolm (1969) and Atkinson (1970). Extensions to multidimensional inequality measurement were proposed among others by Kolm (1977), Tsui (1995), and Gajdos and Weymark (2005).

In health economics, an innovative approach to account for the multifaceted nature of well-being was suggested by Wagstaff et al. (1991). They measured income-related inequalities in health by the concentration index (Kakwani, 1980), which summarizes how cumulative shares of health are associated with cumulative shares of the population ranked by income. Bleichrodt and van Doorslaer (2006) provided a welfare economics foundation for the concentration index by showing which conditions it imposes on social preferences. The key condition they identified is the principle of income-related health transfers.

While the concentration index has been widely used both within and outside economics and has gained worldwide acceptance by policy makers (van Doorslaer et al., 1997; Anand et al., 2001; Gwatkin et al., 2007; Yazbeck, 2009), no insight exists into the

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validity of the principle of income-related health transfers, the condition that underlies it. Do people agree that this principle should govern social choices over multidimensional distributions? The lack of insight into the validity of the principle of income-related health transfers complicates ascertaining whether the concentration index should be used to guide social policy or whether other indices are more appropriate.

The main purpose of this paper is to experimentally test the validity of the principle of income-related health transfers and, hence, to obtain insight into the question whether reductions in the concentration index reflect increases in social welfare. The answer to this question was clearly negative; our experimental data violated the principle of income-related health transfers systematically.

We also explored the appeal of several other conditions that have been proposed in the literature. Two ways of looking at multidimensional inequality can be distinguished (Tsui, 1999), first, as the dispersion in the distribution of the different dimensions and second, as the correlation between the different dimensions. Our data suggest that people are concerned about the dispersion, but care less about the correlation. A majority of our subjects even seemed to favor increases in the correlation between income and health. In other words, our results provide no support for measures that assume that all increases in the correlation between income and health are undesirable. Examples of such measures are the concentration index and the measures that have been proposed by Maasoumi (1986), Tsui (1999), and Abul Naga and Geoffard (2006).

We also explored whether people evaluate the inequality in income and health separately. If so, this would offer support for a two-stage procedure where the first stage measures the inequality in each dimension by standard one-dimensional inequality measures and the second stage aggregates these dimension-specific inequality measures into one overall inequality measure. Our results on this question were mixed, with some tests offering support for such a two-stage procedure and others rejecting it.

2. Background

We consider a social planner who has to choose between allocations of income and life-expectancy. The number of people in society is $n \geq 2$. An *allocation* (y,l) is a vector $((y_1,l_1),\ldots,(y_n,l_n))$ of length $2n$, where y_j denotes the income of person j and l_j denotes his life-expectancy. Both y_j and l_j are positive numbers.

Let $\succcurlyeq$ denote the social planner's preference relation over allocations. As usual, $\succ$ denotes strict preference and $\sim$ denotes indifference. A *social welfare function* W *represents* $\succcurlyeq$ whenever for all allocations (y,l), (y',l'),

$$(y,l) \succcurlyeq (y'l') \Leftrightarrow W(y,l) \geq W(y'l').$$

Kolm (1969) and Atkinson (1970) showed how a normatively significant inequality index can be derived from the social welfare function. For a description of their and related approaches see Weymark (2006). By imposing conditions on the social preference relation, and, consequently, on the social welfare function W, the inequality index can be restricted to specific forms. We will consider several such conditions in this paper. First, we define the principle of income-related health transfers, the central condition underlying the concentration index.

2.1. Condition 1 (Principle of income-related health transfers, PIRHT)

The social planner's preference relation satisfies the *principle of income-related health transfers* if a transfer of health from a richer person to a poorer person increases social welfare, provided the transfer does not change the ranking of the individuals in terms of income.

PIRHT implies correlation increasing majorization, a condition that has frequently been used in the theoretical literature on multidimensional inequality measurement. Consider an allocation (y,l). The allocation (y',l') is obtained from (y,l) through a *correlation increasing majorization* when we rearrange two persons' allocations such that one person has at least as much income and life-expectancy as the other and strictly more of one of these, and the rearrangement is not just a permutation of the two persons. That is, if $y_i > y_j$ for two persons $i,j \in \{1,\ldots,n\}$ then we rearrange life-expectancy such that $l_i' = \max\{l_i,l_j\}$ and $l_j' = \min\{l_i,l_j\}$, or, if $l_i > l_j$ for two persons $i,j \in \{1,\ldots,n\}$ then we rearrange income such that $y_i' = \max\{y_i,y_j\}$ and $y_j' = \min\{y_i,y_j\}$.

2.2. Condition 2 (Correlation increasing majorization, CIM)

For all allocations (y,l), (y',l'), if (y',l') is obtained from (y,l) through a (sequence of) correlation increasing majorization(s) then $(y,l) \succ (y',l')$.

CIM and PIRHT both capture Tsui's (1999) idea that increases in the correlation between income and life-expectancy are socially undesirable. PIRHT is stronger than CIM[1], however, since it allows for all convex combinations of life-expectancy that keep the income rank unchanged, whereas CIM only allows for rearrangements of life-expectancy. In other words, CIM only concerns changes in correlation that do not alter the marginal distributions of income and life-expectancy, whereas PIRHT does allow for (some) changes in the marginal distributions of income and life-expectancy.

CIM was criticized by Bourguignon and Chakravarty (2003) and by Fleurbaey (2005, 2007) for its neglect of individual preferences[2]. If the dimensions are complements, e.g. better health increases the marginal utility of income, then a correlation increasing majorization might actually increase social welfare. In fact, there is some evidence that health and income are complements in the sense that the marginal utility of income increases with better health (Viscusi and Evans, 1990; Sloan et al., 1998).

PIRHT and CIM are conditions that imply that decreases in the correlation between income and life-expectancy are desirable. They are silent, however, about the effect of mean-preserving changes in the spread of income and life-expectancy. The next condition that we tested, uniform majorization, focuses on the effects of such changes in spreads.

Uniform majorization is the multidimensional extension of the well-known Pigou–Dalton principle of transfers for one-dimensional outcomes. The *Pigou–Dalton principle of transfers* says that a transfer of a good from a better-off person to a worse-off person increases social welfare provided that the transfer does not change the ranking of the individuals in terms of the good[3]. For one-dimensional outcomes, a social welfare function can only serve as a satisfactory foundation for an inequality measure when it satisfies this principle. The Pigou–Dalton principle of transfers implies that if allocation x is obtained from allocation y through a series of Pigou–Dalton transfers then x is socially preferred to y. An equivalent formulation is to say that x is socially preferred to y if x is obtained from y by multiplying y by a bistochastic matrix[4]

[1] In the sense that PIRHT implies CIM, but not vice versa.

[2] Obviously the same criticism applies to the stronger condition of PIRHT.

[3] In fact, we could relax the exclusion of rank reversals to demanding that the transfer should not lead to a situation in which the initially worse-off person ends up better than the initial position of the better-off person.

[4] A bistochastic matrix is a nonnegative matrix which rows and columns all sum to 1.

and x is not a permutation of y. This implies that the social welfare function must be Schur-concave (Dasgupta et al., 1973; Kolm, 1977).

We can apply the same idea to multidimensional outcomes. The allocation (y,l) *uniformly majorizes* (y',l') if (y,l) is obtained through multiplying (y',l') by a bistochastic matrix and (y,l) is not a permutation of (y',l'). The next condition says that uniform majorizations increase social welfare.

2.3. Condition 3 (Uniform majorization, UM)

For all allocations (y,l), (y',l'), if (y',l') is obtained from (y,l) through a (sequence of) uniform majorization(s) then $(y',l') \succ (y,l)$.

Kolm (1977, Theorem 3) showed that if the social welfare function is the sum of the individual identical utility functions then UM is equivalent to concavity of the individual utility functions. To illustrate UM, consider the choice between the following two policies which show mean monthly income and life-expectancy per income quintile:

Income	740	745	745	1340	2180
LE	72	72	72	80	84

and

Income	470	750	1010	1340	2180
LE	68	72	76	80	84

This choice was actually one of the tests (UM5) in the experiment described below. The first policy is obtained by multiplying the second policy by the bistochastic matrix:

$$\begin{bmatrix} 0.5 & 0 & 0.5 & 0 & 0 \\ 0.25 & 0.5 & 0.25 & 0 & 0 \\ 0.25 & 0.5 & 0.25 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Hence, if the social planner behaves according to UM he should prefer the first policy to the second.

UM implies that mean-preserving decreases in the spread of income and life-expectancy are socially desirable. UM and CIM are independent conditions (see Proposition 2 in Tsui, 1999). Tsui (1999, Theorem 4) further showed that, in combination with other conditions that are commonly invoked in the literature, UM and CIM jointly imply that the inequality measure must be a generalized entropy measure.

The final condition that we tested was introduced by Gajdos and Weymark (2005). Define a conditional ordering over income by fixing the distribution of life-expectancy at some level $l = (l_1, \ldots, l_n)$, which may, but need not be constant. Income is *separable* from life-expectancy if the conditional ordering thus defined is independent of the level of l (Condition 4(a)). In a similar fashion we define separability of life-expectancy from income (Condition 4(b)).

2.4. Condition 4 (Separability)

The social preference relation satisfies *separability* if for all allocations the following two conditions hold:

$$(y,l) \succcurlyeq (y',l) \Leftrightarrow (y,l') \succcurlyeq (y',l') \quad \text{(a)}$$

$$(y,l) \succcurlyeq (y,l') \Leftrightarrow (y',l) \succcurlyeq (y',l') \quad \text{(b)}$$

In the presence of anonymity, the assumption that social preferences do not depend on the identity of people in society, separability and correlation increasing majorization are incompatible (Gajdos and Weymark, 2005, Theorem 10). If separability holds then correlation increasing majorization cannot hold and vice versa. To see this, consider the choice between the following two policies:

Income	470	750	1010	1340	2180
LE	69	73	76	80	84

and

Income	470	750	1010	1340	2180
LE	69	76	73	80	84

This is the first test of CIM that we performed in the experiment. By CIM the second policy should be strictly preferred to the first. Now suppose that separability holds as well. We will show that this leads to a contradiction. Because the income distribution is common across the two policies we can, by separability, replace it with another common income distribution, say (470, 1010, 750, 1340, 2180), without affecting preference. Hence, policy

Income	470	1010	750	1340	2180
LE	69	76	73	80	84

is strictly preferred to policy

Income	470	1010	750	1340	2180
LE	69	73	76	80	84

By anonymity, the social planner has no preference for the second quintile over the third quintile and, hence, we must have that policy

Income	470	750	1010	1340	2180
LE	69	73	76	80	84

is strictly preferred to policy

Income	470	750	1010	1340	2180
LE	69	76	73	80	84

which contradicts the first strict preference and, hence, CIM.

Gajdos and Weymark (2005, Theorem 3) showed that in the presence of some common conditions, separability implies that social welfare is determined through a two-stage process. The first stage evaluates the distributions of income and life-expectancy separately. The second stage then aggregates these dimension-specific evaluations into an overall measure of social welfare. Gajdos and Weymark (2005, Theorem 6) showed that if social welfare is invariant to independent changes in the scale of each dimension[5] then the first stage functions are generalized Gini social welfare functions (Weymark, 1981) and the second stage function is a Cobb–Douglas function. If social welfare is invariant to independent changes in the location of each dimension[6] then the first stage functions are generalized Ginis and the second stage function is linear. We do not pursue the exploration of invariance properties here, but only note that they are not obviously fulfilled (Erreygers, 2009).

3. Experiment

The purpose of the experiment was to explore the appeal of the principles discussed in Section 2, with a special focus on PIRHT.

[5] That is, social preferences satisfy the invariance assumptions needed to generate relative inequality indices.

[6] That is, social preferences satisfy the invariance assumptions needed to generate absolute inequality indices.

Policy A

	1	2	3	4	5
Income	€ 470	€ 750	€ 1010	€ 1340	€ 2180
Life-expectancy	69	78	69	80	84

Policy B

	1	2	3	4	5
Income	€ 470	€ 750	€ 1010	€ 1340	€ 2180
Life-expectancy	69	69	78	80	84

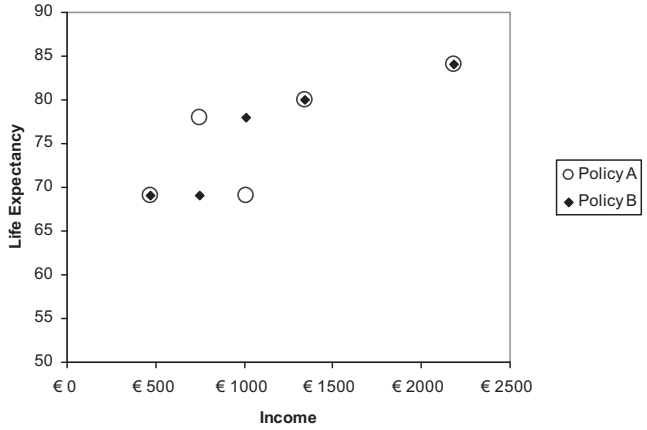

Fig. 1. Presentation of the choices.

3.1. Subjects

Subjects were 84 students (42 female) from Erasmus University Rotterdam. They received a flat fee of € 10 for their participation. On average subjects needed between 15 and 30 min to complete the questionnaire. The questionnaire was in English, but a Dutch translation was available upon request. Before the actual experiment, the questionnaire was tested in pilot sessions involving different students.

3.2. Procedures

Data were collected in group sessions with at most 10 subjects per session. There were always two interviewers present. Subjects were asked to make choices between distributions of life-expectancy and monthly income. Following Amiel et al. (2007, 2009), we told subjects to imagine a small country called Alfaland for which two policies have been proposed, affecting the income and life-expectancy of its inhabitants.

Subjects were asked to choose the policy that they preferred. Indifference was not allowed. The exclusion of indifference is common in experimental studies to avoid that subjects minimize cognitive effort. In the literature, subjects are sometimes asked which of two allocations they consider more equal instead of asking them to choose between these allocations (Amiel and Cowell, 1999). We avoided this type of question. It is inherent in the normative approach that we are interested in the question which allocation subjects prefer and not in the question which allocation subjects consider more equal. We want to ascertain whether decreases in the concentration index reflect increases in social welfare and not whether decreases in the concentration index correspond with decreases in people's perceptions of inequality. Our approach is entirely based on observable decisions (revealed preferences) and does not require introspective data (equality ratings). Hence it is entirely grounded on the rationality requirements of economics.

We told subjects that the population of Alfaland consists of 5 equally sized groups of people. Within each group all persons have the same income and the same life-expectancy. Income was net monthly income in Euros per person. Subjects were told that all life years are spent in good health. The exact instructions are in Appendix A.

We chose the Alfaland formulation to induce subjects to take the perspective of an impartial policy maker. Several studies told subjects to imagine that they have a grandchild and asked them to choose in which society they would want it to be born (Carlsson et al., 2003, 2005; Johansson-Stenman et al., 2002). We used this formulation in the pilot sessions, but it induced many subjects to look only at the income and life-expectancy of the higher income groups in the distribution, because they belonged or expected to belong to these groups. Feedback from some of the subjects indeed indicated that they only looked at their own position in society and viewed the decision problems as concerning their own income and life-expectancy. We wanted subjects to look at the complete distribution and from the perspective of an impartial social planner and, therefore, adopted the Alfaland framing.

Policies were presented both in a matrix and in a graph. Fig. 1 illustrates. To avoid order effects, we randomized the dimension that was presented first in the matrices and the dimension that was displayed on the horizontal axis of the graph. Policies were presented in a rank-ordered fashion. Policies were ranked by the first dimension that was displayed. So sometimes the ranking was by income (as in Fig. 1) and sometimes by life-expectancy. Finally, we randomized which was policy A and which was policy B to avoid labeling effects or the results being affected by subjects resolving indifference by always choosing one particular policy[7].

3.3. Stimuli

Every subject first answered two practice questions, then 21 choice-questions and, finally, 9 background questions. The order of the 21 choice questions was randomized across subjects. Some of the choice questions could be used to test more than one condition. An overview of the choice questions is in Appendix B.

There were 12 tests of the principle of income-related health transfers (PIRHT 1–12) of which 6 could also be used to test correlation increasing majorization (CIM 1–6). For instance, the first test of PIRHT is also a test of CIM because the left option, which yields a life-expectancy distribution of (69, 73, 76, 80, 84) is a correlation increasing majorization of the right option yielding a life-expectancy distribution of (69, 76, 73, 80, 84).

By varying the dimension by which the policies were ranked, we could test whether the support for PIRHT and CIM depended on whether life-expectancy or income was transferred. As an illustration, consider test CIM1:

[7] For example, a bias could arise if subjects resolved indifference by always choosing A and we would not have varied what was policy A.

Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
LE	69	73	76	80	84		69	76	73	80	84

In the displayed test both policies are ranked in terms of income. Subjects might have interpreted this as life-expectancy being transferred between groups 2 and 3. If we would instead rank the policies by life-expectancy the test would be displayed as:

LE	69	73	76	80	84	vs.	69	73	76	80	84
Income	470	750	1010	1340	2180		470	1010	750	1340	2180

which could be interpreted as transferring income between groups 2 and 3.

There were 6 tests of uniform majorization (UM 1–6). In tests UM1 through UM4 income was held constant and only life-expectancy varied. In tests UM5 and UM6 both income and life-expectancy varied.

Finally, there were 8 direct tests of separability (SEP 1-8). To understand how these 8 tests work, consider test SEP1. SEP1 is obtained from PIRHT3 by replacing the common income distribution (470,750,1010,1340,2180) by the common distribution (1150,1150,1150,1150,1150). By separability the subject's policy choice should not depend on the common income distribution and subjects should make the same choice in PIRHT3 and in SEP1. That is, they should either choose the left policy on both occasions or choose the right policy on both occasions. A choice of once right and once left would violate separability.

A heuristic that might affect the tests of separability is cancellation: if the common dimension (income in the example above) is obvious, subjects might simplify the choices by canceling it. Then the two choices would become identical and separability would trivially be satisfied. We tried to limit the impact of cancellation by varying the dimension that was used to rank order the policies. This made it harder to detect the common dimension.

The 6 tests of CIM could also be used to test separability provided that anonymity holds. Because these tests depend on the validity of anonymity we will refer to them as indirect tests of separability. As shown before, separability and anonymity jointly imply that subjects should be indifferent in the CIM questions[8]. Hence, we had 14 tests of separability in total, 8 direct and 6 indirect tests.

For the baseline distribution of monthly after tax income we used the most recent (2001) Dutch wave of the European Community Household Panel and adjusted this for inflation. At the time of the experiment no data on life-expectancy per income quintile existed in the Netherlands. So, based on the pilot sessions, we chose the life-expectancies such that the differences in life-expectancy between the income quintiles appeared sufficiently different, while remaining realistic.

The wording of the background questions is in Appendix C. We obtained information on whether subjects focused more on the tables or on the graphs in answering the questions, on their sex, age, study, political views, family income, expected income in 10 years, health, and life-expectancy. At the end of the experiment we asked whether subjects were familiar with the Gini index, the Lorenz curve, and/or the Pigou–Dalton principle of transfers. Amiel and Cowell (1992) observed that subjects who were familiar with these concepts were more likely to agree with transfers to the worse-off.

3.4. Analysis

We used seemingly unrelated regression (SUR) to analyze whether subjects satisfied the different conditions that we tested (Zellner, 1962, 1963; Zellner and Huang, 1962). For each preference condition we performed a separate SUR regression. That is, we estimated a simultaneous regression model with 12 equations (because there were 12 tests) for PIRHT, a simultaneous regression model with 6 equations for UM and so on. The dependent variable in each equation was binary and equal to 1 if a subject behaved according to the condition tested and 0 otherwise. Hence, we had 12 binary indicators for PIRHT, 6 for UM, and so on. The effect of the background variables was tested through the inclusion of dummy variables.

We used constant-only SUR models where the constants corresponded to the proportion of subjects behaving in agreement with the respective condition. We analyzed for each question whether the proportion of subjects behaving in agreement with a condition differed significantly from 50%, the proportion that could be expected if subjects were indifferent or choice were entirely random. The usual dismissal of models with linear conditional means for analyzing binary variables does not apply to constant-only models (Wooldridge, 2002, pp. 454, 456, 457). We dealt with the heteroskedasticity of the error terms by using a heteroskedasticity-robust covariance matrix (Wooldridge, 2002, p. 160). To account for the limited sample size, we applied a small-sample adjustment in the estimation of the covariance matrix of the SUR estimator, which amounts to dividing the elements of this matrix by the relevant degrees of freedom.

An advantage of SUR is that it allows for dependence of the responses to the different questions. Most studies testing preference conditions unrealistically assume that responses are independent (Iverson and Falmagne, 1985). Subjects often use a common response strategy to answer the different questions and then their responses are not independent. Seemingly unrelated regression accommodates for this dependence between responses by allowing the error terms of the different equations to be correlated. Not allowing for this correlation invalidates statistical inference in case responses are dependent. The only assumption we make is that the different subjects respond independently from each other, which is a much weaker and much more plausible assumption. An additional advantage of SUR is that its coefficients have a similar interpretation as the coefficients resulting from OLS.

In addition, we used negative binomial regression (with a robust covariance matrix adjusted for sample size) to analyze the association between the number of times a subject responded in agreement with a particular condition and the background variables.

4. Results

The mean age of our subjects was 21.5 years and nearly all of them were in good health. The distribution of our subjects over the political spectrum was fairly balanced: on a scale ranging from 1 ("very left-wing") to 5 ("very right-wing"), the mean score was 3.2[9]. Most subjects focused on the tables rather than on the graphs, and only the concept of the Lorenz curve was known by the majority of our subjects (awareness of Gini and Pigou/Dalton was much lower).

None of the background variables, including knowledge of the Gini index, the Lorenz curve, and/or the Pigou–Dalton principle of transfers, significantly affected the response patterns. There was

[8] In Section 2 we showed that separability and anonymity exclude a strict preference satisfying CIM. A similar line of argument shows that the reverse strict preference is impossible. The only answer pattern consistent with separability and anonymity is indifference.

[9] The number of subjects in the different categories was (0,22,30,28,4).

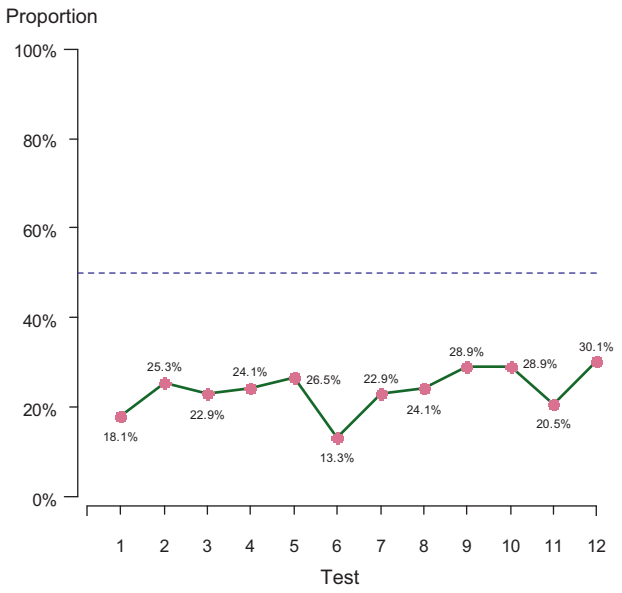

Fig. 2. Proportion of subjects satisfying the principle of income-related health transfers.

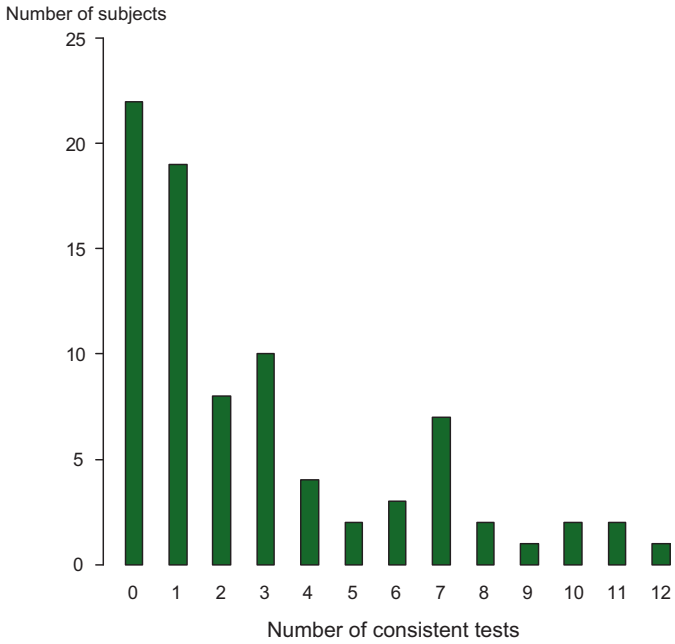

Fig. 3. Frequency distribution number of times subjects behaved in line with PIRHT.

no evidence of order effects and neither did the variable that was used for ranking have an impact on the results. The latter finding suggests that subjects treated transfers of life-expectancy and transfers of income similarly.

The correlations between the error terms of the SUR regressions were positive in all tests indicating that the responses to the different questions were correlated and that subjects used a common strategy in answering the questions. That is, subjects who (dis-)agreed with PIRHT for one question were inclined to (dis-)agree with PIRHT for the other questions as well. We could reject the hypothesis of no correlation between the error terms in all regressions (Breusch–Pagan test, $p < 0.001$ in all cases) indicating unobserved subject-specific characteristics that affected the answers to the choice questions and illustrating the usefulness of using SUR regressions.

4.1. Principle of income-related health transfers

Fig. 2 shows the proportions of subjects satisfying PIRHT in each of the 12 tests that we performed. The dotted line corresponds with subjects being indifferent or choice being purely random. PIRHT was clearly rejected. The proportions of subjects choosing in line with PIRHT varied between 13.3% and 30.1%. All proportions differ significantly from 50% at the 1% level. The question with the lowest support for PIRHT involved lower life-expectancies than the other questions suggesting that the support for PIRHT decreases with mean life-expectancy. This makes intuitive sense: if life-expectancy is relatively low for all groups, people are more reluctant to transfer life-expectancy from the better-off to the worse-off.

The time scale of income and health differed in our experiment. Income was monthly and life-expectancy was a period (in years) in which an individual is enjoying life and income. A consequence of this difference in time scale is that a choice supporting PIRHT implied a sacrifice of some income. Consider, for example, question PIRHT1 in which 3 expected life-years were transferred from income quintile 3 (earning €1010 per month) to income quintile 2 (earning €750 per month). This transfer implies a total loss of income per person in society of $(1010 - 750) \times 3 \times 12 = €9360$. We found no evidence that subjects took this loss of income into account. If this were true, the correlation between the loss of income and the support for PIRHT should be negative. The correlation was, however, equal to 0.13, not significantly different from zero ($p = 0.66$), and positive rather than negative.

There was no indication that the lack of support for PIRHT was caused by subjects considering distributions in which income and health are negatively correlated counterintuitive. We did not find a relationship between the size of the reduction in the correlation between life-expectancy and income and the support for PIRHT. An obvious example is the comparison between the first and twelfth test of PIRHT. In the first test of PIRHT, the reduction in the correlation between life-expectancy and income was much smaller than in the twelfth test. Consequently, the distribution in the 12th test would be more counterintuitive than the distribution in the first test. Nevertheless, we found more support for PIRHT in the twelfth test than in the first test.

We also explored whether our subjects were more sensitive to transfers between the two extreme groups (1 and 5). Psychological research suggests that people are particularly affected by extreme outcomes (Kahneman, 2003). We found no evidence for this hypothesis, however. For instance, the support for PIRHT did not vary between test 3, involving a transfer between the extreme groups, and test 4, involving a transfer between the middle groups. Likewise, a comparison between tests 5, 6, and 12 shows that the support for PIRHT was similar for transfers between above average income groups and for transfers between below average income groups.

Within-individual analyses confirmed the lack of support for PIRHT. Fig. 3 shows the number of times subjects chose in accordance with PIRHT. The distribution is skewed to the right and shows that only a small minority of subjects chose consistently with PIRHT in more than a few tests. The proportion of subjects that satisfied PIRHT in at least 8 out of 12 tests was less than 10%. Over 80% of our subjects violated PIRHT in more than half of the tests. Clearly, the individual analyses did not support PIRHT either.

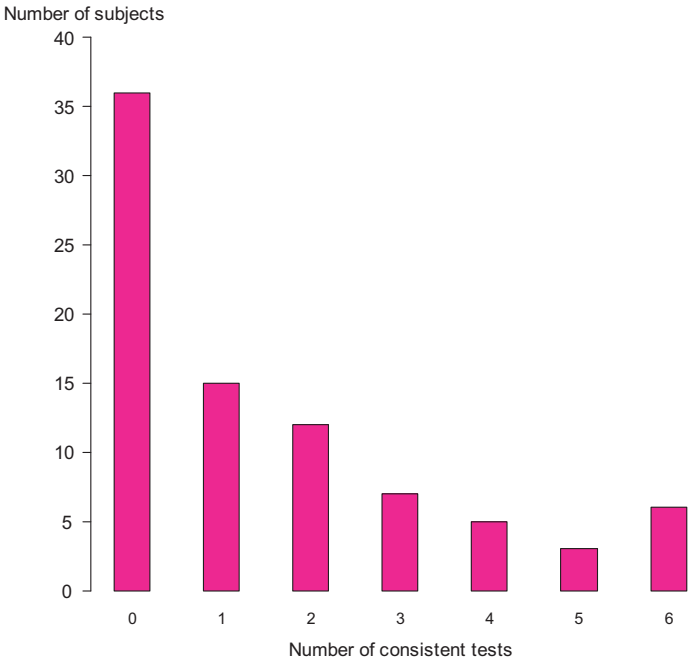

Fig. 4. Frequency distribution number of times subjects behaved in line with correlation increasing majorization.

4.2. Correlation increasing majorization

The results on PIRHT also imply that correlation increasing majorization was violated. Hence, this weakening of PIRHT did not lead to a more accurate representation of social preferences. PIRHT tests 1, 2, 9, 10, 11 and 12 are also tests of correlation increasing majorization. In all tests correlation increasing majorization was rejected ($p < 0.01$ in all cases). Moreover, the support in these questions was not higher than in the questions that tested PIRHT only. Apparently, our subjects were not concerned about the increases in correlation as specified by correlation increasing majorizations.

Fig. 4 shows the lack of support for CIM at the individual level. Only 16% of our subjects chose in accordance with CIM in at least 4 out of 6 tests. Seventy-five percent of the subjects violated CIM in more than half of the tests.

4.3. Uniform majorization

Fig. 5 shows that uniform majorization was generally confirmed in our data. The proportions supporting UM in the first four tests differed significantly from 50% at the 1% level. Support for UM was lower in tests 5 and 6. In the fifth test, the proportion was significantly different from 50% at the 5% level; in the sixth test it did not differ significantly from 50%.

In the first four tests, in which UM was supported, only life-expectancy changed, whereas in the final two tests, in which less support for UM was observed, both life-expectancy and income changed. The lower support for UM in tests 5 and 6 is perhaps not surprising. When both dimensions change simultaneously, the comparison becomes harder and it is not immediately clear that the dimensions of one alternative are more equally distributed than those of the other.

The general support for uniform majorization was confirmed at the individual level. Fig. 6 displays the number of times subjects answered in line with UM. Over 70% of our subjects chose in agreement with UM in at least 4 out of 6 questions.

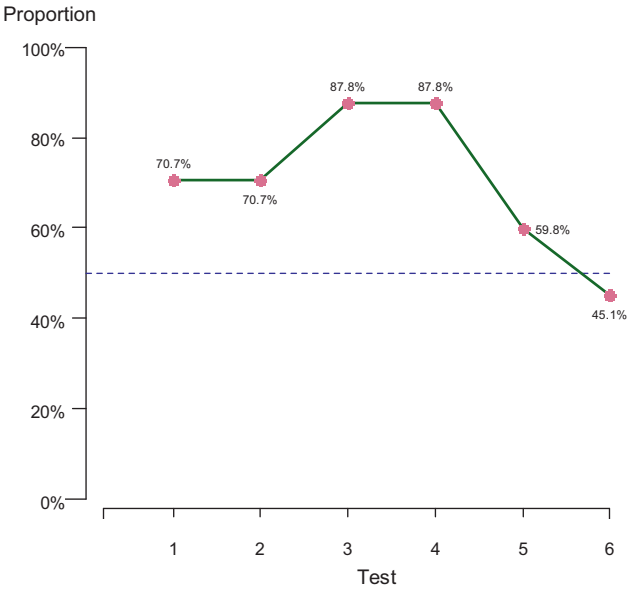

Fig. 5. Proportion of subjects satisfying uniform majorization.

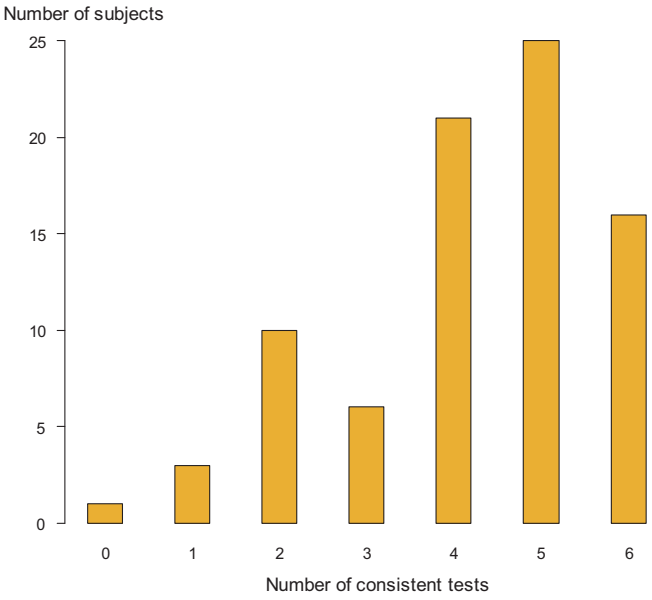

Fig. 6. Frequency distribution number of times subjects behaved in line with uniform majorization.

4.4. Separability

The eight direct tests of separability generally supported separability. Fig. 7 shows the proportions of subjects behaving in agreement with separability. In 6 out of 8 tests this proportion was significantly higher than 50%. In tests 5 and 6 the proportion did not differ significantly from 50%. This lower support could be due to task complexity. Tests 5 and 6 involved redistributions of health among at least three quintiles. The other separability tests involved redistributions of health among only two quintiles, which may have been easier for subjects.

The direct tests also provided support for separability at the individual level. Fig. 8 shows the frequency distribution of how often subjects behaved in agreement with separability. Around 70% of our subjects behaved in agreement with separability in at least 5 out of 8 tests.

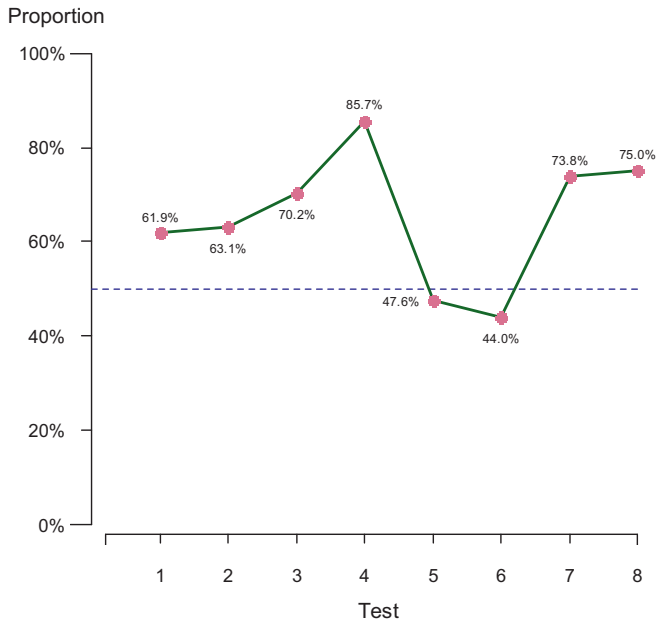

Fig. 7. Proportion of subjects satisfying separability.

The indirect tests, on the other hand, provided no support for separability. As explained in Section 2, separability and anonymity jointly imply that subjects should be indifferent in the tests of CIM. We observed, however, that subjects significantly deviated from indifference in those tests, casting doubt on separability and/or anonymity.

4.5. Combinations of conditions

Correlation increasing majorization is independent from uniform majorization and CIM and separability are incompatible. In this subsection we briefly analyze how the responses to these questions were related. Table 1 shows the Spearman rank correlations between the number of times subjects satisfied particular combinations of conditions. For the separability condition we only consider

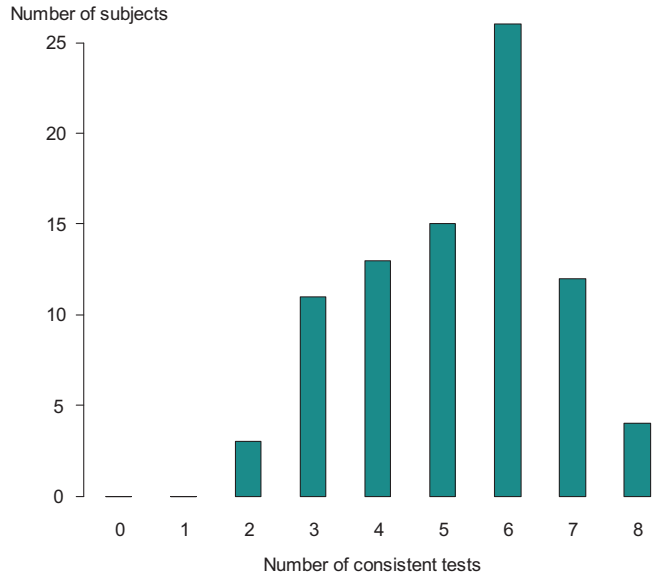

Fig. 8. Frequency distribution number of times subjects behaved in line with separability.

Table 1
Spearman rank correlations between number of times subjects respond in line with a condition.

	CIM	Separability (direct tests)	UM
CIM	1		
Separability (direct tests)	−0.468 ($p = 0.000$)	1	
UM	−0.027 ($p = 0.809$)	0.197 ($p = 0.076$)	1

Table 2
Summary of findings.

Principle	Satisfied?
Principle of income-related health transfers	No
Correlation increasing majorization	No
Uniform majorization	Yes
Separability	?

the direct tests SEP 1-8 in this subsection. As expected, there was a negative correlation between the number of times subjects satisfied CIM and the number of times they satisfied separability. This negative correlation was highly significant ($p < 0.001$). Most subjects satisfied either CIM or separability, rarely did they violate both conditions. Depending on the underlying choice question, between 5% and 15% of the responses satisfied both CIM and separability, which is inconsistent. These responses may reflect error or confusion. The proportion of such erroneous choices is relatively low compared with other choice experiments where error rates up to 30% are common (Stott, 2006).

Table 1 also shows that there was no relationship between the number of times a subject satisfied CIM and the number of times he satisfied UM. There was a positive and marginally significant relationship between the number of times a subject satisfied UM and the number of times he satisfied separability.

5. Discussion

The main purpose of our study was to test experimentally whether decreases in the concentration index, a widely used measure of socio-economic inequalities in health, are considered socially desirable. Our results did not support the concentration index. The crucial condition on which the concentration index relies, the principle of income-related health transfers, was systematically violated.

A second purpose of our study was to shed light on the question which alternative conditions might be used instead. Table 2 summarizes our findings. We found no support for correlation increasing majorization, a weakening of PIRHT. On the other hand, uniform majorization, the multidimensional generalization of the Pigou–Dalton principle of transfers was supported. The results on separability were mixed with support being observed in the direct tests, but inconsistent results in the indirect tests. These inconsistencies could be caused by violations of separability or by violations of anonymity. Even though anonymity is commonly assumed in inequality measurement, it could be violated in case the attributes distinguished in the analysis, life-expectancy and income, do not capture all the relevant information on which social choices should be based.

What do our findings imply for health inequality measurement? Unfortunately, our paper yields more negative than positive answers. The refutation of the principle of income-related health transfers suggests that the concentration index does not connect well with subjects' preferences over distributions of income and life-expectancy. Likewise, the lack of support for correlation increasing majorization suggests that alternative indices that assume correlation increasing majorization do not reflect these

preferences either. Examples of such indices are Tsui's (1999) generalized entropy measure and the indices proposed by Maasoumi (1986), Bourguignon (1999), and Abul Naga and Geoffard (2006). The mixed support for separability means that the question whether a two-stage procedure to health inequality measurement, as put forward by Gajdos and Weymark (2005), may be used to arrive at a more descriptive health inequality measure is still open.

Our data should not be interpreted as saying that people do not care about inequality. The strong support for uniform majorization shows that they are concerned about the spread in the distributions of income and life-expectancy. Reductions in these spreads are clearly perceived as desirable. Unfortunately, uniform majorization is too general to identify a particular inequality measure. Future studies should try to limit the set of appealing indices by testing additional conditions.

Let us conclude with some caveats. In our experiment we only considered inequality in two dimensions: income and life-expectancy. Health has another dimension, quality of life, which we did not include in the present study. In future research we plan to examine whether our conclusions remain valid when quality of life is included as a separate dimension. There is some evidence that people derive less utility from income when in poorer health and taking this into account may affect distributional judgments. An advantage of using quality of life is that it can be measured on the same time scale as income. On the other hand, we found no evidence that the difference in time scale between income and life-expectancy had an impact on the results.

A second concern may be that our sample, consisting of university students, was not sufficiently large and representative and, related to this, that questions about life-expectancy are too theoretical and abstract for university students who still have many expected life-years to come. While we acknowledge these points and aim to design further tests that will be submitted to larger and more general samples, two points are worth making. First, in our sample none of the background variables had an influence on the results. Second, in a study about inequality in health, Bleichrodt et al. (2005) observed no significant differences between the views of a comparable sample of university students and those of a representative sample of the Dutch population. Amiel and Cowell (1992) provided an interesting argument why it may actually be better to use students instead of general population samples when studying social preferences. Members of the general public may have an intuitive idea what tradeoffs between different members of the population mean, but their ideas are often tied to specific situations or examples rather than based on precisely defined abstract principles of distributive justice. Intuition alone can prove a poor guide to criteria of general applicability. Students are better able to think about distributional problems analytically.

A more fundamental question is whether we can have sufficient confidence in the responses of students to inform social policy. One could argue that relevant normative judgments should be based on informed choice: people should be informed about the issues at stake. While confronting people with the pros and cons of different arguments is desirable, we are inclined to believe that this would not have substantially affected our findings. In most of the tests the difference between the two choice options was easy to spot and it was obvious what we were testing. Take the first test of correlation increasing majorization. In one choice option the second quintile had a life-expectancy of 73 years and the third quintile had a life-expectancy of 76 years. In the other option these life-expectancies were reversed. The two options were equal in all other respects. It was clear that we tested whether decreasing the correlation between income and life-expectancy was desirable. Nevertheless the condition was rejected. Moreover, those subjects who were aware of the Gini index, the Lorenz curve, and the Pigou–Dalton principle of transfers behaved exactly like the subjects who were unfamiliar with these concepts, suggesting that additional knowledge of what we were testing had no impact on the results.

That said, we acknowledge that there is a danger that subjects' answers were affected by biases and heuristics, which ought to play no role in social policy. Saying that elicited preferences are important carries with it the responsibility to ensure that what is elicited indeed reflects what people consider important. As explained in the description of the experiment, we tried to control for the biases that we could think of. We used several versions of the questionnaire with different orderings of the different questions to control for the possibility that the order of the questions would affect the results and we randomized what was policy A and policy B to counter cancellation. Of course, the possibility can never be excluded that other biases affected our results.

It is obvious that our study cannot provide the final answer on which health inequality measure to use. We invite other researchers to replicate and extend our findings. The quest for a better measurement of health inequality is important and more research is needed to ascertain the extent to which principles are in line with people's concerns about inequality. We hope that our study will prove a useful step in this quest.

Acknowledgements

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Appendix A.

Thank you very much for participating in this experiment. The purpose of this survey is to obtain information on how people value distributions of income and life expectancy. There are no 'right' or 'wrong' answers in this questionnaire. We are only interested in your own personal opinion.

Alfaland is a small country for which two governmental policies have been proposed. Both policies will have an identical impact on the country, except for the income and life expectancy of people. In the questions below you are asked to choose repeatedly between two distributions of income and life expectancy that result from these two policies.

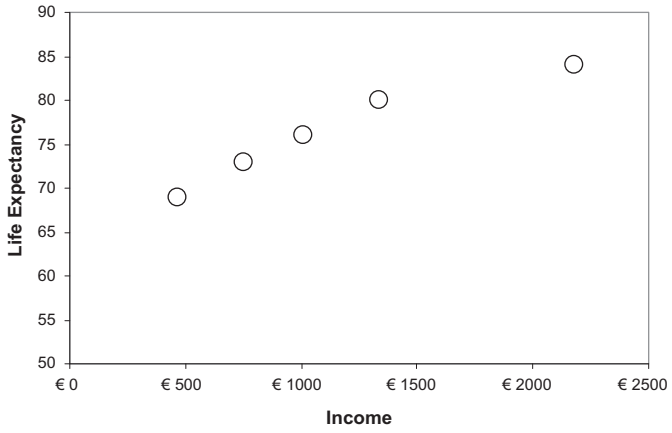
The population of Alfaland consists of 5 groups of people. All 5 groups are equally large. Within every group all persons will have the same income and the same life expectancy throughout their lives. The resulting distribution of income and life expectancy from each policy is described as in the following table.

	1	2	3	4	5
Income	€470	€750	€1010	€1340	€2180
Life expectancy	69	73	76	80	84

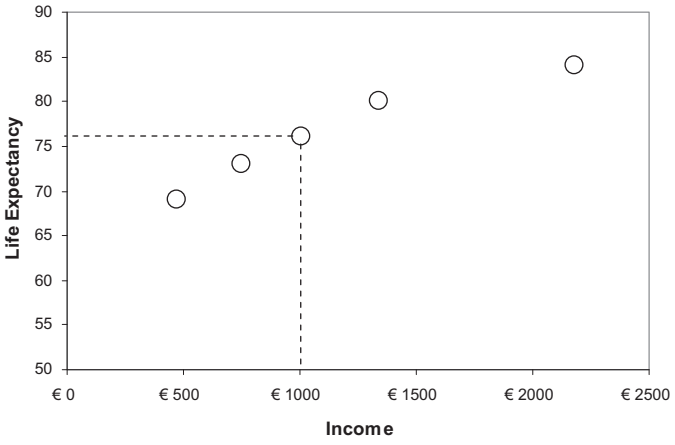
Income is the net monthly income in euros per person. The price level in Alfaland will be similar to the price level in the Netherlands in 2008. Life expectancy is the expected number of years a person in

the group will live in full health, after which he or she dies. The five columns, named 1, 2, 3, 4, and 5, give the income and life expectancy for the five equally large groups of people. In this example one fifth of the population has an income of €1010 and a life expectancy of 76 years.

The distribution of income and life expectancy can also be depicted in a graph as follows:



Every point in the graph denotes a group of people. In the graph below we can see that the third point from the left corresponds to group 3 with the income of €1010 and the life expectancy of 76.



In the questions below you will be asked to compare two policies. We will depict the distributions corresponding to both policies in one graph. The distribution of the first policy is given by points that are indicated through white circles. The distribution of the second policy is given by points that are indicated through black diamonds.

Note that the graphs never contain more information than the tables. Therefore, in determining your choice between two policies it is not mandatory to look also at the graphs.

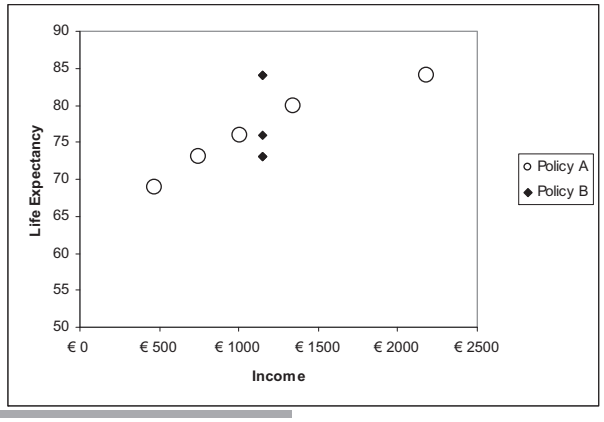
For some policies, two groups will have exactly the same income and life expectancy. For those policies two points will coincide, so that you can see only four, three, two, or one point. This is the case in the following example.

Policy A

	1	2	3	4	5
Income	€ 470	€ 750	€ 1010	€ 1340	€ 2180
Life Expectancy	69	73	76	80	84

Policy B

	1	2	3	4	5
Income	€ 1150	€ 1150	€ 1150	€ 1150	€ 1150
Life Expectancy	73	73	76	84	84



In policy B group 1 is in the same situation as group 2 and group 4 is in the same situation as group 5.

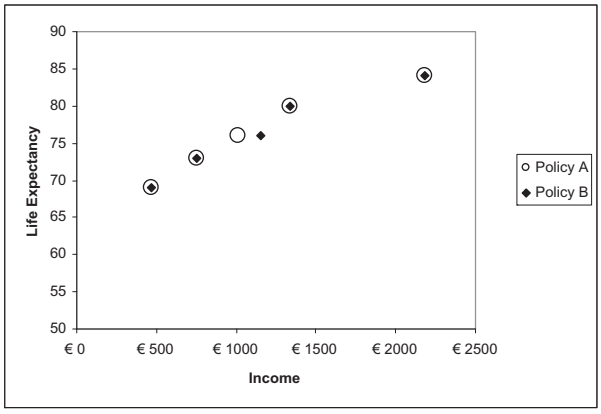
In some questions the two policies considered will only differ for a few groups. This is the case in the following example.

Policy A

	1	2	3	4	5
Income	€ 470	€ 750	€ 1010	€ 1340	€ 2180
Life Expectancy	69	73	76	80	84

Policy B

	1	2	3	4	5
Income	€ 470	€ 750	€ 1150	€ 1340	€ 2180
Life Expectancy	69	73	76	80	84



In each question below, please indicate the policy that you would implement for Alfaland by putting a cross in the circle to the left of the table of the corresponding distribution. In every question you may choose only one policy.

Appendix B. Experimental questions

The shaded options are predicted to be chosen according to the condition being tested. The responses to the eight separability questions should be the same as to PIRHT questions 3,4,5,6,8,4,5, and 1, respectively, in the sense that if the right (left) policy was chosen in the PIRHT question then the right (left) policy should also be chosen in the separability question.

Question	Quintile	1	2	3	4	5		1	2	3	4	5
PIRHT1	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		69	76	73	80	84
PIRHT2	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	60	73	76	80	84		84	73	76	80	60
PIRHT3	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		85	73	76	80	68
PIRHT4	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		69	81	76	72	84
PIRHT5	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		69	73	82	74	84
PIRHT6	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	65	61	69	72	75		68	58	69	72	75
PIRHT7	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		69	79	74	78	82
PIRHT8	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	70	73	76	80	84		78	71	74	78	82
PIRHT9	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	69	76	80	84		69	80	76	69	84
PIRHT10	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	70	70	70	75	80		75	70	70	70	80
PIRHT11	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	70	70	70	75	80		70	75	70	70	80
PIRHT12	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	69	78	80	84		69	78	69	80	84
CIM1	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	73	76	80	84		69	76	73	80	84
CIM2	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	60	73	76	80	84		84	73	76	80	60
CIM3	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	69	76	80	84		69	80	76	69	84
CIM4	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	70	70	70	75	80		75	70	70	70	80
CIM5	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	70	70	70	75	80		70	75	70	70	80
CIM6	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	69	78	80	84		69	78	69	80	84

Appendix B (*Continued*)

Question	Quintile	1	2	3	4	5		1	2	3	4	5
UM1	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		85	73	76	80	68
UM2	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		69	81	76	72	84
UM3	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		69	73	82	74	84
UM4	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	65	61	69	72	75		68	58	69	72	75
UM5	Income	740	745	745	1340	2180	vs.	470	750	1010	1340	2180
	LE	72	72	72	80	84		68	72	76	80	84
UM6	Income	470	1010	1340	1465	1465	vs.	470	750	1010	1340	2180
	LE	68	76	80	78	78		68	72	76	80	84
SEP1	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		85	73	76	80	68
SEP2	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		69	81	76	72	84
SEP3	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	69	73	76	80	84		69	73	82	74	84
SEP 4	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	65	61	69	72	75		68	58	69	72	75
SEP 5	Income	1150	1150	1150	1150	1150	vs.	1150	1150	1150	1150	1150
	LE	70	73	76	80	84		71	74	78	78	82
SEP 6	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	84	80	76	73	69		84	72	76	81	69
SEP 7	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	76	73	69	80	84		82	73	69	74	84
SEP 8	Income	470	750	1010	1340	2180	vs.	470	750	1010	1340	2180
	LE	69	69	78	80	84		69	78	69	80	84

Appendix C. Background questions

• When answering the previous questions, did you focus more on the tables or more on the graphs? Please circle your answer on a scale from 1 to 5.

"focus more on tables"					"focus more on graphs"
1	2	3	4	5	

• Are you male or female? Please circle your answer. M/F

• What is your age?

———

• Which study program are you following or did you follow?

———

• How would you rate your political views? Please circle your answer on a scale from 1 to 5.

"very left"				"very right"
1	2	3	4	5

• How would you rate your family's income 10 years ago? Please circle your answer on a scale from 1 to 5.

"relatively low"				"relatively high"
1	2	3	4	5

• How do you think your income in 10 years will be? Please circle your answer on a scale from 1 to 5.

"relatively low"				"relatively high"
1	2	3	4	5

• How is your health in general? Please circle your answer.

Very good	Good	Fair	Bad	Very bad

• What is the maximum age that you expect to reach?

———

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