Happiness and Loss Aversion:
When Social Participation Dominates Comparison

Maarten Vendrik
Geert Woltjer[1]

Preliminary Version

Abstract

A central finding in happiness research is that a person's income relative to the average income in her social reference group is much more important for her life satisfaction than the absolute level of her income. This dependence of life satisfaction on relative income can be related to the reference dependence of the value function in Kahneman and Tversky's (1979) prospect theory. In this paper we investigate whether the characteristics of the value function like concavity for gains, convexity for losses, and loss aversion apply to the dependence of life satisfaction on relative income. This is tested with a new measure for the reference income on a large German panel for the years 1984-2001. We find indications for significant concavity of life satisfaction in positive relative income, but surprisingly strongly significant concavity of life satisfaction in negative relative income as well. The latter result is shown to be robust to extreme distortions of the reported-life-satisfaction scale. It implies a rising marginal sensitivity of life satisfaction to more negative values of relative income, and hence loss aversion. We explain this in terms of increasing financial obstacles to social participation.

---

[1] Both authors, Department of Economics, Maastricht University, P.O. Box 616, 6200 MD Maastricht, The Netherlands, E-mail corresponding author: M.Vendrik@algec.unimaas.nl. Tel. 0031-43-3883638(3883636).
We thank Andrew Clark, Erik de Regt, Alois Stutzer, Bob Sugden, Peter Wakker, and (other) participants to the 2nd Workshop on "Capabilities and Happiness" in Milano-Bicocca, June 16-18, 2005, for helpful comments on an earlier version of this paper. We are also indebted to Denis de Crombrugghe and Sybrand Schim van der Loeff for econometric advice.

1. Introduction

A basic postulate of utility theory is that utility rises with income. However, empirical research on subjective well-being (see Frey and Stutzer, 2002a, for an overview) has shown that in most developed countries average happiness has not or only slightly increased over the last fifty years despite high economic growth. This paradox has been explained by Easterlin (1974, 2001) and Frank (1997) in terms of rising aspirations and social comparison. The level of one's income relative to that of other people is much more important than its absolute level, and if absolute income rises for everybody at the same pace, relative income does not change. This importance of relative income was already found by Duesenberry (1949) in his seminal study on individual consumption and savings behaviour. In addition, Duesenberry postulated that social comparisons of income are not symmetric. In the context of happiness this means that the happiness of poorer people is negatively affected by the income of their richer peers, whereas richer people do not get happier from comparing their income with that of poorer members of their reference group.

Thirty years later, Kahneman and Tversky (1979) introduced their prospect theory as an alternative to the standard microeconomic theory of choice. It includes a value function that is defined over gains and losses with respect to some natural reference point and that is concave for gains and convex for losses. It is also assumed to be steeper for losses than for gains, which is referred to as loss aversion (Tversky and Kahneman, 1991). Finally, the value function is hypothesized to be as convex for losses as it is concave for gains (reflection effect; see Kahneman, 2003, and see Köbberling et al., 2004, for a different hypothesis).

These characteristics of the value function have been tested quite extensively for decision utility and psychological perceptions (see Köbberling et al. for an overview), but, as Kahneman (1999, p. 19) states, "the extent to which loss aversion is also found in experience is not yet known" (see, however, Galanter, 1990). In this context there is an interesting relationship with the dependence of happiness on the average income in a social reference group as postulated by Easterlin, Frank and others. Such a social reference income provides a natural reference point for people to compare their own income with. Income relative to this social reference income then corresponds to gains for positive values and to losses for negative values. Moreover, the assumed asymmetry in the income comparison amounts to loss aversion in Kahneman and Tversky's theory. This then also raises the question whether the other characteristics of the value function like concavity for gains and convexity for losses may apply to this dependence of happiness on relative income as well.

In this paper we test the characteristics of the value function for individual life satisfaction functions for income levels above and below social reference incomes. A significant positive dependence of life satisfaction on relative income has already been found in the econometric cross-section and panel studies of McBride (2001), Stutzer (2004) and Ferrer-i-Carbonell (2005).

Furthermore, the last study finds support for the asymmetry postulate of Duesenberry. However, the measures for the reference income that were used in the three studies have some drawbacks that we try to improve on by introducing a new measure. With this new measure we then test all the characteristics of the value function mentioned for a large German panel (GSOEP) spanning the years 1984 to 2001.

To test concavity for positive relative income and convexity for negative relative income, we need a more flexible specification of life satisfaction in terms of relative income than the usual logarithmic one since the latter is concave for negative as well as positive relative income. For that purpose a power-function specification is used, which includes the logarithmic specification as a limiting case. We then find indications for significant concavity of life satisfaction in positive relative income, but surprisingly very significant concavity of life satisfaction in negative relative income as well. Moreover, under plausible assumptions on the cardinal properties of the 'true-life-satisfaction' scale, the latter result turns out to be robust to extreme distortions of the reported-life-satisfaction scale (such as suggested by Oswald, 2005). It means a strong rejection of the hypothesized convexity and implies a rising marginal sensitivity of life satisfaction to more negative values of relative income. Our explanation for this result is that as a person's income falls increasingly short of that in the reference group, it becomes increasingly and more than proportionally hard to raise the funds to participate in the social activities of the reference group. This effect of rising marginal social participation costs of falls in relative income apparently dominates a possible social comparison effect of diminishing marginal sensitivity of life satisfaction to such falls, which is suggested by the theory of Kahneman and Tversky. Moreover, it is shown to imply significant loss aversion (at least for larger losses).

The paper is structured as follows. Section 2 formulates the hypotheses to be tested, and Section 3 discusses the problems of testing cardinal properties of true life satisfaction and our way to tackle these problems. Section 4 presents the econometric specifications, Section 5 introduces the new measure of reference group, and Section 6 discusses the data and estimation procedure. Section 7 presents and analyses the estimation results, Section 8 derives their implications for cardinal properties of true life satisfaction, and Section 9 tests the robustness of the results for other specifications and populations. Section 10 discusses our explanation for the results and discusses possible implications for behaviour. Finally, Section 11 concludes.

2. Hypotheses

While the influence of social comparison on individual preferences in decision-making and on income and job satisfactions has already been investigated for quite some time (see Ferrer-i-Carbonell for a recent overview), econometric studies that estimate the impact of social comparison on individual life satisfaction are rather recent. In cross-section and panel studies for American, Swiss and German data

McBride (2001), Stutzer (2004) and Ferrer-i-Carbonell (2005) find that the overall life satisfaction of individuals negatively depends on the average (real) incomes in their social reference groups. Moreover, the difference between their own income and such social reference income (relative income) turns out to be a more important determinant of individual life satisfaction than the absolute level of income.

The empirical findings on the impact of social comparison on individual preferences, income and job satisfactions, and life satisfaction are partially consistent with the more general value-function theory of Kahneman and Tversky (1979) for decisions under risk and of Tversky and Kahneman (1991) for riskless choice (see the latter paper for cross-references). The social reference income provides a 'natural' reference point for people, to which they compare their own income, and the asymmetry result of Ferrer-i-Carbonell suggests loss aversion.[2] On the other hand, most studies employ a utility function that is concave for negative as well as positive relative income.[3] The characteristics of the value function have been tested quite extensively for decision utility and psychological perceptions (see Köbberling et al. for an overview), but, as Kahneman (1999, p. 19) indicates and as far as we know, characteristics like loss aversion have not been tested for experienced utility *as measured ex post*.

Some indications on possible properties of such experienced utility are given by psychophysical experiments reported by Galanter (1990). In one such experiment subjects were asked to imagine that they lost \$5 (or \$50 resp \$500), and to name the amount of money they would have to lose to make them exactly twice as upset as losing \$5 (or \$50 resp \$500). The geometric means of the subjects' judgments was \$21 (or \$160 resp \$1850), and fitting this to a power function of the form $U = aM^b$ yielded an exponent b equal to 0.54. A variety of cross-modality matching experiments yielded similar values of b, always a bit larger than 0.5, for losses, but for gains values of b always a bit smaller than 0.5. In general, loss aversion was found, and this finding as well as those of concavity for gains and convexity for losses is consistent with the characteristics of Kahneman and Tversky's value function.[4]

However, the utility that was measured in these experiments is not experienced utility as measured *ex post*, but rather experienced utility as imagined *ex ante*. In the terminology of Kahneman et al. (1997) this may be called predicted utility as distinct from experienced utility *per se*. It might be considered as an intermediate case between experienced utility and decision utility and may deviate

[2] However, the t-statistic values computed by Ferrer-i-Carbonell are not conclusive since they neglect possible covariances between the two compared parameter estimates.

[3] Clark and Oswald (1998) show that while comparison-concave utility leads to following behaviour, comparison-convex utility implies deviant behaviour.

[4] Kahneman (1999, p. 19) claims that the difference in the estimates of exponent *b* for gains and losses would not account for the extensive loss aversion observed in choice experiments. However, we did not find evidence for this claim in the analysis of Gallanter (see his Fig. 4).

from both. In this paper, we focus on experienced utility as measured *ex post* in surveys. More specifically, we test the characteristics of the value function for the shapes of life satisfaction functions for income levels above and below the average incomes in social reference groups. The hypotheses tested are:

H1: Individual life satisfaction (*S*) depends significantly negatively on the average (real) family income in a social reference group, controlling for (real) family income and other variables.

This hypothesis is based on what one would expect on the basis of psychological and sociological theories of social reference processes (e.g., Festinger, 1954), and has been confirmed by the empirical studies of McBride, Stutzer, and Ferrer-i-Carbonell cited above. On the other hand, Senik (2004) finds a significantly positive sign for Russian panel data, which she explains by the use of the informational content of changes in other people's incomes in forming one's own income expectations (see also Schyns, 2002). We consider family income instead of individual income for two reasons. First, on a conceptual level, family income may be a more adequate determinant of *S* since the impact of income on *S* runs primarily via individual consumption and this is related to family rather than individual income. Second, the dataset that we use (see Sec. 5) contains better data for family than for individual income. However, since the consumption out of the family income is divided over all household members, we control for number of adults and number of children in the household.

H2: *S* depends significantly positively on the difference between family income and the average family income in a social reference group (relative income), controlling for family income (absolute income) and other variables.

This hypothesis corresponds to the reference dependence of Kahneman and Tversky's value function, and is explicitly confirmed by Ferrer-i-Carbonell.

H3: *S* depends significantly more positively on relative income than on absolute income.

This hypothesis investigates the dominance of reference dependence over reference-independent effects.

H4: *S* is concave in positive values of relative family income and convex in negative values of relative family income.

This hypothesis corresponds to the diminishing sensitivity of the marginal value of both gains and losses, which is implied by Kahneman and Tversky's value function and suggested by the results of Galanter reported above.

H5: *S* is as concave in positive values of relative family income as it is convex in negative values of relative family income (for equal absolute magnitudes of negative and positive relative family income).

This hypothesis corresponds to the reflection effect with respect to gains and losses as hypothesized by Kahneman and Tversky (1979, pp. 268-269) except for the asymmetry implied by loss aversion (see below). Several studies on decision utility suggest that the value function for gains and losses is fairly well approximated by power functions with similar exponents, both less than unity (Swalm, 1966; Tversky and Kahneman, 1992; Kahneman, 2003). These exponents reflect the degrees of concavity of the value function for gains and of convexity for losses. On the other hand, for the case of 'predicted utility' Galanter reports higher estimated exponents for losses than for gains (see above). This suggests that experienced utility of money may be less convex for losses than it is concave for gains. For decision utility this is also hypothesized by Köbberling et al. (2004). They argue that the psychological perception-of-quantity effect as decribed by Kahneman and Tversky's value function is then confounded with the economic intrinsic-utility-of-money effect, which is assumed to exhibit diminishing marginal utility. This argument can explain Galanter et al.'s findings for 'predicted utility' as well. However, in the present life-satisfaction context the intrinsic-utility-of-money effect can be associated with the effect of absolute income on *S*, while the effect of relative income may be fully consistent with the characteristics of the value function, including the reflection effect. We therefore maintain hypothesis H6. Accordingly, with respect to the effect of absolute income we hypothesize:

H6: *S* is concave in (positive values of) absolute family income.

Finally,

H7: *S* as a function of relative income is significantly steeper for negative values of relative income than for positive values (at equal absolute levels of negative and positive relative income).

This hypothesis corresponds to the loss aversion implied by Kahneman and Tversky's value function and suggested by the results of Galanter.

3. Testing cardinal properties of true life satisfaction

To test our hypotheses, first of all a reliable measure of life satisfaction is needed. Usually, such a measure involves a person's answer to a survey question about her/his overall life satisfaction. For example, in the GSOEP data set we use in this paper the satisfaction question is:

> Please, answer according to the following scale: 0 means completely dissatisfied, 10 means completely satisfied.
>
> How satisfied are you with your life, all things considered?[5]

The resulting score of reported life satisfaction (R) can be considered as a reasonably reliable measure of a person's 'true' life satisfaction (S), but the reliability of the score is limited by its discreteness and nonrandom measurement errors (see, e.g., Frey and Stutzer, 2002a, 2002b; Ferrer-i-Carbonell and Frijters, 2004). In particular, there may be cultural norms that lead people to overestimate or underestimate their happiness (see, e.g., Johansson-Stenman and Martinsson, 2005). This may especially affect cardinal properties of the life satisfaction function like concavity and convexity, as addressed in our hypotheses H4-H6. To see this, assume that a person's reported life satisfaction R is a stepwise-increasing function of her true life satisfaction or well-being S plus a measurement error term (Blanchflower and Oswald, 2004). If the measurement error would be only random, an imaginary OLS regression of R on S would yield a linear relation with slope 1. However, consider a culture (like perhaps the British) where people are reluctant to give a high assessment of their happiness (Oswald, 2005).[6] This will lead to an underestimation of high values of S, implying a systematic downward bias of R and a concave shape of the regression relation between R and S. Estimated concavity of R in relative or absolute income Y could then be due to a comparable degree of concavity of the estimated $\hat{R}$ in S, leaving no (significant) concavity of true life satisfaction S in Y. This can be seen by writing $\hat{R}(Y)$ as $\hat{R}(S(Y))$ (see Oswald, 2005, for a formal proof, and see Sec. 8 for more details). On the basis of this possibility Oswald concludes that the usual finding of diminishing returns of income in happiness research does not prove diminishing marginal utility. Moreover, in the context of our study, it seems to dismiss regressions of reported life satisfaction R on relative and absolute income as a reliable means to test hypotheses H4-H6.

At first sight, a better way to test these hypotheses seems to be estimation of the relation of S to relative or absolute income by an ordered probit or logit, where the latent variable Z can be considered as a proxy for the true well-being S (Blanchflower and Oswald; Frey and Stutzer, 2002b, p. 406). However, the question is whether this interpretation of Z is valid not only in an ordinal, but also

---

[5] This is the English translation in the GSOEP of 2001 of the German question. Surprisingly, in previous years the same question was translated in terms of 'unhappy' and 'happy' instead of 'dissatisfied' and 'satisfied' (see, e.g., Ferrer-i-Carbonell, 2005). We assume the more recent translation is the more correct one.

[6] It is interesting to note that a similar reluctance to give high grades is found in the grading system at British universities, where an 8 tends to be the virtual maximum (Sugden, personal communication).

in a cardinal sense. The answer seems to be no since ordered probit or logit analysis only uses the *ordinal* information in the reported *R* scores (Van Praag and Ferrer-i-Carbonell, 2004, p. 32; Ferrer-i-Carbonell and Frijters, 2004, Sec. 3.2), and hence can never contain cardinal information on *R*, and so *S*. More specifically, probit (or logit) analysis departs from the assumption that reported *R* is a stepwise-increasing (or decreasing) function of an underlying latent variable *Z*. Combined with the above assumption that *R* is a stepwise-increasing function of true well-being *S*, this implies that *Z* is a monotonously non-decreasing function of *S*. We can make this relation somewhat stronger by plausibly assuming that *Z* is a (continuously differentiable) monotonously increasing function of *S*. Ordinal properties of *S* are then the same as the ordinal properties of *Z*, but cardinal properties of *S* and *Z* may differ from each other.

A more adequate approach then is cardinal probit analysis, which makes use of the *cardinal* information in the reported *R* scores as well (Van Praag and Ferrer-i-Carbonell, 2004, p. 32). *S* is then assumed to be well approximated by the standard normal-distribution function *N* as a function of *Z* plus an error term ε, i.e. $S = N(Z+\varepsilon)$. However, just as regression analysis, cardinal probit analysis suffers from the possibility that estimated $\hat{R}$ is concave in *S*. This may then account for estimated concavity of *S* in relative or absolute income.

Then the question arises how strong concavity of estimated $\hat{R}$ in *S* might be. This question is investigated in Section 8. To make this investigation tractable, we make the following crucial assumptions:

(i) True life satisfaction *S* has, just as *R*, values on a scale from 0 to 10 (up to a linear, i.e. affine, transformation[7]).

(ii) The scale of *S* is continuous and cardinal (cf. Van Praag and Ferrer-i-Carbonell, 2004, Sec. 2.7).

(iii) Scores of reported life satisfaction *R* deviate from true life satisfaction *S* within certain extreme limits (to be specified in Sec. 8).

Cardinality of the scale of *S* means that a difference in *S* between, say, 7.5 and 8.5 represents the same difference in satisfaction intensity as the difference between 5.5 and 6.5. This as well as the other assumptions are metaphysical assumptions since true life satisfaction is a metaphysical concept. Hence, they cannot be verified empirically. We can only observe reported life satisfaction *R*.[8] Still, the

[7] This excludes scales with values ranging from -∞ and/or to +∞. Thus, the basic assumption is that the true life satisfaction scale is bounded from above and below. There are a maximum level and a minimum level of true life satisfaction, corresponding to complete satisfaction and dissatisfaction, respectively.

[8] In the future, cardinal information on true life satisfaction might come available from brain measurements, but even then it will be unknown if such measures represent linear transformations of the subjective scale of true life satisfaction!

assumptions seem plausible (to us). One extreme limit to the deviation of R from S is suggested by a possibility raised by Oswald: people who experience a maximal true life satisfaction $S = 10$ may report this by a score of $R = 8$ (in line with the British grading system, see footnote 3). Section 8 shows that such distortions imply degrees of concavity that are still significantly lower than estimated degrees of concavity of R in relative income according to least squares estimation (LS). This result implies that estimated significant concavity of R in relative income according to LS cannot be (fully) explained by possible concavity of $\hat{R}$ in S, and hence implies significant concavity of S in relative income. Thus, reported life satisfaction R is not assumed to be cardinal, but is nevertheless supposed to contain cardinal information on true life satisfaction S, conditional on assumptions (i)-(iii). In the research reported here this information turned out to be sufficient to test cardinal properties of S like concavity and convexity in relative and absolute income. Hence, we might say that R is assumed to be 'cardinal in sufficiently good approximation' (for our purposes).

Mutatis mutandis, similar arguments will hold with respect to estimated concavity of S in relative or absolute income according to a cardinal probit or logit analysus. However, an LS approach is much simpler and intuitively easier to interpret. Still, a general drawback of the usual LS of a loglinear specification is that it in principle requires estimation on the real axis, whereas the range of R scores is bounded between 0 and 10. This may be remedied by regressing a logit or lognormal specification, but then significance proofs become tedious. Moreover, a loglinear specification may give a good approximation since the variation in R that is explained by the explanatory variables is small relative to the [0,10] scale. In the case of LS with individual fixed effects (which we apply in this paper), the loglinear specification may, for each individual, be considered as a first-order Taylor expansion in the ln explanatory variables (X) around an individual-specific baseline level of well-being as determined by the value of the individual fixed effect (cf. Frey and Stutzer, 2002b, p. 407). Regressing the loglinear specification over all individuals in the sample then amounts to averaging the coefficients of X over all these individual first-order Taylor expansions.

We include individual fixed effects to account for differences in personality characteristics, which explain up to 80% of the total variation in happiness (see **...?)**. Applying LS with individual fixed effects implies that only the variation of R with X over time is estimated (within effects). This has certain disadvantages (see Sec. 6), but a great advantage in the present context is that it seems to require only inter*temporal* (approximately) cardinal comparability of R scores (as in intertemporal utility-maximizing models), but no inter*personal* cardinal or ordinal comparability of R.[9] This is because the individual fixed effects also correct for differences in the levels at which individuals

[9] Thus, our assumptions correspond to general assumption A1 in Ferrer-i-Carbonell and Frijters (2004) with the addition that we make some plausible assumptions about the scale of true well-being S and maximal concavity of the positive monotonic transformation of S into reported life satisfaction R.

"anchor" their R scale (Winkelmann and Winkelmann, 1998). These levels may not be random but correlated with explanatory variables like income and educational level (e.g. via personal characteristics like optimism and intelligence). This causes the regression coefficients to be biased in the absence of individual fixed effects. Thus, controlling for such effects implies a strong unbiased test of properties like concavity of R in X, which seems to avoid the problematic assumption of interpersonal comparability of R scores. Because of this advantage, we adopt LS with individual fixed effects as our baseline estimation.

4. Econometric specifications

The usual specification used in econometric work on life satisfaction and social reference income (e.g., Ferrer-i-Carbonell, 2004) is:

$$R = \alpha + \tilde{\beta} \ln Y - \gamma \ln Y^r + \delta X + e, \quad (1)$$

where Y is family income, Y^r is the average family income in a social reference group, X is a vector of (ln) control variables, e is an error term, and the Greek symbols stand for parameters. Parameters $\tilde{\beta}$ and γ are supposed to be non-negative and δ is a vector of parameters. Equation (1) can be rewritten as

$$R = \alpha + (\tilde{\beta} - \gamma)\ln Y + \gamma(\ln Y - \ln Y^r) + \delta X + e, \quad (2)$$

which separates the relative income effect of the difference between ln income and ln reference income from the absolute income effect of the ln income level. This relative income variable can also be written as $\ln(Y / Y^r)$, and we denote the absolute-income coefficient $\tilde{\beta} - \gamma$ as β.

In the context of Kahneman and Tversky's value-function theory $Y - Y^r$ seems the relevant variable, but $\ln(Y/Y^r)$ can be rewritten as $\ln[1 + (Y / Y^r - 1)] = \ln[1 + (Y - Y^r)/Y^r]$, i.e. as a monotonously increasing function of $(Y - Y^r)/Y^r$. This $(Y - Y^r)/Y^r$ indicates gains and losses as (percentual) fractions of Y^r, which seem even more relevant than the absolute gains and losses $Y - Y^r$. We denote this relative income gap $(Y - Y^r)/Y^r$ as G. Hence, specifications (1) and (2) can be used to test hypotheses H1-H3 and H7. However, specification (2) cannot be used to test hypotheses H4 and H5 since it is concave in G for losses as well as gains. For that purpose, we nest specification (2) into a more flexible power-function specification that is given by

$$R = \alpha + \beta \ln Y + \gamma[(Y / Y^r)^\rho - 1] / \rho + \delta X + e, \quad \rho \neq 0. \quad (3)$$

Here the power-function term approaches $\ln(Y / Y^r)$ for $\rho \to 0$. Rewriting the power function term as $\gamma[(1 + (Y - Y^r)/Y^r)^\rho - 1]/\rho$, it is easily seen that it is concave in $G \equiv (Y - Y^r)/Y^r$ for $\rho < 1$ and convex in G for $\rho > 1$. Concavity of S in positive G and convexity of S in negative G can then be tested as follows. First, we define positive relative income G^+, respectively negative relative income G^- as equal to G for positive, respectively negative values of G, but as equal to zero for negative, respectively positive values of G (cf. Ferrer-i-Carbonell). Then, we modify specification (3) as

$$R=\alpha+\beta\ln Y+\gamma^{+}[(1+G^{+})^{\rho^{+}}-1]/\rho^{+}+\gamma^{-}[(1+G^{-})^{\rho^{-}}-1]/\rho^{-}+\delta X+e\,, \tag{4}$$

where we allow for different parameters γ^{+} and γ^{-} (see below) as well as ρ^{+} and ρ^{-}. Concavity of *S* in G^{+} and convexity of *S* in G^{-} then correspond to $\rho^{+}<1$ and $\rho^{-}>1$.

Assuming that reported life satisfaction *R* is a good proxy for true life satisfaction *S* (see the previous section), the hypotheses in Section 2 imply the following inequalities for the parameters in specifications (1)-(3). Hypothesis H1 corresponds to a significantly positive value of γ in specification (1), and H2 to significantly positive values of γ in specifications (2) and (3) and of γ^{+} and γ^{-} in specification (4). Hypothesis H3 corresponds to a significantly positive values of $\gamma-\beta\equiv 2\gamma-\widetilde{\beta}$ in specification (2).

Hypothesis H4 (concavity in gains and convexity in losses) corresponds to ρ^{+} being significantly lower than one and ρ^{-} being significantly higher than one in specification (4). For hypothesis H5 (equal degrees of concavity in gains and convexity in losses) we need a measure for concavity and convexity. For our power function specification a convenient (though somewhat arbitrary) measure is $\rho^{\pm}-1$, which measures the degree of deviation from a linear relationship ($\rho^{\pm}=1$) and which is positive for a convex curvature and negative for a concave one.[10] Hypothesis H5 then implies that $\rho^{-}-1$ should not differ significantly from $-(\rho^{+}-1)=1-\rho^{+}$. To test the concavity of *S* in absolute family income (hypothesis H6), we replace the term $\beta\ln Y$ in specification (4) by the more flexible term $\beta(Y^{\sigma}-1)/\sigma$, $\sigma\neq 0$ (which approaches $\beta\ln Y$ for $\sigma\to 0$), and estimate whether σ is significantly lower than one while β is significantly positive.

Hypothesis H7 (loss aversion) is consistent with a significantly positive value of γ in specifications (2) and (3) for $\rho<1$ (concavity) since the marginal utility of relative income $G\equiv(Y-Y^{r})/Y^{r}$ then rises as *G* falls from positive to negative values. In specification (4) we have a discontinuity in the slope $\partial S/\partial G^{\pm}=\gamma^{\pm}(1+G^{\pm})^{-1+\rho^{\pm}}=\gamma^{\pm}$ for $G^{\pm}=0$ if $\gamma^{+}\neq\gamma^{-}$, but not if $\rho^{+}\neq\rho^{-}$ and $\gamma^{+}=\gamma^{-}$. It is then easily seen that there is loss aversion for all positive values of $|G^{-}|=G^{+}$ if $\gamma^{-}\geq\gamma^{+}$, $\rho^{+}<1$ and $\rho^{-}<1$ (concavity for gains as well as losses). However, if hypothesis H4 (concavity in gains and convexity in losses) holds, this condition cannot be fulfilled since ρ^{-} will then be greater than one. Fulfilment of hypothesis H7 then depends on the values of γ^{-} and ρ^{-} relative to γ^{+} and ρ^{+} and of $|G^{-}|=G^{+}\equiv G$ in a complicated way according to the slope condition $\partial S/\partial G^{-}(-G)>\partial S/\partial G^{+}(G)$. On the other hand, if hypothesis H4 is rejected, matters may become less complicated (see Sec. 7). A stronger version of hypothesis H7 is that this slope condition also holds in the limit for *G* approaching zero. This implies a kink in the satisfaction function for $G=0$

[10] For concave relations this measure equals minus Pratt's measure of relative risk aversion $rr(Y/Y^{r})\equiv-(Y/Y^{r})(\partial^{2}R/\partial(Y/Y^{r})^{2})/(\partial R/\partial(Y/Y^{r}))=1-\rho$, which is a commonly used index to describe curvature of utility.

(see Kahneman, Knetsch and Thaler, 1991), and so a significantly higher value of γ^- than the value of γ^+.

It is interesting to note that the power-function specification used here differs from that employed by Galanter (1990) and Tversky and Kahneman (1992, p. 309). In the present context the latter specification would amount to terms $\gamma^+ G^{+\rho^+}$ and $-\gamma^-(-G^-)^{\rho^-}$ for the relative income effects in specification (4), where all parameters are supposed to be positive. For decision utility Tversky and Kahneman obtained parameter estimates that in the present context would imply that both ρ^+ and ρ^- are smaller than one (about 0.9) and equal to each other, and that γ^+ is more than twice as high as γ^-. This would mean similar concavity in gains and convexity in losses (H4, H5) and loss aversion (H7). For 'predicted utility' Galanter calculated parameter values that in our context would imply that $\rho^+ = 0.45$ and $\rho^- = 0.55$ (the relative size of γ^+ and γ^- cannot meaningfully be inferred because of different scaling in combination with $\rho^+ \neq \rho^-$). Hence, we would again have concavity in gains and convexity in losses (H4), but not similar (H5). Furthermore, in the context of Galanter's utility function loss aversion can easily be shown to hold except for very small values of money.

However, in contrast to specification (4), the Galanter and Tversky and Kahneman (GTK) specification has the drawback of a lack of flexibility: For G^+ and G^- approaching zero the slopes $\partial S / \partial G^+ = \gamma^+ \rho^+ G^{+^{-1+\rho^+}}$ and $\partial S / \partial G^- = \gamma^- \rho^- (-G^-)^{-1+\rho^-}$ go to ∞ for $\rho^+ < 1$ and $\rho^- < 1$, but to 0 for $\rho^+ > 1$ and $\rho^- > 1$, while the slopes $\partial S / \partial G^\pm$ according to specification (4) equal $\gamma^\pm$ at $G^+ = G^- = 0$ for any values of ρ^+ and ρ^-. Hence, in the former as opposed to the latter case the slopes at $G^+ = G^- = 0$ do not vary continuously and independently from the concavity and convexity parameters ρ^+ and ρ^-. Another drawback of the GTK specification in the present context is that, in contrast to specification (4), it does not include the asymmetric variant of the usual loglinear specification (2) (cf. Ferrer-i-Carbonell) as a special or limiting case.

5. Measures for social reference income

An important question is how to define the (social) reference group(s) of a person, i.e. who belongs to his/her reference group(s). The reference group that has the strongest influence on the person is likely to be the social group to which the individual belongs and which consists of people of similar age, education, income, region of residence, etc. (Ferrer-i-Carbonell, 2002; cf. Senik, 2004). In addition, there will be a less strong influence from wider groups like the person's community or region of residence (Diener et al., 1993; Stutzer, 2004), the person's cohort (McBride, 2001), or the person's country (Easterlin, 1995). Thus, in general there will be more than one reference group the average income of which can be assumed to affect a person's life satisfaction (see Kapteyn and Wansbeek, 1985; Vendrik and Hirata, 2005). However, in econometric research it is usually assumed that there is only one reference group which is either identified as the social group of the person (Ferrer-i-Carbonell) or approximated by one of the wider groups mentioned above.

Ferrer-i-Carbonell uses education, age and region as reference group categories. Her reference group contains all individuals with a similar education level, inside the same age bracket, and living in the same region (West or East Germany for Ferrer-i-Carbonell's German data). The five different education categories are: less than 10, 10, 11, 12, and more than 12 years of education, and the age brackets are: younger than 25, 25-34, 35-44, 45-65, and 66 years or older. This leads to 50 different (exogenous) reference groups. However, this measure has the drawback that the age brackets are fixed. This implies, for instance, that when a person becomes 35 years old, his/her reference group suddenly changes from 25-34 to 35-44 years old. This is, of course, implausible, and in this respect the measure used by McBride (2002) is better. For USA data, he approximates the influence from the reference group by the average income in a person's cohort consisting of everyone from 5 years younger than the person to 5 years older. Thus, this reference group moves along with the age of the person. On the other hand, a severe downside of this measure is that it does not distinguish between different education categories, as Ferrer-i-Carbonell's measure does. Therefore, in this paper we introduce a new measure which combines the best of both measures, i.e. a moving age bracket as McBride's in combination with the education and region categories of Ferrer-i-Carbonell and sex. We added sex since especially men may primarily be influenced by the family income of other men.

6. Data, variables and estimation procedure

The database used for all estimations is the German Socio-Economic Panel (GSOEP; see Wagner et al., 1993; Kroh and Spiess, 2005). The panel covers the years 1984-2001 for West Germany and 1991-2001 for East Germany. The sample includes about 16000 individuals who stayed on average more than eight years in the panel. For most households all individuals are in the sample. The number of missing observations for the variables we use is less than 3%.

The dependent variable used in all estimations is reported individual life satisfaction (see Sec. 3). The main independent variable is real family income, i.e. family income corrected for the consumer price index. For social reference income we calculated the different measures discussed in the previous section. As control variables we use more or less the standard variables: First, the number of adults and children in the households (see Sec. 2); second, the number of years of education, since people with a higher educational level tend to have more skills to become happy; third, unemployment, since unemployed people will have a lower level of happiness; fourth, ln age since happiness varies with age[11]; fifth, a number of dummies for family situation (married without children, single parent,

[11] We did not include ln age squared to account for a possible U-shape of happiness as a function of age since we estimate with fixed individual and time effects that catch the effect of the variation of age between individuals

married with children up to or higher than sixteen years old); and finally, working hours with a dummy for missing observations. Time-invariant variables like gender are not included, because we estimate with fixed individual effects that catch the effect of those variables.

For our baseline estimations we use non-linear least squares with fixed time and fixed individual effects. We use fixed time effects to account for period effects on happiness. For example, people may be influenced by the phase of the business cycle, events in history like the reunion of Germany, and the price index may not always be adequate to calculate real income. We use fixed individual effects for two related reasons: First, since then only the variation of life satisfaction with explanatory variables over time is estimated (within effects), we seem to avoid the problematic assumption of interpersonal comparability of life satisfaction scores over time (see Sec. 2). Second and more generally, we prevent biases due to unobserved personality traits like optimism and intelligence affecting at the same time life satisfaction and explanatory variables like income and educational level, giving rise to spurious correlations between life satisfaction and these variables. However, estimating only within effects of course means that the information from between effects of interindividual variation is not used. As noted above, this eliminates the impact of time-invariant explanatory variables like gender and greatly reduces that of age. In a dynamic context it means that only short-run shock effects are estimated, implying a potential underestimation of long-run level effects of explanatory variables (Van Praag et al., 2003; Van Praag and Ferrer-i-Carbonell, 2004, p. 50). For that reason, we also run estimations with random individual effects (but fixed time effects) as a robustness check of the results from the baseline estimations with fixed individual effects (see Sec. 9).

7. Estimation results

This section presents estimation results for our new reference group measure. We restrict ourselves to the West-German sample, because the transformation process in Eastern Germany may have generated less stable behaviour over time when the former country was adapting to its new situation. We focus on the coefficients that are relevant for testing the hypotheses. The other coefficients will be discussed as far as they yield unexpected results.

To test hypothesis H1 we estimated equation (1) with the logarithmic specification of the impact of social-reference income. The estimated coefficients are presented in the first column of Table 1. The coefficient γ of $\ln Y^r$ (social reference income) is indeed negative and very significant. Thus, hypothesis H1 is confirmed. Moreover, γ is strikingly similar in absolute magnitude to the

---

and part of the intertemporal effect, respectively (see below), and since adding ln age squared gave rise to a significantly negative coefficient of absolute income, which is implausible. In the latter variant the coefficients and exponents of relative income were not essentially different from those without ln age squared, but they were more strongly significant while the coefficients were higher (perhaps as compensation for the negative coefficient of absolute income).

coefficient β of $\ln Y$ (family income). The size 0.31 of β indicates that a *ceteris paribus* increase in family income by 10 % would raise life satisfaction *R* of the average West German individual by 0.031. On the other hand, if at the same time the family income of people in the social reference group rises by the same 10%, implying a rise in Y^r by 10%, this would lower *R* by the same amount. The net effect of these rises in *Y* and Y^r on *R* would then be zero! In a nutshell this explains the empirical finding of no effect of income growth on average happiness in Germany (as in most other developed countries) over time (Glatzer, 1991; Easterlin, 1974, 1991). Note that the separate effects of such rises in *Y* and Y^r on life satisfaction are small, but very significant. Here one should keep in mind that income is only one of the many determinants of life satisfaction (see also Ferrer-i-Carbonell). Further note that the coefficients of the other determinants in Table 1 have plausible and mostly significant values.

Hypothesis H2 was tested using equation (2) with the logarithmic specification of the effect of relative income as well as equations (3) and (4) with the power-function specification. The estimates for equation (2), as presented in the second column of Table 1, show that the coefficient γ of ln (relative family income) is indeed positive and very significant. In fact, this and the other OLS estimates except that for absolute income are identical to the corresponding estimates for equation (1). Note that the coefficient of absolute income in equation (2) ($\beta = \tilde{\beta} - \gamma$) differs from the income coefficient in equation (1) ($\tilde{\beta}$), and is insignificant. In equation (3) (see the first column of Table 2) the estimated power coefficient ρ is small and not significantly different from zero, implying that the specification does not significantly differ from the logarithmic specification (2) (supporting the reliability of a logarithmic specification). Accordingly, the coefficient γ of the relative income term deviates only little from the estimate for γ in equation (2) and is again significantly positive. For the asymmetric specification (4) (second column of Table 2) we estimated $\gamma^+ = 0.29$ and $\gamma^- = 0.40$, which are significantly positive as well. The estimated exponents $\rho^+ = -0.93$ and $\rho^- = 0.22$ are not significantly different from zero, again implying that the specification does not significantly differ from a logarithmic one. We therefore also estimated the corresponding asymmetric variant of equation (2), yielding similar and significant estimates of γ^+ and γ^- (third column of Table 1; cf. Ferrer-i-Carbonell, 2005, fourth specification). Thus, hypothesis H2 was confirmed for all specifications.

The relative and absolute-income coefficients in equation (2) strongly suggest that they are significantly different (hypothesis H3). A Wald test indeed showed this marginally to hold (p = 0.06), thus giving support to hypothesis H3.

Surprisingly, hypothesis H4 (concavity in gains and convexity in losses) is only partially supported by the estimates of ρ^+ and ρ^- in equation (4): $\rho^- = 0.22$ is significantly lower than one (0.215 + 2 x standard error 0.185 = 0.585), implying significant concavity of life satisfaction in negative relative income, and $\rho^+ = -0.93$ is considerably lower than one, but not significantly due to the large standard error 1.22 (-0.93 + 2 x 1.22 = 1.51). The non-linear estimation procedure required starting values of ρ^+ and ρ^- close to their final values due to the closeness to 0 (causing overflow). To obtain suitable starting values of ρ^+ and ρ^-, we first estimated equation (4) for a grid of fixed values of ρ^+ and ρ^- between -4 and 4 with a difference 0.1 between successive values. The log likelihoods for all these fixed values of ρ^+ and ρ^- revealed a lower and very flat local maximum besides the sharper absolute maximum for both ρ^+ and ρ^- (see Fig. 1a and b). For ρ^- this did not pose a problem since the local maximum is located at about $\rho^- = -3$, i.e far below 1. Applying a likelihood-ratio test to the null-hypothesis H_0: $\rho^- = 1.0$ yielded $2|\ln L(0.22) - \ln L(1.0)| = 11.34 > 3.86$ ($\chi^2(1)$ threshold value at p = .05), and so rejection of H_0. Thus, just as with the t-test (or, equivalently, Wald test), we can conclude that $\rho^- = 0.22$ is significantly lower than one. For ρ^+ matters are more complicated since the local maximum is now located at $\rho^+ = 2.0$, i.e. above 1. This seems to explain the large standard error in the estimate -0.93 for ρ^+. However, applying a likelihood–ratio test to the null-hypothesis H_0: $\rho^+ = 2.0$ (i.e. at the local-maximum) yielded $2|\ln L(-0.93) - \ln L(2.0)| = 11.64 > 3.86$, and so rejection of H_0. Since $\ln L(\rho^+)$ is lower than the local maximum $\ln L(2.0)$ for any other value of ρ^+ higher than or equal to one, it then follows that a likelihood-ratio test rejects the null-hypothesis H_0: $\rho^+ = \rho_0^+$ for any $\rho_0^+ \geq 1$. Thus, in contradiction to the t-test result, this suggests that $\rho^+ = -0.93$ is significantly lower than one! Such contradictions are well-known in non-linear estimation, and it does not seem to be justified to trust one test result more than the other. Nevertheless, in this case of bimodality of the log-likelihood function, the likelihood-ratio test seems to make more sense. This would imply that life satisfaction is significantly concave in positive relative income as well.

Insert Fig. 1 about here

Hypothesis H5 (equal degrees of concavity in gains and convexity in losses) is obviously rejected since *R* is significantly concave in negative relative income. On the other hand, the estimated exponents $\rho^+ = -0.93$ and $\rho^- = 0.22$ imply $\rho^+ - 1 = -1.93$ and $\rho^- - 1 = -0.78$, and hence suggest that *R* is more concave in positive relative income than it is in negative relative income. However, due to the large standard error 1.22 in ρ^+, the t-value of the difference in degree of concavity $\rho^+ - \rho^-$ is 1.02, implying no significant difference. On the other hand, a likelihood-ratio test of H_0: $\rho^+ - \rho^- = 0$ yields $2|\ln L(-0.93,0.22) - \ln L(0.2,0.2)| = 5.36 > 3.86$, and so a significant difference in degree of concavity. Thus, according to this test, *R* is significantly more concave in positive relative income than it is in negative relative income.

Hypothesis H6 (concavity in absolute income) could not be tested because of overflow problems that are related to the insignificance of the effect of absolute income.

Hypothesis H7 (loss aversion) is confirmed for equations (2) as well as (3) due to the concavity in relative income ($\rho = -0.10 < 1$ in eq. (3)). For equation (4) we found $\gamma^- > \gamma^+$, $\rho^+ < 1$ and $\rho^- < 1$, implying loss aversion. However, this loss aversion is not significant for all values of $|G^-| = G^+$ since γ^- is not significantly greater than γ^+ (t-value of $\gamma^- - \gamma^+$ = 0.6) and ρ^+ may not be significantly smaller than one (see above). Therefore, we performed Wald tests on the slope condition $\partial S / \partial G^-(-G) = \gamma^-(1-G)^{\rho^- -1} > \partial S / \partial G^+(G) = \gamma^+(1+G)^{\rho^+ -1}$ for fixed values of *G*. This indicated that the slope condition is significant for $G \geq 0.16$, so for incomes at least 16 % higher or lower than the social reference income (note that $\partial S / \partial G^-(-G) = \gamma^-(1-G)^{\rho^- -1}$ approaches ∞ for *G* going to one). Since the outcome of the Wald test for a nonlinear parameter restriction tends to depend on the specification of the restriction, we also did the test for the log of the slope condition. This indicated significance of the slope condition for $G \geq 0.12$, so for somewhat lower values of *G* than above. For our sample considerably less than 50 % of the individuals are in these domains. Loss aversion is also implied for the asymmetric variant of logarithmic specification (2), but now it is significant for all values of $|G^-| = G^+$ because γ^- is now significantly greater than γ^+ (t-value of $\gamma^- - \gamma^+$ = 3.1). In view of this difference in results for the general specification (4) and the asymmetric variant of logarithmic specification (2), we also estimated equation (4) with fixed optimal values $\rho^+ = -0.93$ and $\rho^- = 0.22$. The difference between the estimated $\gamma^+ = 0.29$ and $\gamma^- = 0.40$ then turned out to be marginally significant (t-value = 1.71, p-value = 0.086). This implies (marginally) significant loss aversion for all values of $|G^-| = G^+$ if we assume that the concavity in positive relative income is significant, as suggested by the pertinent likelihood-ratio test (see above). This would then confirm Duesenberry's asymmetry postulate except that the impact of positive relative income is still significant. However, the test results on loss aversion are mixed.

8. Implications for cardinal properties of true life satisfaction

Do the significant cardinal properties of reported life satisfaction *R* as a function of negative and positive relative income that we have found in our estimations imply similar cardinal properties of true life satisfaction *S*? In particular, does the estimated significant concavity of *R* in negative (and positive) relative income reflect similar concavity of *S*, or can it be explained by possible concavity of "OLS-estimated" $\hat{R}$ in *S*? To tackle this question, we make the plausible assumptions (i), (ii), and (iii) that have been introduced in Section 3 and consider what may be maximal plausible concavities of *R* in *S*.

One extreme distortion of *R* relative to *S* is suggested by Oswald: people who experience a maximal *S* = 10 may report this by a score of *R* = 8. However, Figure 2 shows that although most individuals in the West German sample reported *R* = 8, there are also a lot of people who reported a 9 or 10. This implies that even if a number of West Germans who experienced *S* = 10 or 9 reported *R* =

8, others did not. It might be possible that on average West Germans who experienced $S = 10$ reported around $R = 9$, but an average score of $R = 8$ for these people seems implausible. Let us therefore first consider the former possibility and construct a continuous concave function $\hat{R}(S)$ such that $\hat{R}(5) = 5$, $\hat{R}(7) = 7$ and $\hat{R}(10) = 9$. For this we need a flexible function with at least three parameters and a suitable one turns out to be the power function $\hat{R}(S) = a(S - c)^b$ with parameters $a > 0$, $0 < b < 1$ and $c > 0$. The inverse of this function is the convex function $S(\hat{R}) = \hat{R}^r / a^r + c$, where $r \equiv 1/b > 1$. Since $\hat{R} = R - e$, it is given by the right-hand side of equation (4) minus e. Substituting this expression for $\hat{R}$ into the function $S(\hat{R})$ then yields S as a function $S[\hat{R}(Y, G^+, G^-, X)]$ of Y, G^+, G^-, and X. What we want to know is whether according to our estimates of equation (4) S is significantly concave in G^- and G^+ despite the convexity of $S(\hat{R})$. For that we need to investigate whether the second-order partial derivative $\partial^2 S / \partial G^{\mp 2}$ is significantly negative for all values of $G^{\mp}$ and $\hat{R} \geq 5$ ($S(\hat{R})$ is likely to be less convex or even concave for $\hat{R} < 5$). First, the first-order derivative $\partial S / \partial G^{\mp}$ can be derived as $\partial S / \partial G^{\mp} = (\partial S / \partial \hat{R})(\partial \hat{R} / \partial G^{\mp}) = (r\gamma / a^r)\hat{R}^{r-1}(1 + G^{\mp})^{\rho^{\mp} - 1}$. Differentiating this to $G^{\mp}$ and imposing negativity yields the condition

$$\left(\hat{R}_0 - \frac{\gamma^{\mp}}{\rho^{\mp}}\right)(1 - \rho^{\mp}) > \gamma^{\mp}(1 + G^{\mp})^{\rho^{\mp}}\left(r - 1 - \frac{1 - \rho^{\mp}}{\rho^{\mp}}\right) \quad (5)$$

for all values of $G^{\mp}$ and $\hat{R}_0 \equiv \hat{R}(Y, 0, 0, X) \geq 5$. On the left-hand side of this equation we see the estimated degree of concavity $1 - \rho^{\mp}$ of $\hat{R}$ in $G^{\mp}$, while on the right-hand side the maximal plausible degree of convexity $r - 1$ of S in $\hat{R}$ appears.

Insert Fig. 2 about here

Our estimates $\gamma^- = 0.404$ and $\rho^- = 0.215$ for equation (4) imply $\gamma^- / \rho^- = 1.88$, which is smaller than $\hat{R}_0 \geq 5$, making the left-hand side of condition (5) positive. The three restrictions $\hat{R}(5) = 5$, $\hat{R}(7) = 7$, and $\hat{R}(10) = 9$ for $\hat{R}(S)$ lead to a power equation in r (see Appendix A) that can only be solved numerically and yielded a value $r = 2.41$. The factor $r - 1 - (1 - \rho^-)/\rho^- = r - 4.65$ on the right-hand side of (5) is then negative, rendering this side negative. Condition (5) is then satisfied for all $G^{\mp}$ and $\hat{R}_0 \geq 5$. Estimates $\gamma^+ = 0.293$ and $\rho^+ = -0.928$ imply $\gamma^+ / \rho^+ < 0$, making the left-hand side of condition (5) again positive. However, the factor $r - 1 - (1 - \rho^+)/\rho^+$, and hence the right-hand side of (5), is then positive. In this case fulfilment of condition (5) is not trivial, but $\rho^+ < 0$ implies $(1 + G^+)^{\rho^+} < (1 + 0)^{\rho^+} = 1$ for all $G^+ \geq 0$, and hence fulfilment of condition (5) for all $G^+ \geq 0$ if and only it holds for $G^+ = 0$. Condition (5) then simplifies to

$$5(1 - \rho^+) > \gamma^+(r - 1), \quad (6)$$

where we substituted *5* for $\hat{R}_0$ since the condition for $\hat{R}_0 = 5$ implies the condition for $\hat{R}_0 > 5$. This condition is satisfied for values of r such that $9.640 > 0.293$ (r-1), i.e. for $r < 33.24$, and hence for the value 2.41 of r found above. Thus, for this rather extreme distortion of the reported life satisfaction scale condition (5) is fulfilled for negative as well as positive relative income (and $\hat{R}_0 \geq 5$). This implies that despite of the distortion true life satisfaction is concave in both domains. This even holds for the implausibly extreme concavity of $\hat{R}$ in S that is implied by the restrictions $\hat{R}(5) = 5$, $\hat{R}(7) = 7$, and $\hat{R}(10) = 8$, yielding $r = 6.30$.

However, for the concavity of S in negative and positive relative income to be significant, condition (5) should be satisfied significantly. Therefore, for negative relative income we performed Wald tests on condition (5) for $r = 2.41$ and $r = 6.30$, various values of G^- between 0 and -1 and $\hat{R}_0 = 5$ (since $1 - \rho^-$ is significantly positive fulfilment of (5) for $\hat{R}_0 = 5$ implies (5) for $\hat{R}_0 > 5$). For $r = 2.41$ the H_0 of equality was strongly rejected with p ranging from 0.0015 for $G^- = 0$ to 0.0000 for $G^- = -1$. On the other hand, for $r = 6.30$ the H_0 of equality was not rejected for $G^- = 0$ ($p = 0.23$), but only rejected for $G^- \leq -0.7$, which comprised very few observations. Thus, for negative relative income condition (5) is satisfied significantly for $r = 2.41$, but not for $r = 6.30$. For positive relative income ρ^+ is not significantly smaller than one according to a t-test, or equivalently Wald test (see Sec. 7). Therefore, Wald tests on the stronger concavity condition (5) will not reject the H_0 of equality. However, we also did likelihood-ratio tests (see Sec. 7), which yielded the opposite result for $r = 2.41$ as well as $r = 6.30$ (see Appendix A and cf. Sec. 7).

Summarizing, we can then conclude that, according to our estimates of equation (4), true life satisfaction S is significantly concave in negative relative income even in the presence of a rather extreme concavity of reported life satisfaction $\hat{R}$ in S as assumed above ($r = 2.41$). On the other hand, for positive relative income we can only conclude that S is significantly concave on the basis of likelihood-ratio tests, but not on the basis of Wald tests.

9. Robustness of results

The control variables age and years of education are also determinants of our measure of social reference income (see Sec. 5). This may give problems of multicollinearity. In order to test for that we estimated equation (4) without either age or education or both. Omitting age did not essentially change the estimates for negative relative income, but it made the coefficient of positive relative income insignificant, while the coefficient of absolute income became less insignificant (especially when education was omitted as well). The exponent for positive income became even more negative, but remained insignificantly different from one (according to a Wald test). Omitting only education did not affect the estimates for relative income.

In order to test for robustness of our results we also conducted estimations for the Galanter and Tversky and Kahneman (GTK) specification of the impact of relative income in equation (4) (see Sec. 4), for three alternative populations, and with random individual effects. The estimates for the GTK specification are shown in the third column of Table 2. The relative-income coefficients $\gamma^{+} = 0.13$ and $\gamma^{-} = -0.69$ have the expected sign and γ^{-} is significant, but γ^{+} is only marginally significant (p = 0.08). The absolute-income coefficient β is insignificant and the other coefficients are similar to those for equation (4). The exponents $\rho^{+} = 0.43$ and $\rho^{-} = 1.67$ indicate concavity of S in positive as well as negative relative income, and both concavities are significant since both coefficients are significantly different from one. The degrees of these concavities do not significantly differ. Finally, because γ^{-} is significantly greater in absolute value than γ^{+} significant loss aversion for all values of G is implied. Thus, these results are more or less in line with those for our baseline-estimations with some characteristics being more significant despite of the drawbacks of the GTK specification (as mentioned at the end of Section 4).

Equation (4) was also estimated for the subpopulations of West German men and women and for the sample from East Germany (see Sec. 6). For both West German men and women the relative-income coefficients γ^{+} and γ^{-} are significantly positive with the coefficients for women being insignificantly higher. The absolute-income coefficient β is insignificant for both sexes. Furthermore, for both men and women S is insignificantly concave in positive relative income (according to a Wald test) and significantly concave in negative relative income with the concavity for men being insignificantly stronger. Thus, there is no significant difference in the effects of relative income between the sexes. For the East-German sample we found significantly positive relative-income coefficients γ^{+} and γ^{-}, which are insignificantly higher than the estimates for West Germany in Table 2. The effect of absolute income is again insignificant and S is concave in positive as well as negative relative income, but both concavities are insignificant. This last result may be related to the smaller sample size for Eastern Germany (36313 observations).

Finally, Equation (4) was estimated with random instead of fixed individual effects (along the lines of Ferrer-i-Carbonell, 2005). In this case the exponents ρ^{+} and ρ^{-} could not be estimated directly, but only via an estimation of equation (4) for a grid of fixed values of ρ^{+} and ρ^{-} and determination of the global maximum of the log likelihoods (cf. Sec. 7). The results were similar results to those for the fixed individual effects in Table 2 with a somewhat higher coefficient γ^{-} and a somewhat lower coefficient γ^{+}, but not significantly. Hence, we did not find indications of significant differences between long-run level and short-run shock effects of relative income (see Sec. 6).

10. Explanation and possible implications for behaviour

Thus, the most striking result that we found is that of strongly rising sensitivity of life satisfaction S to more negative values of relative income. On the basis of the theory of Kahneman and Tversky we expected the opposite, namely a diminishing sensitivity of S to more negative relative income. How can this be explained? One possible explanation is that the average income in the reference group of a person affects her (his) life satisfaction not only since she compares her income with this reference income, but also since her income relative to the reference income influences the extent to which she and her family can participate in social activities in the reference group. Such social activities, like trips, theatre visits, school outings, etc. cost money, and tend to be more costly as the average income in the reference group is higher. When your income is only little below the reference income, this will not be a problem, but if your income is considerably lower, it may become a financial problem for you and your family to participate in all social activities that your family members would like to participate in. As your income falls increasingly short of that in your reference group, it becomes increasingly and more than proportionally hard to raise the funds to participate in the social activities of the reference group. This effect of rising marginal social participation costs of falls in relative income apparently dominates a possible social comparison effect of diminishing marginal sensitivity of life satisfaction to such falls, which is suggested by the theory of Kahneman and Tversky. This interpretation is supported by our result from a likelihood-ratio test that reported life satisfaction R is significantly more concave in positive relative income than it is in negative relative income. Since variations in R around a specific social reference income cover only a small range of the total scale of R (see above), this result probably carries over to true life satisfaction S. It can then be explained by the interpretation that in the positive domain the diminishing marginal sensitivities of life satisfaction to relative income due to social comparison and social participation effects reinforce each other, whereas in the negative domain the diminishing marginal sensitivity of life satisfaction to relative income due to social comparison is counteracted and even dominated by the rising marginal sensitivity of life satisfaction to relative income due to social participation deficits. Thus, in this case the objective functioning (Sen, 1985) effect of a lack of social participation seems to be more important for happiness than the subjective perception effect of social comparison (see Vendrik and Hirata, 2006, for the distinction between both kinds of effect).

The properties of the relative-income dependence of life satisfaction that have been discussed above may also have implications for certain decisions that people take. In general, people can be expected to aim at raising their happiness by their decisions. By now there is a lot of evidence that people are often not successful in that, for instance when they fail to take into account that when their own income rises that of others may rise as well (implying little change in their relative income, and hence in their happiness, see Sec. 7). However, this lack of anticipation of changes in exogenous variables does not deny that the *structure* of their decision utility function may be similar to that of their experienced utility function of life satisfaction. In such a situation, the concavity properties of the latter function that we have found have interesting implications.

First, when the decision involves risky alternatives, the decision-taker will be risk averse for negative as well as positive relative income, in contrast to the risk seeking in losses that is implied by prospect theory. Second, in a context of riskless labour supply decisions, when the income is the result of a choice of working hours of effort, there are two implications. The first one is an application of a model for status behaviour that has been developed by Clark and Oswald (1998). Translated in the context of our life-satisfaction study, that model addresses the question whether people will raise or lower their working hours or effort when their social reference income Y^r rises. According to the so-called ratio-comparison variant of the model, the strong concavity of *S* in positive relative income that is associated with the negative sign of $\rho^+ = -0.93$ implies that in the positive domain people will raise their working hours or effort when Y^r rises (following behaviour in the terminology of Clark and Summers). On the other hand, the weaker concavity of *S* in negative relative income that is associated with the positive sign of $\rho^- = 0.22$ implies that in the negative domain people will start to work less or make less effort when Y^r rises (deviant behaviour). Unfortunately, both implications are insignificant since neither ρ^+ nor ρ^- differ significantly from zero. In other words, the estimated equation (4) does not significantly differ from the asymmetric logarithmic equation, according to which people do not react to rises in their social reference income.

Another labour supply implication is suggested by the research of Goette et al. (2004) on within-day labour supply of cabdrivers and bicycle messengers. They formulate an intertemporal model of reference-dependent preferences for allocation of effort over a working day. The model is based on the Kahneman-Tversky value function with an income target acting as the reference point. The convexity of the value function for income below this target and the concavity for income above the target lead to the prediction that in the course of the day effort will first increase as earnings approach the target and then decrease as earnings have passed the target. This pattern is confirmed by empirical studies of the labour supply of cabdrivers and bicycle messengers. However, the estimates obtained for our life satisfaction function suggest a different pattern: when the social reference income acts as an income target, the concavity of the life satisfaction function for negative as well as positive relative income implies diminishing marginal life satisfaction as income rises. This would imply falling effort or working hours as income rises for levels below as well as above the target.

11. Conclusion

This paper investigated seven hypotheses about the importance of reference income for individual life satisfaction. These hypotheses are based on Kahneman and Tversky's prospect theory, which uses asymmetric utility functions to explain human decisions. But the first two of the hypotheses are also standard in the happiness literature on the impact of social reference income. Prospect theory has been tested for decision utility, but not for experienced utility. The estimation results confirm asymmetric effects for positive and negative relative income, and indicate significant concavity for positive relative income. But in contrast to prospect theory, the experienced utility of life satisfaction turns out to be significantly concave in negative relative income as well. Moreover, under plausible assumptions on the cardinal properties of the 'true-life-satisfaction' scale, this result was shown to be robust to extreme distortions of the reported-life-satisfaction scale. The result is not as surprising as it seems at a first glance. People participate in activities within their social reference groups. As their income is lower it becomes more and more difficult to do so because they don't have enough income for these activities. It is, therefore, not odd that the marginal effect of a fall in income below the reference income increases with the relative income gap.

Appendix A. Concavity conditions

Consider the case of an implausibly extreme distortion with $r = 6.30$ in Section 8. For positive relative income condition (6), and hence (5), is then obviously satisfied, but for negative relative income the right-hand side of condition (5) becomes positive. Fulfilment of (5) is then again not trivial, but $\rho^- > 0$ implies $(1 + G^-)^{\rho^-} \leq (1 + 0)^{\rho^-} = 1$ for all $G^- \leq 0$, and hence fulfilment of condition (5) for all $G^- \leq 0$ if and only if it holds for $G^- = 0$. Condition (5) then simplifies to $5(1 - \rho^-) > \gamma^-(r - 1)$ (analogous to condition (6)). This condition is satisfied for $r < 10.83$, and hence for $r = 6.30$.

For positive relative income we did likelihood-ratio tests to determine whether condition (5) is satisfied significantly. For that we determined the highest ρ^+ for which condition (5) is just trivially satisfied. This is ρ^+ for which the factor $r - 1 - (1 - \rho^+)/\rho^+$ in (5) equals zero, i.e for which $\rho^+ = 1/r$. For $r = 2.41$ this yields $\rho^+ = 0.41$. Hence, for $\rho^+ = 0.40$ (for which we obtained a log-likelihood value; see Sec. 7) the right-hand side of condition (5) is just negative, while the left-hand side is positive since $\gamma^+/\rho^+ = 0.73$ is smaller than $\hat{R}_0 \geq 5$. Thus, for $\rho^+ = 0.40$ condition (5) is satisfied, and applying a likelihood-ratio test to H_0: $\rho^+ = 0.40$ yielded $2\left|\ln L(-0.93) - \ln L(0.4)\right| = 8.60 > 3.86$, and so rejection of H_0. This means that the estimated $\rho^+ = -0.93$ is significantly lower than $\rho^+ = 0.40$, for which condition (5) is satisfied. We can then conclude that, according to a likelihood-ratio test for $r = 2.41$, concavity condition (5) is satisfied significantly for our estimated $\rho^+ = -0.93$. For $r = 6.30$ condition (5) is just trivially satisfied for $\rho^+ = 0.10$, and H_0: $\rho^+ = 0.10$ is rejected by a likelihood-ratio test as well. Hence, even for this implausibly extreme distortion of the reported-life-satisfaction scale concavity condition (5) is fulfilled significantly. Thus, in both cases we have a contradiction with the result from a Wald test.

References

Blanchflower, D.G. and A.J. Oswald (2004). "Well-being over Time in Britain and the USA". *Journal of Public Economics*, 88, 1359-1386.

Clark, A.E. and A.J. Oswald (1996). "Satisfaction and Comparison Income." *Journal of Public Economics*, 61, 359-381.

Clark A.E. and A.J. Oswald (1998), "Comparison-Concave Utility and Following Behaviour in Social and Economic Settings", *Journal of Public Economics*, 70, 133-155.

Diener, E., E. Sandvik, L. Seidlitz, and M. Diener (1993). "The Relationship between Income and Subjective Well-Being: Relative or Absolute?" *Social Indicators* Research, 28, 195-223.

Duesenberry, J.S. (1949), *Income, Saving and the Theory of Consumer Behavior*, Cambridge, MA.

Easterlin, R.A. (1974). "Does Economic Growth Improve the Human Lot? Some Empirical Evidence." In P. A. David and M. W. Reder (eds.), *Nations and Households in Economic Growth: Essays in Honor of Moses Abramowitz*. New York and London: Academic Press: 89-125.

Easterlin, R.A. (1995), "Will Raising the Incomes of All Increase the Happiness of All?", *Journal of Economic Behavior and Organization*, 27, 35-47.

Easterlin, R.A. (2001). "Income and Happiness: Towards a Unified Theory". *The Economic Journal*, 111 (473), 465-484.

Ferrer-i-Carbonell, A. (2005). "Income and Well-being: An Empirical Analysis of the Comparison Income Effect", *Journal of Public Economics*, 89, 997-1019.

Ferrer-i-Carbonell, A. and P. Frijters (2004). "How Important is Methodology for the Estimates of the Determinants of Happiness?". *The Economic Journal*, 114 (July), 641-659.

Festinger, L. (1954). "A Theory of Social Comparison." *Human Relations*, 7, 117-140.

Frank, R.H. (1997). "The Frame of Reference as a Public Good", *The Economic Journal,* 107 (Nov), 1832-47.

Frey, B.S., and A. Stutzer (2002a). *Happiness and Economics: How the Economy and Institutions Affect Well-Being*. Oxford: Princeton University Press.

Frey, B.S. and A. Stutzer (2002b). "What can economists learn from happiness research?", *Journal of Economic Literature*, 40: 402-435.

Galanter, E., "Utility Functions for Nonmonetary Events", *American Journal of Psychology*, 103 (4), 449-470.

Goette, L., E. Fehr, and D. Huffman (2004), "Loss Aversion and Labor Supply", *Journal of the European Economic Association*, 2 (2-3), 216-218.

Johansson-Stenman, O. and P. Martinsson (2005), "Identity, Self-Deception and Subjective Well-Being", Working paper, Department of Economics, Götenborg University.

Kahneman, D. (1999), "Objective Happiness", in D. Kahneman, E. Diener, and N. Schwarz (eds.), *Well-Being: The Foundations of Hedonic Psychology*, New York: Russell Sage Foundation, Ch. 1.

Kahneman, D. (2003), "A Perspective on Judgment and Choice: Mapping Bounded Rationality", *American Psychologist*, 58, 697-720.

Kahneman, D., J.L. Knetch, and R.H. Thaler (1991), "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias", *Journal of Economic Perspectives*, 5, 1: 193-206.

Kahneman, D. and A. Tversky (1979), "Prospect Theory: An Analysis of Decision under Risk", *Econommetrica,* 47, 263-291.

Kahneman, D., P.P. Wakker and R. Sarin (1997), "Back to Bentham?: Explorations of Experienced Utility", *The Quarterly Journal of Economics*, May, 375-405.

Kapteyn, A., and T. Wansbeek: 1985, "The individual welfare function: A review." *Journal of Economic Psychology,* 6, 333-363.

Köbberling, V., C. Schwieren and P.P. Wakker (2004), "Prospect-Theory's Diminishing Sensitivity versus Economic's Intrinsic Utility of Money: How the Introduction of the Euro Can Be Used to Disentangle the Two Empirically", Working paper, Faculty of Economics and Business Administration, Maastricht University.

Kroh, M., and M. Spiess (2005). "Documentation of Sample Sizes and Panel Attrition in the German Socio Economic Panel (SOEP), 1984-2004", *Data Documentation* 6, 2005, DIW, Berlin.

McBride, M. (2001). "Relative-Income Effects on Subjective Well-Being in the Cross-section", *Journal of Economic Behavior and Organization*, 45, 251-278.

Oswald, A.J. (2005). "On the Common Claim that Happiness Equations Demonstrate Diminishing Marginal Utility of Income". *IZA Discussion Paper*, No. 1781, IZA, Bonn.

Schyns, P. (2002). "Wealth Of Nations, Individual Income and Life Satisfaction in 42 Countries: A Multilevel Approach." *Social Indicators Research*, 60, 5-40.

Sen, A. K. (1985). *Commodities and Capabilities*. Amsterdam: North-Holland.

Senik, C. (2004), "When Information Dominates Comparison: Learning from Russian Subjective Panel Data', *Journal of Public Economics*, 88, 2099-2123.

Stutzer, A. (2004), "The Role of Income Aspirations in Individual Happiness, *Journal of Economic Behavior and Organization*, 54, 89-109.

Swalm, R.O. (1966), "Utility Theory: Insights into Risk Taking", *Harvard Business Review*, 44, 123-136.

Thaler, R. (1980), "Toward a Positive Theory of Consumer Choice", *Journal of Economic Behavior and Organization*, 1, 39-60.

Tversky, A. and D. Kahneman (1991), "Loss Aversion in Riskless Choice: A Reference-Dependent Model", *The Quarterly Journal of Economics*, 106, 1039-1061.

Tversky, A. and D. Kahneman (1992), "Advances in Prospect Theory: Cumulative Representation of Uncertainty", *Journal of Risk and Uncertainty*, 5, 297-323.

Van Praag, B.M.S. and A. Ferrer-i-Carbonell (2004), *Happiness Quantified: A Satisfaction Calculus Approach*, Oxford University Press.

Van Praag, B.M.S., P. Frijters, A. Ferrer-i-Carbonell (2003), "The Anatomy of Subjective Well-Being", *Journal of Economic Behavior & Organization*, 51, 29-49.

Vendrik, M. and J. Hirata (2003), "Experienced versus Decision Utility of Income: Relative or Absolute Happiness", Research Memorandum METEOR, RM/03/039, Faculty of Economics and Business Administration, Maastricht University, forthcoming in L. Bruni and P.L. Porta (eds.; 2006), *Handbook of Economics and Happiness*, Edward Elgar

Wagner, G.G., R.V. Burkhauser, and F. Behringer (1993), "The English Language Public Use File of the German Socio-Economic Panel, *Journal of Human Resources*, 28: 429-433.

Winkelmann, L. and R. Winkelmann (1998), "Why are the Unemployed So Unhappy? Evidence from Panel Data". *Economica*, 65, 1-15.

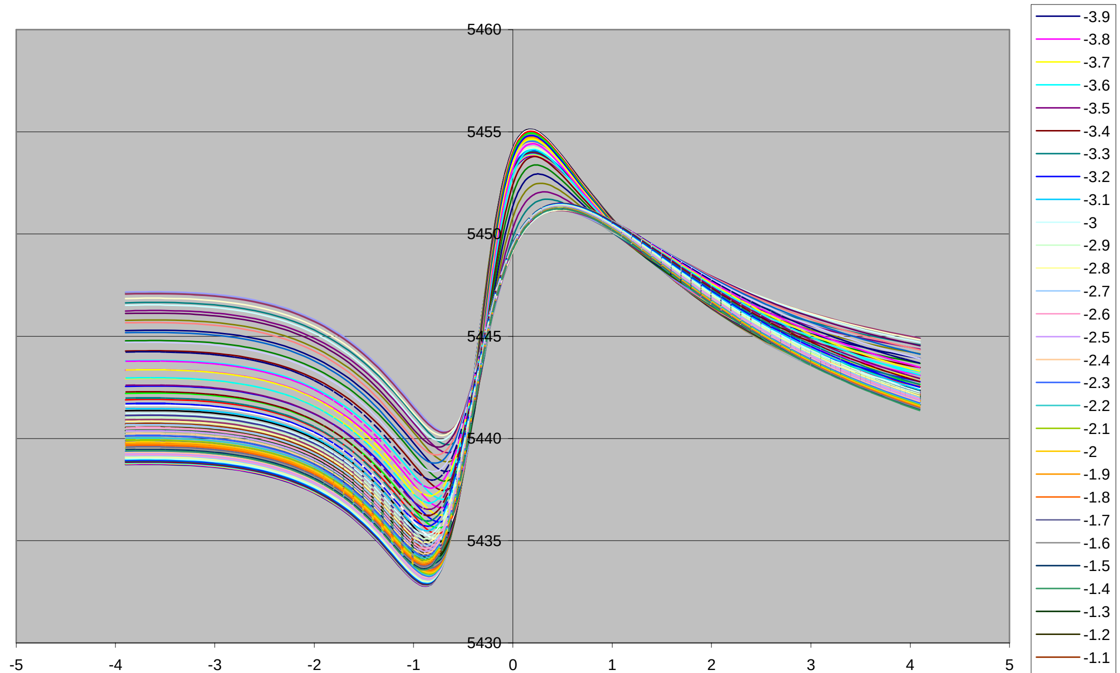
Table 1. Tests of hypotheses 1-3 and 7

Least squares estimation with fixed individual and time effects for Western Germany 1984-2001, with White cross-section standard errors.

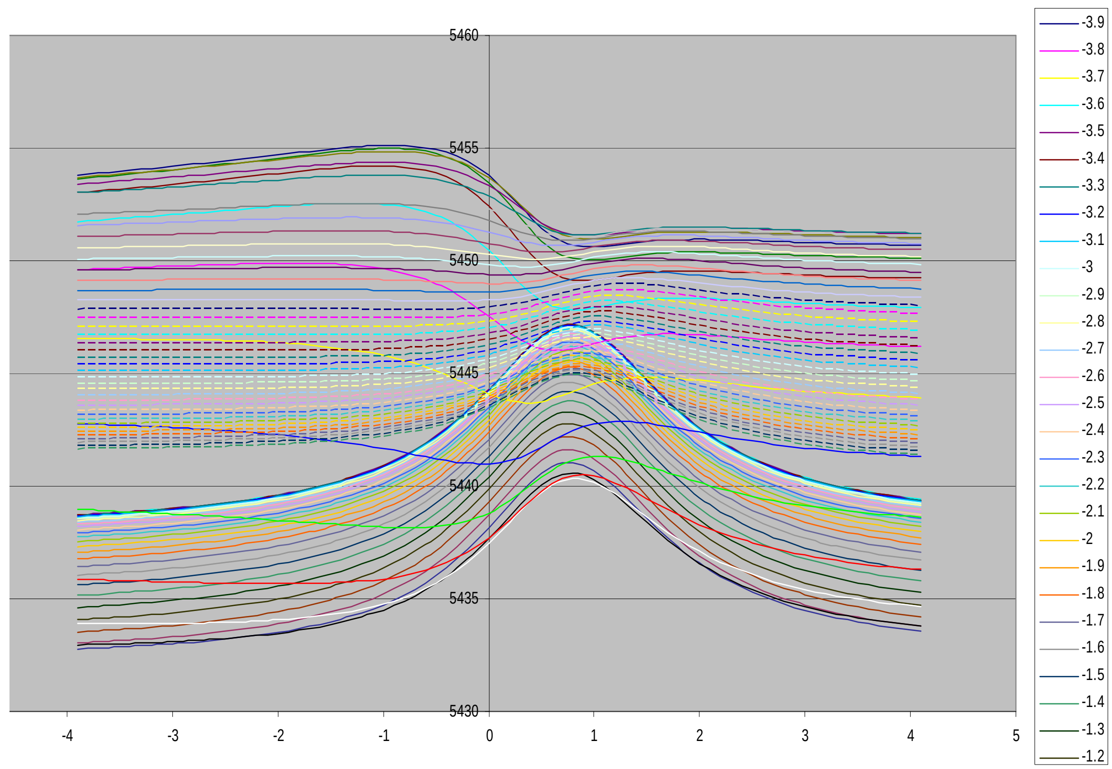
	Equation 1		Equation 2		Equation 2, asymmetric	
Variable	Coefficient	T-ratio	Coefficient	T-ratio	Coefficient	T-ratio
Constant	2.158	2.05	2.158	2.05	2.156	2.06
Ln(family income)	0.313	14.04	0.003	0.04	0.010	0.12
Ln(reference income)	-0.310	-4.02				
Ln(fam. inc./ref. Inc.)			0.310	4.02		
Pos. ln (fam. inc./ref. inc.)					0.207	2.34
Neg. ln (fam. inc./ref. inc.)					0.358	4.78
Ln(number of adults)	-0.141	-6.02	-0.141	-6.02	-0.141	-6.02
Ln(1+number of children)	-0.076	-2.27	-0.076	-2.27	-0.079	-2.35
Unemployed	-0.633	-11.96	-0.633	-11.96	-0.627	-11.82
Ln(years of education)	-0.020	-0.18	-0.020	-0.18	-0.022	-0.19
Ln(age)	1.271	9.59	1.271	9.59	1.267	9.53
Couple	0.305	10.08	0.305	10.08	0.292	9.97
Single parent	-0.168	-4.69	-0.168	-4.69	-0.174	-4.87
Couple with children below 17	-0.188	-8.14	-0.188	-8.14	-0.183	-8.00
Couple with children above 16	-0.115	-3.87	-0.115	-3.87	-0.114	-3.88
Couple with children both below 17 and above 16	0.160	3.80	0.160	3.80	0.148	3.57
Ln(1+weekly hours worked)	0.021	1.00	0.019	0.93	0.018	0.89
Weekly hours dummy	0.043	0.66	0.041	0.63	0.040	0.61
Number of observations	102068		102068		102068	
Number of individuals	11077		11077		11077	
R^2	0.50		0.50		0.50	
Adjusted R^2	0.44		0.44		0.44	
Durbin-Watson statistic	1.76		1.76		1.76	

Table 2. Tests of hypotheses 2, 4, 5 and 7
Least squares estimation with fixed individual and time effects for Western Germany 1984-2001, with White cross-section standard errors.

	Equation 3		Equation 4		GTK equation	
Variable	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	2.205	2.09	2.139	2.03	1.604	1.79
Ln(family income)	-0.003	-0.03	0.015	0.17	0.096	1.62
$((\text{Fam. inc/ref. inc})^{\rho}-1)/\rho$	0.308	3.50				
ρ	-0.095	-0.64				
Pos. $((\text{fam inc/ref inc})^{\rho+}-1)/\rho^{+}$			0.293	3.88		
ρ^{+}			-0.928	-0.76	0.432	2.54
Neg. $((\text{fam inc/ref inc})^{\rho-}-1)/\rho^{-}$			0.404	3.21		
ρ^{-}			0.215	1.16	1.672	6.36
Pos. $(\text{fam inc/ref inc}-1)^{\rho+}$					0.128	1.73
Neg. $(\text{fam inc/ref inc}-1)^{\rho-}$					-0.686	-2.81
Ln(number of adults)	-0.139	-6.13	-0.149	-6.44	-0.152	-6.60
Ln(1+number of children)	-0.076	-2.27	-0.082	-2.46	-0.084	-2.48
Unemployed	-0.631	-11.81	-0.627	-11.84	-0.627	-11.81
Ln(years of education)	-0.021	-0.18	-0.018	-0.16	-0.027	-0.25
Ln(age)	1.274	9.66	1.260	9.44	1.226	8.54
Couple	0.302	10.30	0.291	9.77	0.289	9.73
Single parent	-0.170	-4.79	-0.172	-4.83	-0.175	-4.95
Couple with children below 17	-0.187	-8.06	-0.183	-8.17	-0.184	-7.99
Couple with children above 16	-0.115	-3.88	-0.111	-3.82	-0.111	-3.73
Couple with children both below 17 and above 16	0.157	3.81	0.148	3.53	0.142	3.43
Ln(1+weekly hours worked)	0.021	1.00	0.019	0.93	0.018	0.89
Weekly hours dummy	0.043	0.66	0.041	0.63	0.040	0.61
Number of observations	102068		102068		102068	
Number of individuals	11077		11077		11077	
R^2	0.50		0.50			
Adjusted R^2	0.44		0.44			
Durbin-Watson statistic	1.76		1.76			



(a)



(b)

Figure 1. Log-likelihood profiles for fixed values of ρ^+ and ρ^- in equation (4): (a) as a function of ρ^- for various ρ^+, (b) as a function of ρ^+ for various ρ^-

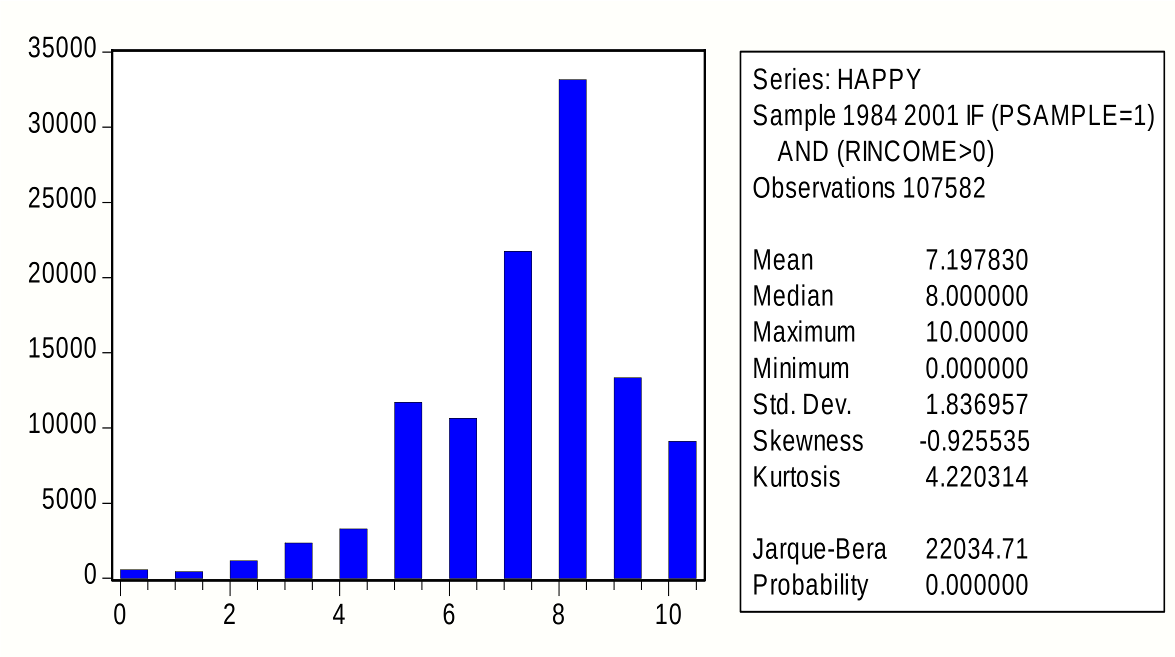


Figure 2. Sample distribution of reported life satisfaction

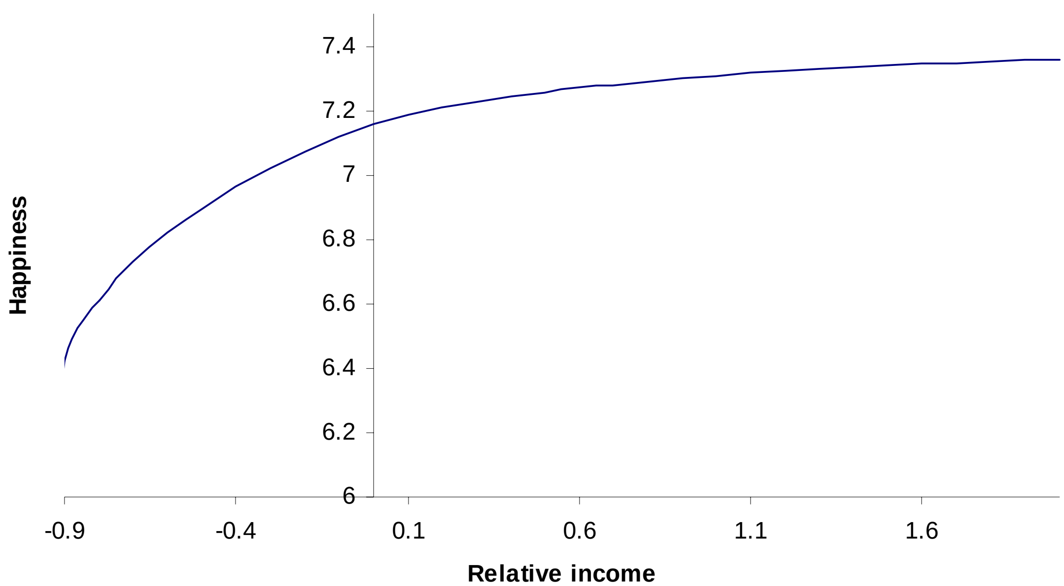


Figure 3. Dependence of individual life satisfaction on relative income for Western Germany, 1984-2001 (equation 4)