Can Behavioural Economics Be Applied To Life Satisfaction?: Evidence From Annual Panel Data

Fırat Yaman* Patricia Cubí-Mollá† Sergiu Ungureanu‡

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Abstract

We use an annual household panel to test whether a number of findings in behavioural economics can be supported by measures of life satisfaction and other variables. We test the following hypotheses: life satisfaction is increasing and concave in income gains; life satisfaction is decreasing and convex in income losses; changes in income, health, and employment are evaluated against a reference point; loss aversion applies to income, health and employment; recalled or expected life satisfaction is anchored at current life satisfaction and adjusted in the direction of the recall or expectation. Using a fixed effects estimator, we find that life satisfaction is increasing and concave in income gains, decreasing and convex in income losses, influenced by both the levels of income, health and employment, as well as their changes compared to the previous year. Moreover, we find that current levels of life satisfaction are better predictors of remembered (expected) life satisfaction than past (future) life satisfaction. The results provide support for prospect theory, anchoring and adjustment, and raise doubts about using the status quo as the correct reference point.

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*Department of Economics; City, University of London. Email: Firat.Yaman.1@city.ac.uk.

†Office of Health Economics. Email: Pcubi-molla@ohe.org.

‡Department of Economics; City, University of London. Email: Sergiu.Ungureanu.1@city.ac.uk.

1 Introduction

Since the publication of "Prospect theory: An analysis of decision under risk" by Kahneman and Tversky (1979), non-expected utility theory has been develped in a very active literature. Many authors have proposed alternatives or extensions to the classical expected-utility model[1] and another strand of the literature has tested the assumptions of, and hypotheses derived from, prospect theory and subsequent extensions by means of laboratory or field experiments.[2]

Less work has been devoted to the question of to what extent the building blocks of prospect theory – and related theories in the behavioral economics field – can be validated in survey data. In particular, using life satisfaction or subjective well-being as a utility proxy, Boyce et al. (2013), De Neve et al. (2015), and Di Tella et al. (2010) test and affirm the loss aversion hypothesis with respect to income, and Fang and Niimi (2015) and Vendrik and Woltjer (2007) test and affirm loss aversion with respect to relative income.[3]

In this paper we investigate which elements of prospect theory can be supported by observational data. In particular, which elements of prospect theory can be validated in a panel in which life satisfaction, interpreted as utility, is self-reported on an annual basis? We consider the following properties of prospect theory: (1) utility is evaluated against a reference point; (2) marginal utility is decreasing in gains and losses; (3) there is loss aversion, that is the decrease in utility due to a loss is greater than the increase due to an equivalent gain. These are relevant aspects of prospect theory in choices that do not involve chance (Kahneman and Tversky, 1979; Tversky and Kahneman, 1991). We do not test for the presence of probability weighting in this paper[4] because our data do not provide a good source of identification of probability weighting.

Prospect theory was initially created as a decision theory but has since its inception been extended to applications of life satisfaction and well-being. The theory has grown out of and has been tested through experimental findings. By their nature experiments are restricted to short time spans between the presentation of the experiment and the observation of the participant's response, and to the participant's evaluation

[1]There are many examples. Kőszegi and Rabin (2006) propose a model with reference-dependent utility where the reference-point is defined to be expected consumption shortly before consumption occurs. Bénabou (2012), Brunnermeier and Parker (2005), Gollier (2011), and Gottlieb (2014) all build models in which agents can - to some extent - choose what to believe in order to enjoy anticipatory utility.

[2]See DellaVigna (2009) for an overview of this burgeoning literature.

[3]Fang and Niimi (2015) do not define relative income but use the individual's subjective evaluation of how rich/poor he is. Vendrik and Woltjer (2007) use the average income of an age-education-region-sex cell as reference income.

[4]Probability weighting appears in the original article Kahneman and Tversky (1979) and in many, though not all, subsequent presentations of prospect theory.

of a controlled experience. However, prospect theory also has intuitive appeal when we consider longer time spans and a global evaluation of life satisfaction. Household or individual panels are thus a well-suited source of data to test whether and to what extent prospect theory can explain the evolution of life satisfaction over longer periods of time. The contribution of this paper is precisely to evaluate how well each of the above elements of prospect theory can explain levels and changes in life satisfaction over the course of a year. In addition to the above elements, we also exploit a set of questions of our data to evaluate whether expected (recalled) life satisfaction is better explained by future (past) levels or current levels of life satisfaction. This test is motivated by the psychological literature showing that individuals' perceptions of past feelings or experiences are affected by conditions in the present (see for example O'Brien et al. (2012), Wilson et al. (2003) and Gilbert (2006)).

In this paper, we also look for supporting evidence for the anchoring and adjustment heuristic. Anchoring and adjustment was originally proposed in Tversky and Kahneman (1974) as a descriptive model of how answers to difficult questions are generated. In the model, an initial starting value serves as the *anchor*, and this value is improved (*adjusted*) until it becomes a satisfactory answer. The anchor is often the answer to an easier question, a hint suggested by the question itself, or even unrelated information in the question. The model lacks a specific description of the cost benefit analysis of the search process, but its qualitative features are very well supported by evidence. Epley and Gilovich (2006) provide an up-to-date discussion. In the analysis of the dataset, it was readily apparent that the current life satisfaction values could be seen anchors for the harder questions of what future expected and recalled life past satisfaction were. To further test this theory, we looked for evidence of the adjustment process, relative to the anchor.

In line with prospect theory, we find that household income (the only continuous variable in our model) exhibits a diminishing marginal effect on life satisfaction, and that decreases in life satisfaction due to losses are larger than increases due to symmetric gains, which is evidence of loss aversion. Contrary to prospect theory, we find that levels of life satisfaction are much better explained by levels of independent variables, whereas first differences (changes over a year) in life satisfaction are better explained by changes rather than levels of independent variables. This suggests that lagged variables are not an adequate model for the formation of the reference point in prospect theory. Finally, we find compelling evidence for the anchoring and adjustment heuristic when respondents try to determine past and future life satisfaction. Current life satisfaction is a much better predictor of remembered life satisfaction than past life satisfaction, and a much better predictor of expected life satisfaction than actual future life satisfaction – suggesting that the current life satisfaction value is the anchor used in determining the answers. Moreover, the true values of future and past life satisfaction go in the same direction as the predicted values relative to the anchor value, which is evidence for adjustment. This implies that views of the past and expectations of the future are considerably influenced by present levels of life satisfaction.

2 Data and Models

We use the German Socio-Economic Panel (SOEP), a panel that has been widely used in life satisfaction (henceforth LS) research, covering the survey years 1992 – 2015, and 1984 – 1987. Self-assessed health is only available from 1992 onwards, and questions relating to recalled and expected LS are available only for the first four survey years. We consider individuals aged 18-85. The outcome of interest is the answer to the question: 1) "How satisfied are you at present with your life as a whole?" The respondents can answer with an integer number between 0 and 10, with 0 being the lowest and 10 the highest level of LS.[5] For the anchoring and adjustment model we also use as dependent variables the answers to the following two questions: 2) "How satisfied with your life were you a year ago?" 3) "And what do you think will it [LS] be in a year?" Both questions could be answered on the same scale as the question about current LS. The order of the questions in the questionnaire is the same as presented here: 1) current LS, 2) LS last year, and 3) LS next year. The questions about past and expected LS were asked only in the survey years 1984 - 1987. The explanatory variables we use are a dummy for males, a dummy for living with a partner, a dummy for having children, dummies for the labour force categories employed, unemployed, and retired (not in labour force is the omitted category), dummies for the self-reported health status (very good, good, satisfactory, and not so good; the category *bad* is omitted), years of education, a quadratic polynomial in age, equivalised monthly real household income,[6] and the number of nights spent in hospital in the past year. Table 1 presents summary statistics of our sample.

We treat LS as a cardinal variable. This is a choice of convenience. Treating it as an ordinal but non-

[5]The question clarifies that "0 means completely dissatisfied and 10 means completely satisfied", but no labels (such as "excellent", "good", etc. are attached to the values.

[6]We use the OECD equivalence scale: Total net household income is divided by a weighted sum of household members, where the first adult household member is counted fully, any other person above the age of 13 as 0.7, and all younger household members as 0.5. The SOEP has a number of different income variables (reported vs. constructed, post vs. pre government taxes and transfers). We have tried different income variables and have decided to use reported net household equivalised income because this variable had the best fit in explaining LS among all income variables.

Table 1: Summary statistics

	Mean
Life satisfaction (0-10)	6.98
Male	0.47
Has partner	0.74
Has children	0.38
Nights hospitalised	1.64
Self-assessed health (1-5)	2.66
Employed	0.60
Unemployed	0.06
Retired	0.17
Not in labor force	0.17
Years of education	11.90
Age	48.4
Income (equivalised in 1,000 Euros)	1.31
Income gain (equivalised in 1,000 Euros)	0.07
Income loss (equivalised in 1,000 Euros)	-0.06

Observations: 317,139. Persons: 50,187.

cardinal variable adds a number of complications to the estimation, (especially for fixed effects models, which are an important factor for LS) and interpretations of results are less intuitive. It has also been shown in different contexts that LS models exhibit no important sensitivity to the choice of cardinal or ordinal models (see Ferrer-i Carbonell and Frijters (2004) and Yaman and Cubí-Mollá (2016)).

We test whether LS exhibits the properties of reference dependence, diminishing marginal utility, and loss aversion. We then analyse whether an anchoring and adjustment model can explain subjects' responses to recalled and expected LS. We discuss these models and hypotheses in turn. To test for reference dependence, diminishing marginal utility, and loss aversion we estimate the following equation:

$$ls_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 y_{it}^2 + \mathbb{1}_{\Delta y_{it}>0}\left(\gamma_1 \Delta y_{it} + \gamma_2 \Delta y_{it}^2\right) + \mathbb{1}_{\Delta y_{it}\leq 0}\left(\delta_1 \Delta y_{it} + \delta_2 \Delta y_{it}^2\right) \tag{1}$$

$$+ \alpha_2 H2 + \cdots + \alpha_5 H5 + \sum_{j=1}^{5}\left(\sum_{k>j}\alpha_{jk}^{g} TH_{it}^{jk} + \sum_{k<j}\alpha_{jk}^{l} TH_{it}^{jk}\right) \tag{2}$$

$$+ \rho_E E + \rho_U U + \rho_R R + \sum_{l\in L}\sum_{m\in(L-l)} \rho_{lm} TL_{it}^{lm} \tag{3}$$

$$+ \eta \mathbf{X_{it}} + u_i + v_t + \varepsilon_{it} \tag{4}$$

In the model equation above, the first line (1) includes the income variables, the second line (2) the health variables, the third line (3) the employment status variables, and the fourth line (4) includes other control variables, $\mathbf{X_{it}}$, person fixed effects, u_i, year fixed effects, v_t, and the classical error term, ε_{it}. In (1) $\Delta y_{it} := y_{it} - y_{i,t-1}$, and $\mathbb{1}_A$ is an indicator variable which evaluates to 1 if the statement A is true, and to 0 if A is false. The income specification thus allows for level effects (through β_1 and β_2), and for different gain and loss effects (through γ_1, γ_2, δ_1 and δ_2). In (2) we include dummy variables for all but one of the different health categories, $H2$ to $H5$, as well as all possible transitions TH from one health state to another. For example, TH^{23} is 1 if an individual reported the second health category in the previous year, and reports the third category in the current year. Finally, for employment, we also include dummies for being employed, unemployed, and retired, E, U, and R, as well as all possible transitions TL from one labour force status to another, where L is the set $L = \{E, U, R, N\}$. For example, TL^{EU} is 1 if an individual was employed in the previous year, but is unemployed in the current year.

2.1 Reference point

Prospect theory postulates that utility is derived from the value of a variable compared against a reference value. What that reference value in a given context should be is not always clear. Kőszegi and Rabin (2006) argue that "a person's reference point is her probabilistic beliefs about the relevant consumption outcome held between the time she first focused on the decision determining the outcome and shortly before consumption occurs", thus proposing expected consumption as reference point. Others have argued that in evaluating their LS people compare themselves to a peer group (see Vendrik and Woltjer (2007) and the papers cited there). In that case the reference point is usually constructed as the average of the variable of interest within a subsample which share the demographic characteristics of the individual for whom the reference point is being calculated. Most commonly in panel data the reference point is taken to be the lagged value of the variable of interest, assuming that the reference point is the person herself in her near past. If true, this should imply that changes in variables should be better predictors of LS than levels. The test is straightforward. If LS is not evaluated against a reference point (or, more conservatively, if the past value of a variable is not a reference point) then the coefficients on changes and transitions should be zero. Conversely, if LS is evaluated *only* against reference points, then the coefficients on the current levels should be zero.

Hypotheses: (RP1) *LS is not evaluated against a reference point in the domain of gains,*

$$\mathbf{H_{0,y}}: \quad \gamma_1 = \gamma_2 = 0,$$

$$\mathbf{H_{0,h}}: \quad \alpha_{jk} = 0 \quad \forall\, j,k \quad \text{such that } j < k,$$

$$\mathbf{H_{0,l}}: \quad \rho_{UE} = 0.$$

(RP2) *LS is not evaluated against a reference point in the domain of losses,*

$$\mathbf{H_{0,y}}: \quad \delta_1 = \delta_2 = 0,$$

$$\mathbf{H_{0,h}}: \quad \alpha_{jk} = 0 \quad \forall\, j,k \quad \text{such that } j > k,$$

$$\mathbf{H_{0,l}}: \quad \rho_{EU} = 0.$$

(RP3) *LS is not evaluated in levels,*

$$\mathbf{H_{0,y}}: \quad \beta_1 = \beta_2 = 0,$$

$$\mathbf{H_{0,h}}: \quad \alpha_j = 0 \quad \forall\, j \in \{1,\ldots,5\},$$

$$\mathbf{H_{0,l}}: \quad \rho_E = \rho_U = 0.$$

In the hypotheses above, only transitions between the employed and unemployed statuses are considered, since only these are unambiguously ranked in relation to each other.

2.2 Diminishing marginal utility

Testing for the presence of diminishing marginal utility in LS requires certain assumptions on the variables. If both LS and the independent variable are cardinal, testing for diminishing marginal utility is straightforward. If we relax the cardinality assumption for LS but retain its ordinal property, we can still apply a latent variable framework such as ordered probit or logit. The literature has analysed the sensitivity of LS regressions with respect to methods that do or do not assume cardinality, and has found that the choice of method makes little qualitative or quantitative difference to the results. We therefore assume that LS is a cardinal variable.

Cardinality in the independent variable however cannot be dispensed with. To see this, consider a person who reports the same increase in LS when going from satisfactory to good and from good to very good health. If these two changes in health categories reflect an equivalent change in the person's underlying "true" health we would conclude that marginal utility is constant. But if the incremental gain in health in the former is smaller, the person would still exhibit diminishing marginal utility with respect to health.

Of our explanatory variables, income is the only cardinal variable, therefore it is the only variable for which we can test whether it exhibits diminishing marginal LS. While years of education and health categories can be ordered, we do not assume that gains in education and health are linear in these variables.

For income *levels* to have positive and diminishing marginal effects on LS, necessary conditions are

$$\beta_1 > 0, \quad \beta_2 < 0.$$

Given our choice of a quadratic function, LS will achieve a maximum income, but our estimates will give us a range of income for which positive and diminishing marginal income effects provide a good fit of the data.

For income changes, consider only the income part of our LS model (equation 1). If we take the first difference in LS (and we assume that $y_{t-1} = y_{t-2}$) we arrive at the following equation (omitting the individual subscript):

$$\Delta ls = \beta_1 \Delta y + \beta_2 (y_t^2 - y_{t-1}^2) + \mathbb{1}_{\Delta y > 0} \left(\gamma_1 \Delta y + \gamma_2 \Delta y^2 \right) + \mathbb{1}_{\Delta y \leq 0} \left(\delta_1 \Delta y + \delta_2 \Delta y^2 \right).$$

Using the fact that

$$\begin{aligned} y_t^2 - y_{t-1}^2 &= (y_t - y_{t-1})(y_t + y_{t-1}) \\ &= \Delta y (\Delta y + 2 y_{t-1}), \end{aligned}$$

we obtain

$$\begin{aligned}\Delta ls =& \Delta y\left(\beta_1 + 2\beta_2 y_{t-1} + \mathbb{1}_{\Delta y>0}\gamma_1 + \mathbb{1}_{\Delta y\leq 0}\delta_1\right)\\ &+ (\Delta y)^2\left(\beta_2 + \mathbb{1}_{\Delta y>0}\gamma_2 + \mathbb{1}_{\Delta y\leq 0}\delta_2\right).\end{aligned}$$

For income gains to increase LS, but at a diminishing rate, we require

$$\begin{aligned}\frac{\Delta ls}{\Delta y} &= (\beta_1 + 2\beta_2 y_{t-1} + \gamma_1) + \Delta y\,(\beta_2 + \gamma_2) > 0,\\ \frac{\Delta\left(\frac{\Delta ls}{\Delta y}\right)}{\Delta y} &= \beta_2 + \gamma_2 < 0.\end{aligned} \tag{5}$$

For income losses to decrease LS, but at a diminishing rate (for LS to be convex in the loss domain) we require

$$\begin{aligned}\frac{\Delta ls}{\Delta y} &= (\beta_1 + 2\beta_2 y_{t-1} + \delta_1) + \Delta y\,(\beta_2 + \delta_2) > 0,\\ \frac{\Delta\left(\frac{\Delta ls}{\Delta y}\right)}{\Delta y} &= \beta_2 + \delta_2 > 0.\end{aligned} \tag{6}$$

Equipped with our estimates, we can calculate the range of income changes for which income has a positive marginal effect on LS. The hypotheses are the following

Hypotheses: (DMU1) *LS is not concave in income levels,*

$$\mathbf{H_0}: \quad \beta_2 \geq 0.$$

(DMU2) *If* $\beta_2 < 0$*, LS is not increasing in income,*

$$\mathbf{H_0}: \quad \beta_1 \leq 0.$$

(DMU3) *LS is not concave in income gains,*

$$\mathbf{H_0}: \quad \beta_2 + \gamma_2 \geq 0.$$

(DMU4) *LS is not convex in income losses,*

$$\mathbf{H_0}: \quad \beta_2 + \delta_2 \leq 0.$$

2.3 Loss Aversion

Loss aversion means that the decrease in utility due to a loss (of income, health, employment) is greater than the increase in utility due to the corresponding gain. To classify anything as a loss or a gain a reference point must be presupposed. While marginal effects for health and employment status could not be estimated, the presence of loss aversion can, as individuals can go from good to bad health and vice versa, or from employment to unemployment and vice versa. For loss aversion in income, we need to compare $\frac{\Delta ls}{\Delta y}$ in the domain of gains to the same fraction in the domain of losses. Loss aversion requires that the rate of change of LS a negative value $-\Delta y$ be greater than the rate of change in LS for the positive value Δy. From equations (5) and (6),

$$\delta_1 + (-\Delta y)(\beta_2 + \delta_2) > \gamma_1 + \Delta y(\beta_2 + \gamma_2), \quad \forall \Delta y \geq 0.$$

In particular, $\Delta y = 0$ implies $\delta_1 > \gamma_1$, giving the utility function with loss aversion its characteristic kink at the origin. For labour force status we compare only two states: employment and unemployment, as by definition employment is preferred to unemployment by both the employed and the unemployed. The change in LS for someone who moves from unemployment to employment (assuming that in $t-2$ her labour force status was also unemployed) is $(\rho_E - \rho_U) + \rho_{UE}$, the change in LS for someone who moves from employment to unemployment (assuming that in $t-2$ her labour force status was also employed) is $(\rho_U - \rho_E) + \rho_{EU}$. The former is expected to be positive, and the latter to be negative. If so, loss aversion would also imply:

$$(\rho_E - \rho_U) + \rho_{UE} < -((\rho_U - \rho_E) + \rho_{EU})$$
$$\Rightarrow \quad \rho_{UE} < -\rho_{EU}.$$

For health, the same argument as in the labour force status case applies. However, as there are 5 (ordered) health categories, there are 10 comparisons that can be made. Before turning to our hypotheses about loss aversion, we first test the following two auxiliary hypotheses to establish that employment and good health are "goods":

Hypotheses: (H1) *Deteriorating health does not decrease LS, improving health does not increase LS,*

$$\mathbf{H_{0,l_1}}: \quad (\alpha_j - \alpha_k) + \alpha_{kj} \geq 0 \quad \forall\, j < k,$$
$$\mathbf{H_{0,l_2}}: \quad (\alpha_j - \alpha_k) + \alpha_{kj} \leq 0 \quad \forall\, j > k.$$

(L1) *Going from employment to unemployment does not decrease LS, going from unemployment to employment does not increase LS,*

$$\mathbf{H_{0,l_1}}: \quad (\rho_U - \rho_E) + \rho_{EU} \geq 0,$$
$$\mathbf{H_{0,l_2}}: \quad (\rho_E - \rho_U) + \rho_{UE} \leq 0.$$

The hypothesis on loss aversion is:

Hypothesis: (LA1) *LS does not exhibit loss aversion in income, health and employment,*

$$\mathbf{H_{0,y}}: \quad \delta_1 \leq \gamma_1,$$
$$\mathbf{H_{0,h}}: \quad -\alpha_{kj} > \alpha_{jk} \quad \forall\, k < j,$$
$$\mathbf{H_{0,l}}: \quad -\rho_{EU} > \rho_{UE}.$$

2.4 Recall and expectations

The final question we address is whether recalled LS is better explained by past or by present LS, and whether expected LS is better explained by future or by present LS. We simply estimate:

$$R_{it}(ls_{i,t-1}) = \beta_0 + \beta_1 ls_{i,t-1} + u_i + \varepsilon_{it}, \tag{7}$$

$$R_{it}(ls_{i,t-1}) = \beta_0 + \beta_1 ls_{it} + u_i + \varepsilon_{it}, \tag{8}$$

$$E_{it}(ls_{i,t+1}) = \beta_0 + \beta_1 ls_{i,t+1} + u_i + \varepsilon_{it}, \tag{9}$$

$$E_{it}(ls_{i,t+1}) = \beta_0 + \beta_1 ls_{it} + u_i + \varepsilon_{it}. \tag{10}$$

Here $R_{it}(ls_{i,t-1})$ gives the LS at time $t-1$ recalled by individual i at time t, and $E_{it}(ls_{i,t+1})$ gives the LS at time $t+1$ expected by individual i at time t. There are significant reasons to doubt the ability of individuals to correctly recall and predict their LS, so we had no a priori hypotheses about which of these models will perform better. It is important to note though that almost all models of choice currently in use require perfect recall, implying a perfect fit and positive coefficient in (7). Furthermore, if individuals are able to accurately predict their life satisfaction, we would expect model (9) to perform well. The model equations (7) to (10) are estimated with the fixed effects estimator.

Based on the results for the models above, we have proposed the two following models to test whether *anchoring and adjustment* (henceforth AA) is a good way to explain how the individual respondent evaluates recalled and expected LS for the survey:

$$ls_{it} = \beta_0 + \beta_1 ls_{i,t-1} + \beta_2 E_{t-1}(ls_{it}) + \varepsilon_{it}, \tag{11}$$

$$ls_{i,t-1} = \delta_0 + \delta_1 ls_{i,t} + \delta_2 R_t(ls_{i,t-1}) + \mu_{it}. \tag{12}$$

Applied to the questions of how satisfied the subject was with his life a year before (recalled LS), and how satisfied he thinks he will be in a year (expected LS), we propose that the current life satisfaction level is the anchoring point for the estimates. That is, at time $t-1$, the anchor for the estimate of next period LS, $E_{t-1}(ls_t)$, is ls_{t-1}. At time t, the anchor for the recalled LS, $R_t(ls_{t-1})$, is ls_t. Therefore, we expect the anchor to serve as a good predictor of recalled LS in equation (8) and expected LS in equation (10). Moreover, if the adjustment process improves the answer starting at the anchor, we should see evidence for the adjustment process in (11) and (12). That is, if the expected value of life satisfaction in a previous year is adjusted towards the true future LS value, starting at the anchor, it must have additional predictive power and should be positively related to current life satisfaction. Similarly, the adjustment process should give recalled LS additional predictive power for true past LS, when controlling for the anchor value.

Hypotheses: (AA1) *Past expected life satisfaction positively predicts current life satisfaction when controlling for past life satisfaction. That is, in equation (11),*

$$\mathbf{H_0}: \quad \beta_2 \leq 0.$$

(AA2) *Current recalled life satisfaction positively predicts past life satisfaction when controlling for current life satisfaction. That is, in equation (12),*

$$\mathbf{H_0}: \quad \delta_2 \leq 0.$$

An advantage of AA is that it allows us to make sense of imperfect recall, since the procedure can be applied to all questions where the answer is numeric or ordinal, and where a suitable anchor can be posited.

3 Results

Table 3 presents the results for our main econometric model from equation (1 – 4) where we have restricted the sample to observations whose incomes do not change by more than 500 Euros (the sample mean is 1,414 Euros).[7] The results are generally in line with what is known about life satisfaction. Having a partner, having children, not being unemployed, being in good health, and income are associated with higher levels of life satisfaction. The differences between the OLS and fixed effects coefficients demonstrate the importance of unobserved individual characteristics. Our preferred specification is therefore the fixed effects estimator.

[7]Restricting the sample to changes of no more than 1,000 Euros yielded very similar results.

Table 2: Summary of hypotheses to be tested.

	H_0	H_a	H_a supports:
Reference point			
RP1	LS is not evaluated against a reference point in the domain of gains.	LS is evaluated against a reference point in the domain of gains.	Prospect theory
RP2	LS is not evaluated against a reference point in the domain of losses.	LS is evaluated against a reference point in the domain of losses.	Prospect theory
RP3	LS is not evaluated in levels.	LS is evaluated in levels.	Expected Utility Theory
Diminishing marginal utility – only income			
DMU1	LS is not concave in income levels.	LS is concave in income levels.	Expected Utility Theory
DMU2	LS is not increasing in income levels.	LS is increasing in income levels.	Expected Utility Theory
DMU3	LS is not concave in income in the domain of gains.	LS is concave in income in the domain of gains.	Prospect Theory
DMU4	LS is not convex in income in the domain of losses.	LS is convex in income in the domain of losses.	Prospect Theory
Health and employment			
H1	Better health does not increase LS.	Better health increases LS.	——-
L1	Employment is not better than unemployment.	Employment is better than unemployment.	——-
Loss aversion			
LA1	LS does not exhibit loss aversion.	LS exhibits loss aversion.	Prospect Theory
Anchoring and adjustment			
AA1	Expected LS is not adjusted towards the true value.	Expected LS is adjusted from the anchor towards the true value.	Anchoring and Adjustment
AA2	Recalled LS is not adjusted towards the true value.	Recalled LS is adjusted from the anchor towards the true value.	Anchoring and Adjustment

Table 3: Determinants of life satisfaction.

	(1) OLS	(2) Fixed effects
Male	-0.087***	
	(0.005)	
Partner	0.334***	0.247***
	(0.007)	(0.011)
Nights hospitalized	-0.004***	-0.005***
	(0.000)	(0.000)
Children	0.202***	0.052***
	(0.007)	(0.009)
Employed	-0.119***	-0.014
	(0.009)	(0.011)
Unemployed	-0.840***	-0.534***
	(0.017)	(0.018)
Retired	-0.036**	-0.010
	(0.014)	(0.014)
Years of education	-0.015***	-0.014***
	(0.001)	(0.004)
Health:not so good	1.707***	1.239***
	(0.022)	(0.024)
Health:satisfactory	2.617***	1.888***
	(0.021)	(0.024)
Health:good	3.470	2.355***
	(0.021)	(0.025)
Health:very good	4.190***	2.718***
	(0.025)	(0.029)
Age	-0.037	-0.009***
	(0.001)	(0.002)
$Age^2/100$	0.048***	0.001
	(0.001)	(0.002)
Household income	0.501***	0.294***
(in 1,000 Euros)	(0.007)	(0.011)
Household $income^2$	-0.025***	-0.011***
	(0.001)	(0.001)
Income gain	-0.075	0.015
	(0.080)	(0.070)
Income $gain^2$	-0.184	-0.199
	(0.201)	(0.175)
Income loss	0.232***	0.250***
	(0.085)	(0.074)
Income $loss^2$	0.567***	0.536***
	(0.218)	(0.188)
Observations	317,139	317,139
Number of persons		50,187
R-squared	0.273	0.102

Standard errors in parentheses. Omitted categories are Health:bad, and not in labour force. Regressions include a full set of year fixed effects and transitions between all health and labor force states. The R-squared for the fixed effects model is the squared correlation between the de-meaned life satisfaction and predicted de-meaned life satisfaction. Stata reports this measure as R-squared within. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4: Results: reference point.

H_0	p–value
RP1	
Positive income changes do not affect LS.	0.027
Health improvements do not affect LS.	0.000
Finding employment does not affect LS.	0.034
RP2	
Negative income changes do not affect LS.	0.003
Health deteriorations do not affect LS.	0.000
Loosing employment does not affect LS.	0.004
RP3	
Income levels do not affect LS.	0.000
Health levels do not affect LS.	0.000
Unemployment does not affect LS.	0.000

3.1 Reference point

Table 4 summarizes the result for hypotheses RP1 to RP3, which are all rejected. We remind the reader that what are tested for in RP1 and RP2 are any effects on LS of changes over and above level effects. Level effects are tested in RP3. Three results stand out: First, both levels as well as changes of all three variable groups are significant. Thus, LS seems to be best described by a hybrid of Expected Utility Theory and Prospect Theory, or by a version of Prospect Theory where the reference point depends on more than past outcomes. Second, the level effects are more significant than the change effects, and third, the change effects in the loss domain are more significant than the changes in the gain domain (for income and employment), giving a first indication of the presence of loss aversion.

3.2 Diminishing marginal life satisfaction

Table 5 presents the results for the hypotheses DMU1 to DMU4. LS is concave in income levels, and it is increasing for a certain range of income – the estimates imply increasing LS up to a monthly income of 13,500 Euros (only 21 observations report higher incomes than that). The hypothesis that LS is not concave in gains cannot be rejected at the 10% significance level, but the p–value comes close to 0.1. However, there is strong evidence for convexity in the loss domain.

Table 5: Results: diminish marginal life satisfaction.

H_0	p–value
DMU1	
LS is not concave in income levels.	0.000
DMU2	
LS is not increasing in income levels.	0.000
DMU3	
LS is not concave in the domain of income gains.	0.114
DMU4	
LS is not convex in the domain of income losses.	0.005

Table 6: Results: loss aversion.

H_0	p–value
H1	
Deteriorating health does not decrease LS.	0.000
Improving health does not increase LS.	0.000
L1	
Becoming unemployed does not decrease LS.	0.000
Becoming employed does not increase LS.	0.000
LA1	
LS does not exhibit loss aversion in income.	0.030
LS does not exhibit loss aversion in health.	0.445*
LS does not exhibit loss aversion in employment.	0.000

*In the case of LA1 for health, we tested each possible transition between health states separately. The reported p–value is the lowest among the 10 tests.

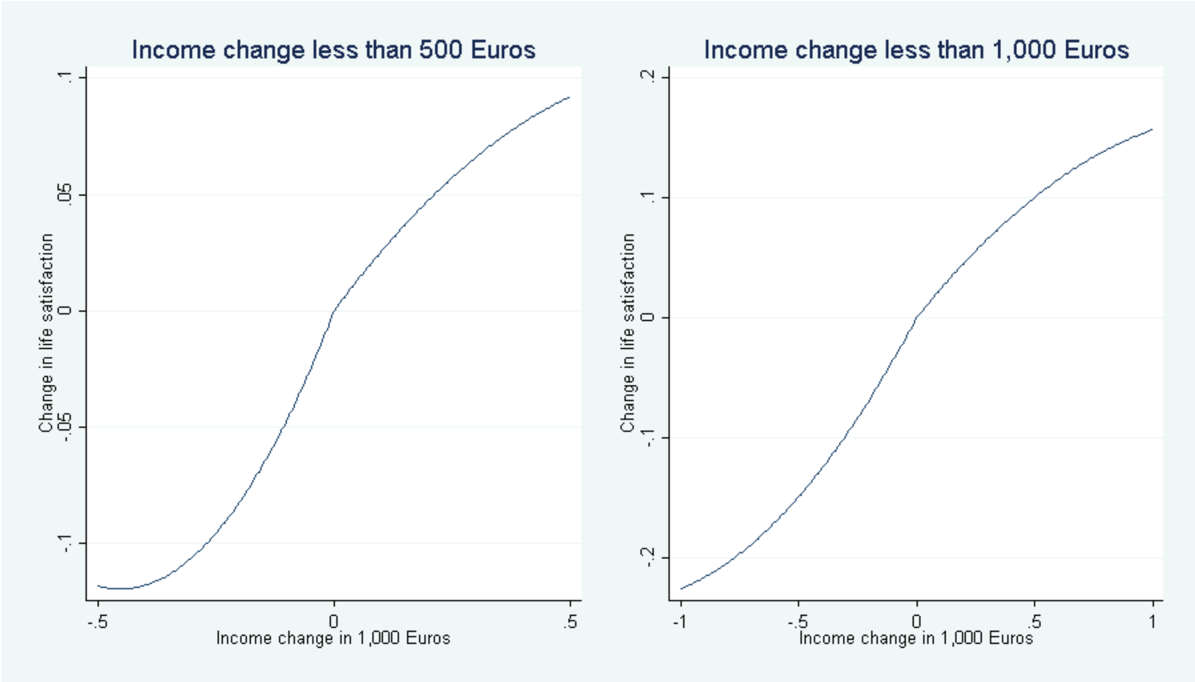

Figure 1: Life satisfaction as function of income for changes of less than 500 Euros (left) and less thant 1000 Euros (right).

3.3 Loss aversion

Table 6 presents the results of our auxiliary hypotheses H1 and L1, and the hypotheses regarding loss aversion. The results for H1 and L1 show that health and employment are indeed regarded as “goods”. Loss aversion is present at the 5% significance level for income, and is strongly present for employment/unemployment. For health there is no evidence of loss aversion. To the contrary, out of 10 possible health transitions, only one test statistic had the sign that would indicate loss aversion. There is evidence that health does not exhibit loss aversion. Another explanation could be that both LS and self-assessed health are measures that reflect how the respondent sees herself. If the respondent over-values her health gain – compared to her actual health improvement – loss aversion would not be detected using self-assessed health even if it is present in actual health.

The LS function for changes in income in a range of -500 to +500 Euros (at a reference income of 1,000 Euros) is depicted in the left panel of figure 1. All the characteristic features of Prospect Theory are present: the kink at the origin, concavity in gains, convexity in losses, and a general stronger effect of losses than gains. We have repeated the analysis with restricting the sample to income changes of at most 1,000 Euros, with the same test results as in table 6 (the *p*–value for concavity in gains is 0.051). The corresponding LS function is depicted on the right panel of figure 1.

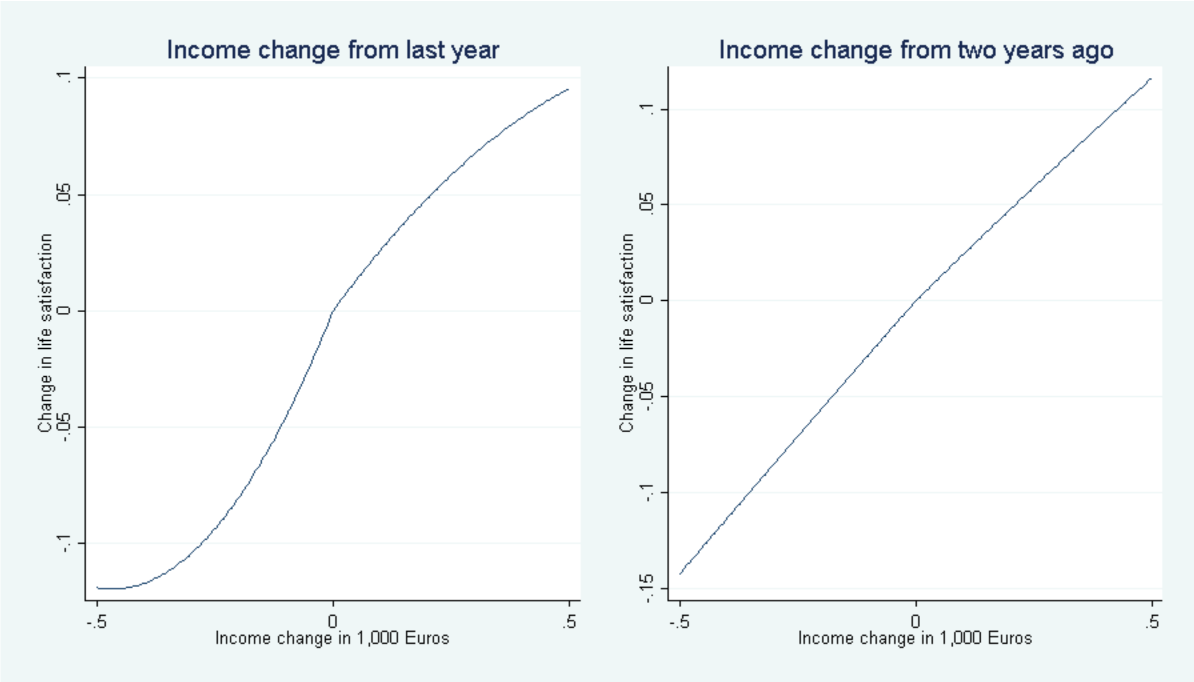

Figure 2: Life satisfaction as function of income for changes of income relative to the previous year (left) and relative to two years before (right).

We repeated the regression after adding lagged values of the variables Δy and $(\Delta y)^2$ to see whether the characteristic shape of the LS function is preserved, and whether the shape is also present when we track the change in LS over two periods. Figure 2 shows the LS function of this regression. The left panel shows the LS function with respect to income changes compared to last year, and the right panel with respect to income changes compared to two years ago. While the loss in LS is sustained over two years, the characteristic shape of the LS function with loss aversion is visible only with respect to the previous year's income, perhaps due to individuals applying the features of prospect theory only in comparison to the previous year or the previous survey time.

3.3.1 Heterogeneity in income sensitivity

In this section we analyse whether the loss aversion in income that we have detected is an artefact of heterogeneous income sensitivities in our sample. The question is motivated by findings in the consumer choice literature. Price-sensitive consumers will purchase cheaper brands and have lower reference prices. Since prices will often be above their reference price, they will be facing "losses" more often than consumers who are less price-sensitive and who have higher reference prices. As a result, in a sample of consumers, a kink around the reference price will be estimated which reflects price-response parameter heterogeneity rather than loss aversion (see Bell and Lattin (2000)). In our case, if income-sensitive individuals face income losses relatively more often, we would also find a steeper slope of income on LS in the domain of income losses than income gains. To see if this is a plausible scenario we first test whether observations with high incomes are more or less likely to experience an income gain or loss. We found that high incomes entail a higher probability of ensuing losses and smaller expected income changes.[8] While this could easily be explained by a regression to the mean, even at an individual level, it still poses a challenge to the identification of loss aversion as explained above (e.g. if individuals are more loss averse when their incomes are high). We then estimated equation (1 – 4) on two subsamples, one consisting of individuals whose first observed income is below the median, and the other above. The test for hypothesis RP3 shows evidence of loss aversion for the lower half of the income distribution (p–value = 0.03), but for the upper half the hypothesis of no loss aversion cannot be rejected (p–value = 0.28).

To account for heterogeneity in income-sensitivity we use a finite-mixture model: We assume that there are K segments in the population which each have different sensitivities (in terms of LS) to income gains and losses. The fraction of the segment k in the population is given by

$$P_k = \frac{\exp(\alpha_k)}{\sum_{i=1}^{K} \exp(\alpha_i)}.$$

where α_i are parameters to be estimated (and α_1 is normalized to zero). The LS function of individual i in segment k and at time t is given by

$$ls_{itk} = \beta_k + \beta_{yk} y_{itk} + \beta_{y^+k} y^+_{itk} + \beta_{y^-k} y^-_{itk} + \varepsilon_{itk},$$

where ε_{itk} is assumed to be a normally distributed random variable with mean zero and the same variance across the different segments, and y^+ and y^- are as defined in section 2.3. To keep these models tractable, and because our interest is in income loss aversion, we only include income and a linear gain and loss component. The likelihood contribution of an observation (suppressing subscripts), conditional on belonging to segment k, is thus

$$\phi(\varepsilon|k) = \phi(ls - (\beta_k + \beta_{yk} y + \beta_{y^+k} y^+ + \beta_{y^-k} y^-)),$$

and the unconditional likelihood contribution is $\sum_k P_k \phi(\varepsilon|k)$. The parameters to be estimated are the β for

[8] Results not reported, but available upon request.

Table 7: Loss aversion heterogeneity: Summary of model fits.

	Number of parameters	Log likelihood	AIC/2
One segment	5	-601,035	601,040
Two segments	10	-586,007	586,017
Three segments	15	-582,094	582,109
Four segments	20	-579,039	579,059

$n = 373,385$. The four segments model has also the lowest BIC.

Table 8: Loss aversion heterogeneity: One segments.

	y	y^+	y^-
Segment 1	.142***	.070***	-.080***
	(0.007)	(0.014)	(0.015)

$n = 335,363$. Standard errors in parentheses.

each segment ($4 \times K$), the segment probability parameters α ($K-1$) and the variance of ε (1).

Table 7 presents statistics relating to four models that we have estimated. The simplest model is one with only one segment and consequently no heterogeneity. The results from this model are in table 8. While the signs of parameters are as we would expect, there is no evidence for loss aversion. The most complex model is the one with four segments. The AIC (and BIC) is lowest for this model. We therefore only present the results of the model with four segments in table 9. The sample is dominated by observations belonging to the first segment (87%) who exhibit some familiar properties: income levels have a positive effect on life satisfaction, gains increase life satisfaction (over and above the level effects) and losses decrease it (over and above the level effects). However, there is no loss aversion.

An individual in segment 2 experiences strong level effects of income, but this effect is not fully realized

Table 9: Loss aversion heterogeneity: Four segments.

	y	y^+	y^-	Fraction (in %)
Segment 1	.092***	.100***	-.010	87.0
	(0.006)	(0.012)	(0.013)	
Segment 2	.390***	-.189***	-.381***	7.8
	(0.027)	(0.057)	(0.055)	
Segment 3	-.050	.411***	.094	4.4
	(0.036)	(0.067)	(0.065)	
Segment 4	.449***	-.132	-.225	0.8
	(0.058)	(0.145)	(0.144)	

$n = 335,363$. Standard errors in parentheses.

in the time period of an income gain (the first period effect is a gain of 0.201, the second period is an additional gain of 0.189). The loss component is quite strong. For a segment 3 individual there is a strong effect of gains on life satisfaction, but no significant loss effect. Segment 4 resembles most closely segment 2, but has a very low probability mass. The results suggest that loss aversion in the majority of the population is not present. One can hypothesise that the previous results are driven by segment 2 individuals accounting for the loss, and segment 3 individuals accounting for the gain components of income. Pursuing this line of thought is out of the scope of this paper and we leave this question open. We would also like to caution the reader that the finite mixture model is very parsimonious and treats all observations as independent.

3.4 Recall and expectations

Table 10 shows results from the estimation of equations (7)–(10). The main result is that current life satisfaction is a much better predictor of recalled life satisfaction than the actual life satisfaction that was reported in the past. Similarly, current life satisfaction is a much better predictor of expected life satisfaction than life satisfaction reported a year later. The recall result for equation (7) cannot be reconciled with any models in which the individual can recall LS. Even more, the negative coefficient suggests that the recalled LS does not even adjust for reversal to the mean, which speaks poorly for the ability of individuals to answer such questions correctly. Similarly, models that make strong assumptions on the ability of individuals to predict future LS are also hard to reconcile with the result for equation (9). This is all in contrast with AA, which is in strong agreement with the results. In AA, the current LS serves as the anchor for determining the answer for both the recalled past LS and the expected future LS.

The margin by which current LS outperforms the alternative measure is remarkable. The R^2 is orders of magnitude higher for (8) and (10) than for (7) and (9). This result has important consequences for example in the evaluation of the effectiveness of medical treatments. Treatments can be evaluated prospectively (patients are asked to evaluate their health before and after treatment), or retrospectively (patients are asked to evaluate their health after treatment and compare it to their health before treatment). Prospective evaluations can be biased by adaptation by patients, and retrospective evaluations are prone to recall errors. The results on recalled life satisfaction here demonstrate how strongly the remembrance of the past can be tainted by the present.

Table 11 shows the results of the estimation of equations (11) and (12), and Table 12 confirms hypotheses AA1 and AA2. So, not only is the degree of correlation between LS last year and last year's expected LS high, which we know from estimating (9) – suggesting anchoring–, but the last year's expected LS has additional predictive power for the true LS today – suggesting adjustment. A similar observation can be made regarding recalled LS.

Three more ex-post observations can be made. First, the coefficients for the true LS independent variables in (11) and (12) are negative (Table 11), suggesting mean reversal, and therefore a relatively high degree of randomness in measured LS. Second, the R^2 for equation (12) is higher than for (11), and the size of the coefficient for recalled LS is higher than for expected LS. This suggests that recalled LS is a better predictor of past LS than expected LS is of future LS. This is not surprising, in light of the fact that recalling information on LS should be much easier than making a prediction of LS. The relative improvement as a result of the adjustment process should therefore be better for recall. Further support for this interpretation comes from observing that the anchor (LS today) has better predictive power in (10) than in (8) (Table 10).

The third observation is that expectations and recalls seem to be systematically biased. Figures 3 and 4 display the histograms for the difference between expected and recalled LS, and the corresponding realised LS, that is $E_{it}(ls_{i,t+1}) - ls_{i,t+1}$ for expectations and $R_{it}(ls_{i,t-1}) - ls_{i,t-1}$ for recalls. Deviations of expectations from realisations are skewed to the right, and deviations of recalls from realisations are skewed to the left. The mean of the former is significantly positive, and the mean of the latter is significantly negative. In general, respondents seem to have an overly optimistic view of the future, and an overly negative recall of the past. From the result for (9), note that expecting LS above the mean is weakly negatively correlated with having a realized LS below the mean. But, when controlling for current LS, (11), expected LS and realized LS are now positively correlated.

Table 10: Expected and recalled life satisfaction.

	Dependent variable			
	$E_t(ls_{t+1})$	$E_t(ls_{t+1})$	$R_t(ls_{t-1})$	$R_t(ls_{t-1})$
ls_t	0.738***		0.657***	
	(0.004)		(0.005)	
ls_{t+1}		-0.091***		
		(0.006)		
ls_{t-1}				-0.069***
				(0.007)
Constant	2.072***	8.125***	2.386***	7.642***
	(0.028)	(0.046)	(0.034)	(0.038)
Observations	42,646	38,177	43,036	29,288
R-squared	0.558	0.008	0.402	0.005

Standard errors in parentheses.
*** p <0.01, ** p <0.05, * p <0.1

Table 11: Anchoring and adjustment.

	Dependent variable	
	ls_t	ls_{t-1}
ls_{t-1}	-0.178***	
	(0.009)	
ls_t		-0.347***
		(0.009)
$E_{t-1}(ls_t)$	0.048***	
	(0.009)	
$R_t(ls_{t-1})$		0.138***
		(0.009)
Constant	8.114***	8.867***
	(0.047)	(0.060)
Observations	38,177	29,288
R-squared	0.023	0.074

Standard errors in parentheses.
*** p <0.01, ** p <0.05, * p <0.1

Table 12: Results: Anchoring and adjustment.

H_0	p–value
AA1	
Expected LS is not adjusted towards the true value.	0.000
AA2	
Recalled LS is not adjusted towards the true value.	0.000

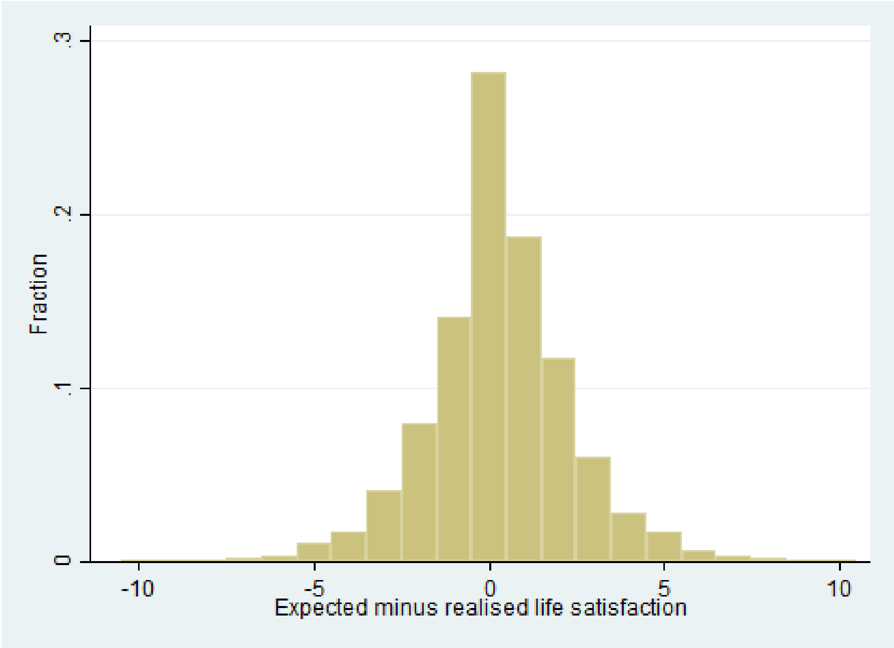

Figure 3: Expected minus realised life satisfaction.

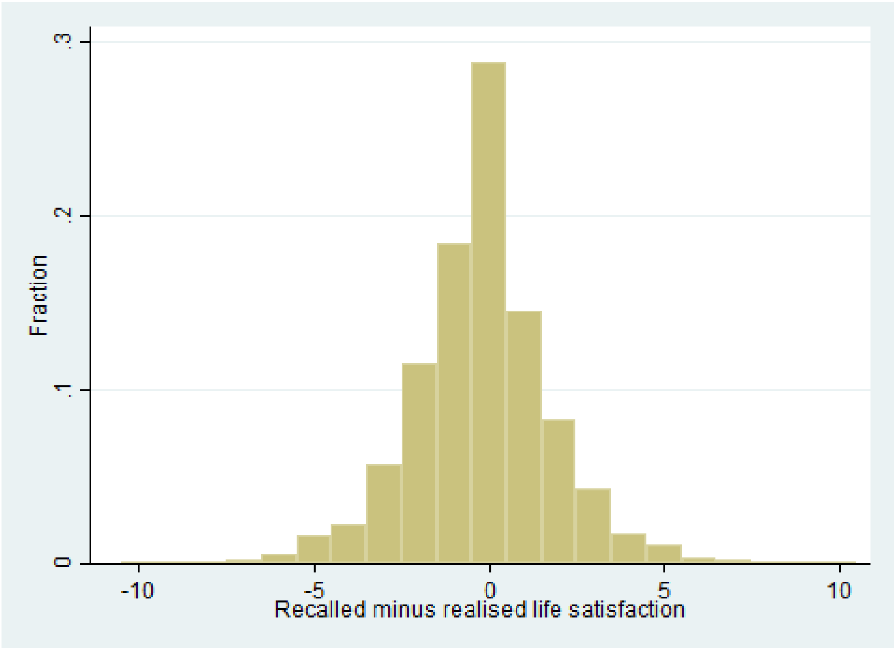

Figure 4: Recalled minus realised life satisfaction.

4 Conclusion

We have tested three components of prospect theory using an annual household panel and using life satisfaction as the dependent variable: positive but diminishing marginal life satisfaction, sensitivity of life satisfaction to changes rather than levels, and loss aversion. Our findings by and large support the presence of diminishing marginal effects of levels and changes on life satisfaction, and the presence of loss aversion, but reject the use of changes only rather than levels in the evaluation of life satisfaction. This means that the reference point in prospect theory is not well modelled by lagged values of predictors. However, this rejection might well be specific to the particular context we have considered here (life satisfaction as the outcome of interest, using changes over the course of a year, and using the individual's past self as reference point), and analysing for which contexts this finding can be replicated or rejected would be an interesting research agenda.

Our finding about remembered and expected life satisfaction can also be analysed in a similar way. For example, a less distant past might be remembered more accurately, and therefore individuals might be more responsive to changes over a short time interval than to changes over the course of a year. Similarly, extrapolation of current to future life satisfaction might be based on an inability to foresee future events or to misjudge the probabilities of such events, or it might be a – conscious or unconscious – choice in order to enjoy anticipatory utility. In general, finding support for diminishing marginal life satisfaction and loss aversion is reassuring, given the popularity that prospect theory has enjoyed.

We have also tested the use of the anchoring and adjustment heuristic, by looking at the relative importance of current and past (future) life satisfaction in predicting remembered (expected) life satisfaction. We found that current life satisfaction is a much better predictor of remembered as well as expected life satisfaction than lagged or leading life satisfaction, and that the reported expected and recalled life satisfaction values are adjusted towards the true values, relative from the anchor. These observations provide compelling evidence for the use of the heuristic.

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