Which Decision Theory Describes Life Satisfaction Best? Evidence From Annual Panel Data

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Abstract

We use an annual household panel to conduct a comparative analysis of which decision theory explains life satisfaction better. We consider expected utility theory and prospect theory. We consider mainly the effects of three domains on life satisfaction: income, health, and (un)employment. Using a fixed effects estimator we find that life satisfaction contains features of both expected utility theory and prospect theory. However, the elements of expected utility theory are stronger predictors of life satisfaction. Life satisfaction depends positively on levels of income, good health, and on employment. It also depends positively on income and employment improvements, however the reverse is true for health improvements. Life satisfaction is concave in income gains and convex in income losses, and it exhibits loss aversion in income and employment status, but not in health. The results support viewing life satisfaction as representing a mixture of expected utility theory, and some aspects of prospect theory.

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1 Introduction

We investigate which decision theory best explains life satisfaction (henceforth LS) as reported in an annual household panel. We consider the two most prominent decision theories in economics: expected utility theory (EUT), and prospect theory (PT). We analyse their predictions by looking in the German Socio-Economic Panel (SOEP) at three outcomes which have consistently been found to improve LS: income, health, and employment. Throughout, we interpret LS as a proxy of decision utility. We discuss this interpretation and its alternatives further below in section 6.3.

We consider the following properties of PT: First, whether individuals evaluate their LS against a reference point. Specifically, we test whether changes in an outcome can help explain LS levels. An affirmative answer would be consistent with individuals using their past outcome as a reference point in evaluating their current LS. Second, whether individuals exhibit loss aversion in outcomes, that is, whether the effect of a decrease in one of those variables reduces LS more than an equivalent increase improves it. Finally, and only for the case of income, whether individuals exhibit the reflection effect. That is, we test whether LS is concave in income gains and convex in income losses. In PT, these three features—a reference point, loss aversion and the reflection effect—are identified as the distinguishing elements of the value function. PT is a theory of "decision under risk" but these properties are relevant even in choices not involving chance (Kahneman and Tversky, 1979; Tversky and Kahneman, 1991).[1]

The two theories considered in this paper may, but need not, be exclusive. Evidence in favour of EUT need not be evidence against PT and vice versa. For example, the literature has found support for both absolute and relative income effects (Blanchflower and Oswald, 2004; Clark et al., 2008b). Empirically, one theory is not nested within the other in explaining LS. This is reflected in our model which allows for absolute effects, relevant to EUT, and relative effects, relevant to PT. We find that LS is best described by an empirical model that incorporates features of both EUT and PT. However, EUT predicts LS much more strongly than PT. In line with the literature on subjective well-being (SWT), we find that LS is increasing in income levels and in good health. Being employed implies higher LS than being unemployed, and LS is concave in income. In addition, many, but not all, of the features of PT are also supported. The marginal ef-

[1] We do not test for the presence of probability weighting in this paper, another important assumption in PT, because our data do not provide a good source of identification of probability weighting.

fect of income changes is asymmetric and supports loss aversion. The positive effect of income gains on LS is non-significant, but the negative effect of losses is highly significant. Similarly, LS concavity in income gains is not significant, but LS convexity in income losses is strong and highly significant, consistent with the reflection effect of PT. As expected, losing a job decreases LS while finding a job increases it. Maybe our most striking finding is that LS is *decreasing* in health improvements and *increasing* in health losses, when controlling for health status. While a person's LS is strictly increasing in their health, it is also sensitive to whether they arrived at their current health status from better or from worse health. A person, whose health has gotten worse and currently reports health status x, reports higher LS than if their health status were x both now and in the past. In turn, a person whose health was and still is x reports higher LS than if their health improved and is currently x. We also find a significant loss aversion effect in employment changes. The only domain for which we do not find evidence of loss aversion is health. Instead, in this domain we find that individuals have a loss preference.

Our paper is related to two areas of research in the literature: the (quasi-)experimental research on PT and related decision theories, and the LS research, which mainly builds on survey data. The main contribution of our paper to the literature is that we estimate a model which can nest elements of both EUT and PT in one empirical model. In contrast, the literature has typically focused on one aspect of a decision theory and sought to find evidence for or against it. For example, Boyce et al. (2013) test for loss aversion in income changes, but do not include income levels as an explanatory variable. While they support the notion of loss aversion, it is not clear whether income changes contribute more to life satisfaction than income levels, or indeed whether loss aversion would still hold once income levels are controlled for. The second contribution is that we consider life domains other than income. The importance of labour force status and of health on LS is well documented, and there is also a literature which looks at dynamic phenomena such as adaptation to certain health states (Oswald and Powdthavee, 2008) and to a lesser extent to employment states (Clark et al., 2008a, 2001). However, most of the research comparing EUT and PT focus on income. We are not aware of any research which compares the said theories with respect to health and employment. Since health is a good, and employment is by definition preferred to unemployment,[2] we should expect LS to display characteristics of a value function with respect to those goods too. We use the individual's past self as a reference point. We believe this to be a more natural choice for panel data than a peer group

[2]The *unemployed* are a subset of those that seek work.

based definition, which is severely restricted by data constraints. However, section 7 includes a discussion of alternative reference points.

The rest of the paper is organised as follows. Section 2 discusses the related literature and the contribution of our work. Section 3 describes the dataset, section 4 presents the main econometric model and our hypotheses and section 5 analyses the results. Section 6 discusses the results, and section 7 explores a number of extensions and robustness checks. Section 8 concludes.

2 Literature Review

Since the publication of "Prospect theory: An analysis of decision under risk" by Kahneman and Tversky (1979), non-expected utility theory has developed into a very active literature. Many authors have proposed alternatives or extensions to the classical expected-utility model,[3] and another strand of the literature has tested the assumptions of, and hypotheses derived from, PT and its subsequent extensions, by means of laboratory or field experiments.[4] The strongest support for PT, and other reference-dependent value models, comes from such laboratory and field experiments (Abdellaoui et al., 2007; List, 2004).

In contrast, the literature on LS and SWB in general has relied on survey data and this is the approach followed in this paper. Dolan et al. (2008) and Clark (2018) provide good surveys of the literature. The work closest to ours is Boyce et al. (2013), Di Tella et al. (2010), Vendrik and Woltjer (2007), Ferrer-i Carbonell (2005), who also use the SOEP, Fang and Niimi (2017), who use Japanese panel data, and De Neve et al. (2018), who use large nationally representative surveys. The listed papers, however, have different goals and differ greatly in important aspects from ours. First, the modelling choices in the literature are such that only some feature of EUT or PT can be tested for at once, while our model contains the main features of both theories and leaves it to the data to retain or to reject them. Second, we extend the analysis of aspects of PT to life domains other than income. Specifically, we test whether reference point effects and loss aversion are present in health and in employment status.

[3] 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.

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

Boyce et al. (2013) consider the effect of income changes on well-being and find evidence for loss aversion. They use the SOEP and the British Household Panel Survey. Their paper is closest in spirit to ours. While informative, the empirical model used is, we believe, improper as a test of discriminating between PT and EUT, because it does not map to the value functions of either of those theories. In particular, they use previous-period LS as a control variable (with a large, highly significant effect found) and allow for a jump discontinuity between negative and positive income changes. Unfortunately, this feature makes it impossible to identify LS with any value function known in decision theory. EUT as an explanation for LS is ruled out ex-ante, as income levels are not included as an explanatory variable.

Di Tella et al. (2010) are mainly concerned with the long-run adaptation to income and status of individuals. This work is best placed in the strand of literature concerned with finding an explanation to the Easterlin paradox (Easterlin, 1974). Using the SOEP, they find that there is adaptation to income but not to status. The results are reversed for sub-samples defined as "politically right-leaning", as "men", and as "self-employed", compared to the complementary sub-samples. They consider a model with changes in income as independent variables. They also allow asymmetric effects from gains and losses, i.e., loss aversion, but these gains and losses are from the present to the *next* period (this also assumes that the future income is closely related to anticipated income). The model only accommodates a symmetric effect of the change in income from the previous period. By contrast, our choice of reference point can be interpreted as looking for the asymmetric effect of already-realised income changes on currently experienced utility. In addition, we also allow for diminishing marginal effects and look for differences in curvature over gains and losses.

Fang and Niimi (2017) look for loss aversion in a Japanese household panel. For loss aversion in income, they select to use a very similar specification to the one of Di Tella et al. (2010), discussed above. A similar discussion regarding the reference point can be made, but they enjoy an advantage over Di Tella et al. (2010) in that they have data for expected future income changes. This means they do not have to proxy expected future income by future income in the panel, which brings their empirical reference point closer to its theoretical counterpart. As Di Tella et al. (2010), they do not consider possible diminishing marginal effects of income changes. Their quantile regression approach shows that the loss aversion comes from the bottom quantiles, and no effects can be seen at the mean.

Vendrik and Woltjer (2007) have the same goal as us of testing the predictions of PT on the SOEP, but make a very different choice for the reference point, namely the income of the social reference group of an individual. This group is defined to be a cell of individuals with similar education, similar age, from the same region and of the same gender. This specification has advantages and disadvantages over ours. Since PT has no clearly defined theory of reference point formation, one can see these results as being complementary to ours. With this choice of reference point, they are able to use a general specification to look for all features of PT, like loss aversion and asymmetries in the diminishing marginal effects of relative income. In addition, they look carefully at the robustness of the concavity results to distortions of the LS scale. One result is significant concavity for both positive and negative relative income. The concavity is stronger for losses and robust to distortions in the LS scale. Their proposed explanation for loss concavity is that there are two competing effects: there are declining marginal effects of social comparison, but stronger increasing marginal effects of "social participation", which dominate.

In a similar vein, Ferrer-i Carbonell (2005) also looks at the importance of "comparison income", that is, the income relative to a social group, with an ordered probit model. She concludes that the income relative to the reference group is about as important as the absolute income level for individual happiness. Restricting the analysis to West Germany, she finds support for loss aversion. McBride (2001) also considers comparison income with ordered probit techniques, but does not allow for asymmetric effects of positive and negative differences. He finds stronger effects at lower levels of income, but does not consider features of prospect theory.

Using large survey datasets, De Neve et al. (2018) find that measures of SWB are linked to growth, but individuals are more than twice as sensitive to negative as to positive economic growth, a sign of loss aversion. This has implications for the long term effect of economic growth with volatility, and is one of the proposed explanations to the Easterlin paradox. They use the Gallup World Poll for 150 countries, Behavioral Risk Factor Surveillance System data on the US, and Eurobarometer data. They test the fit of a piecewise linear relationship between growth and SWB. The effect of growth changes on SWB subsumes the effects of income changes, unemployment changes, and perhaps inflation and inequality. When the authors introduce controls for these other macro variables, it weakens their main result.

Table 1: Summary of most relevant literature

Study	Variables	Features	Reference point
Boyce et al. (2013)	Household income	Loss aversion	Past self
Di Tella et al. (2010)	Household income	Loss aversion	Future (realised) self
Fang and Niimi (2017)	Household income, Living standards	Loss aversion	Future (expected) self, Social peers
Vendrik and Woltjer (2007)	Household income	Loss aversion, Reflection effect	Social peers
Ferrer-i Carbonell (2005)	Household income	Loss aversion	Social peers
De Neve et al. (2018)	National income	Loss aversion	Past national income
This study	Household income, Health, Employment	Loss aversion, Reflection effect	Past self

Table 1 summarises the most relevant literature and highlights our contribution. While most papers have considered loss aversion (and by extension reference points), only Vendrik and Woltjer (2007) is a comprehensive test of PT on LS. Our paper differs from theirs in two important respects: We consider income, but also health and employment, and we use individuals' past values of those variables as reference points, instead of social peer groups.[5]

More widely speaking, considerations of absolute and relative effects also provide the background to the literature on the Easterlin paradox—the apparent contradiction between the strong short-term association of GDP and SWB and the lack of long-term association seen in developed countries. Proto and Rustichini (2013), Di Tella et al. (2010), Fang and Niimi (2017), Stevenson and Wolfers (2013), Clark et al. (2008b) can be seen as contributions on this topic. Sacks et al. (2012) also discuss the effect of absolute and relative income on SWB, in a comparison across countries. De Neve and Oswald (2012) look for the inverse effect of LS on later income in a US panel, and Binder and Coad (2015) look for the inverse effect of LS on later unemployment or mental well-being measures in the British Household Panel Survey. Using the SOEP, Lucas et al. (2004) look for short and long-term effects on SWB, Clark et al. (2008a) look for evidence of habituation after life and labour market events, Frijters et al. (2004) find a strong long-term effect of income growth on LS in East Germany after reunification, and Clark et al. (2016) find that there is no adaptation to

[5] Vendrik and Woltjer (2007) include employment as a control variable. They do not include health at all and explain this omission by: "A control variable for health status was not included since this may represent an important intermediate variable between absolute income and life satisfaction. Moreover, one third or more of the observations are missing." (page 1,434, footnote 15.

poverty in terms of LS. Luttmer (2005) uses information on the earnings of neighbours to see if there are any comparison income effects.

3 Data

We use the German Socio-Economic Panel (2016), version 32, a dataset that has been widely used in LS research and is described in detail in Goebel et al. (2019). We use survey years 1995–2015, as the health variable that we use is continually available from 1994 onwards. We consider individuals aged 18–85.

3.1 Outcomes

Current LS is measured with 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.[6] We treat LS as a cardinal variable. This is a choice of convenience, but supported by practice in the psychology literature for scales of at least 11 points (see Nunnally and Bernstein (1994), p. 115). It is also robust. We have also conducted all our estimations and tests based on the Blow-up and Cluster estimator in Baetschmann et al. (2015). The estimator treats the dependent variable as ordinal but not necessarily cardinal. It is consistent and based on the dichotomisation of the dependent variable at every threshold and the application of the conditional logit model in Chamberlain (1980). The estimator allows for individual fixed effects and makes no assumption about their correlation with the independent variables. The results were only marginally different from our main results. Ferrer-i-Carbonell and Frijters (2004) also support the robustness of LS regression results to treating LS as cardinal or ordinal. The results for the Blow-up and Cluster estimator can be found in table 9 in the appendix.

3.2 Main independent variables

Literature reviews of correlates of subjective well-being typically identify the following variables and domains: Social relationships (family and friends), income and wealth, employment status, demographic characteristics (sex, age), health, education, and religion (Argyle, 1999; Dolan et al., 2008; Clark, 2018; Diener et al., 2018). However, not all of those variables lend themselves to a ranking of values. More income ranks

[6] 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.

higher than less income, and the case of someone preferring the latter would be very exceptional. However, having a partner might not be preferred over not having a partner, at least for some people, or some of the time. We therefore focus on three variables for which we can confidently establish a preference ranking.

For *income* we use equivalised net monthly real household income. We use the consumer price index (base year 2011) to calculate real household income. Household income is typically used in LS research to account for the fact that resources are often pooled and distributed at the household level (Proto and Rustichini, 2015). We use the OECD equivalence scale: Total net monthly 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. To eliminate the effect of outliers we restrict the estimation sample to observations whose equivalised net monthly household income does not change by more than 500 Euros from one year to another, which comprise 88.8% of all person-year observations, with a sample mean of 1,414 Euros. Our estimation results are mostly not sensitive to this restriction. Table 7 in the appendix compares the main results for different sample restrictions based on income changes. The only result that is affected is the significance on the concavity of income gains.

Health is captured by the individuals' self-assessment. Survey participants are asked: "How would you describe your current health?" and can choose between the answer boxes "Bad", "Poor", "Satisfactory", "Good" and "Very good", which we code from 1 to 5 in the same order. We create dummy variables for each category and use "Bad" as the omitted category in the regressions. Self-assessed health is far from ideal in our setting and is almost certain to be endogenous. Omitted variables which have an effect on self-assessed health are likely to affect LS in the same direction thus causing an upward bias in the estimated health effect. Unfortunately, the SOEP does not offer convincing alternatives. Since 2002 a health questionnaire based on the SF-12 is administered (Andersen et al., 2007) but this is done only every other year. We would thus have to assume that people use their health status from two years ago as a reference point, or we would have to interpolate the missing years, both of which we deemed to be indefensible in the context of our research question. Omitting any health variable is equally problematic. Health certainly correlates with income and employment and by omitting it from the model we would only substitute one type of omitted variable bias for another one.

As an alternative to self-assessed health we create a health index which is the sum of a dummy for not having visited a doctor in the previous three months, a dummy for not having any hospital visit in that year, and a variable categorising the extent to which health interferes with daily functions (0: substantially, 1: partially, 2: not at all). Our index ranges from 0 to 4, and we have used the same parametrisation as for our original health variable (dummies for all categories and transitions). We will discuss further implications of using self-assessed health in the next section.

Labour force status is captured by three dummy variables for being employed (E), being unemployed (U), and not being in the labour force (N, the omitted category). Among the three categories only two can be ranked in terms of which is preferred by the respondent. For an employed person, unemployment is an available option, so employment is preferred to unemployment. For an unemployed person, employment is preferred by definition.[7] We therefore treat employment as a status better than unemployment. For a pair-wise comparison between employment and non-participation or between unemployment and non-participation we cannot make any general assumptions in terms of their preference ranking.

3.3 Control variables

The choice of the remaining explanatory variables is informed by the literature on happiness. We include the following individual characteristics: A dummy for males, a dummy for living with a partner, a dummy for having children, years of education, and six age categories (18–29, 30–39, 40–49, 50–59, 60–69, 70–85). Table 2 presents the summary statistics of our sample.

3.4 Choice of reference point

PT 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 belief about the relevant consumption outcome held between the time she first focused on the decision determining the outcome and shortly before consumption occurs" (page 1,141), thus proposing expected consumption as the reference point. Others have argued that, in eval-

[7] Unemployment can be voluntary. We therefore would like to qualify our statement. An unemployed person is looking for work, and is therefore preferring *some* employment to being unemployed, though it is only known to them which jobs they would accept and which they would reject. Still, we can say that the person is preferring employment (as understood by themselves) to unemployment. Since we use a fixed effects estimator any concerns about inter-person comparability of job and employment types should be negligible. We thank an anonymous referee for alerting us to this point.

Table 2: Summary statistics

	Mean	S.d.
Outcomes		
Life satisfaction (0-10)	6.98	1.75
Main independent variables		
Income (equivalised in 1,000 Euros)	1.31	0.68
Income gain (equivalised in 1,000 Euros)	0.07	0.11
Income loss (equivalised in 1,000 Euros)	-0.06	0.11
Self-assessed health (1-5)	3.34	0.95
Employed (E)	0.60	0.49
Unemployed (U)	0.06	0.23
Control variables		
Not in labor force (N)	0.34	0.47
Male	0.47	0.50
Has partner	0.74	0.44
Has children	0.38	0.48
Years of education	11.95	2.61
Age	48.5	16.3

Survey years 1995-2015. Observations: 302,777. Persons: 49,606. Income is net real income, equivalised by the OECD scale. The health categories range from bad (1) to very good (5).

uating their LS, people compare themselves to a peer group (e.g., Vendrik and Woltjer (2007) and work cited within). 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. Another choice, which is natural with panel data, is setting the reference point as the lagged value of the variable of interest. This means that the reference point is unique to the person, as it is based on the individual's own past responses. This approach has been taken by many papers discussed above which have, sometimes implicitly, used past income values as reference point.

Whether people use their past self or a social comparison group as reference depends on a number of factors (Schwarz and Strack, 1999; Wilson and Ross, 2000): their goal in engaging in the comparison (an accurate self-assessment or increasing their self-esteem), what their attention is focused on (depending on the previous question, the surroundings, or other people in the room), and their recent experiences or concerns (whether they have recently transitioned from one life stage to another, e.g., retired, married, etc.). While social comparisons received more attention in the psychological literature, Wilson and Ross (2000) demonstrate that comparisons to one's own self are at least as common as social comparisons, and Steffel and Oppenheimer (2009) show that individuals might be more likely to spontaneously adopt an intra- rather than inter-personal reference point. The main independent variables (income, health, and employment) lend themselves intuitively to intra-personal comparisons. A salary increase, a recovery from illness, and finding a job are all likely to be experienced as improvements or achievements, suggesting that the past self is a proper reference point, albeit maybe one of several.

There are two more arguments to support the past self as a reference point in our context. First, the fact that any respondent included in the estimation sample must have answered the survey in the previous year, and probably has done so over a number of years. Second, the LS question is the last question being asked during the interview, after the respondent has been engaged in a lengthy interview about their life circumstances, opinions and attitudes. Questions about satisfaction with certain life domains are asked at the beginning of the interview, so that an attention focus on any particular aspect of their lives induced by the interview itself is unlikely. Finally, the variables characterising the state of the past self are readily available. Using a social reference point would require a number of ad-hoc or data-driven choices: which social group to choose, over which spatial and temporal dimension, and which statistic to use as reference point. There is likely to be a considerable mismatch between such constructed reference groups (e.g., all of West Germany) and the true social reference points that people compare themselves against (e.g., one's neighbours). Hence, we use the past self as reference point, but we return to social comparisons in the robustness and extensions section.

4 Model and estimation

We test whether LS exhibits the properties of reference dependence, diminishing marginal utility, and loss aversion, all of which are discussed further below. To this end we estimate an equation which can accommodate and potentially reject all these properties:

$$
\begin{aligned}
ls_{it} = & \beta_0 + \beta_1 y_{it} + \beta_2 y_{it}^2 + \mathbb{1}_{\Delta y_{it}>0}\left(\gamma_1 \Delta y_{it} + \gamma_2 (\Delta y_{it})^2\right) + \mathbb{1}_{\Delta y_{it}\leq 0}\left(\delta_1 \Delta y_{it} + \delta_2 (\Delta y_{it})^2\right) && (1)\\
& + \alpha_2 H2 + \cdots + \alpha_5 H5 + \sum_{j\in J}\sum_{k\in(J\setminus j)} \alpha_{jk} TH_{it}^{jk} && (2)\\
& + \rho_E E + \rho_U U + \sum_{l\in L}\sum_{m\in(L\setminus l)} \rho_{lm} TL_{it}^{lm} && (3)\\
& + \eta \mathbf{X_{it}} + u_i + v_t + \varepsilon_{it} && (4)
\end{aligned}
$$

where i indexes the person, and t the survey year. 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 *change* effects, differentiated by gain and loss effects (through γ_1, γ_2, δ_1 and δ_2). In the former case the amount of income available to the individual affects her LS. In the latter the change in income affects her LS. Using a quadratic function allows for concavity and convexity. One anticipated objection is that the quadratic function imposes an (inverted) U-shape on the LS-income relationship. However this will not be a problem as long as most of the observed incomes fall into the domain for which LS is only increasing. The decreasing part of the function would be empirically irrelevant.

The model for income is parsimonious in the sense that it contains the minimum number of parameters that we need to test for the shape of LS with respect to income. For example, we want to test for the direction and the curvature of the income effect and therefore require two parameters. If we had included only the natural logarithm of income as is often done in the literature, then finding a positive effect of income on LS would also impose this effect to be concave. The same reasoning holds for estimating the shape of the LS function for income gains and for income losses. Note that the power function employed by Vendrik and Woltjer (2007) achieves the same: it employs one parameter which governs the direction of income gains and losses (γ_+ and γ_-) and another which governs the concavity or convexity (ρ_+ and ρ_-). However, the power function is not linear in parameters and needs to be estimated by non-linear methods. This gives rise to the incidental parameters problem when combined with a large number of fixed effects, or otherwise complicates the estimation. For example, Vendrik and Woltjer (2007) seem to combine a grid search for the parameters which enter non-linearly with a within transformation at every point on their grid.[8] We therefore decided to settle for the quadratic specification for levels, gains, and losses. We have also estimated the specification as in Vendrik and Woltjer (2007) to check robustness, and it did not substantially affect our main results. It resulted in a very strong convexity parameter for income losses and a negative coefficient for income gains. A graphical comparison between our model and the model in Vendrik & Woltjer is presented in figures 2 and 3 further below.

An important limitation of our model is the linear dependence between current income, past income, and the difference between the two. In our specification a separate effect of past income is not identified in the linear model. However, under the assumption that past income has a positive independent effect on LS, its omission leads to an overestimation of the effect of current income and to an underestimation of the effect of income changes. To see this for example for income gains, consider that $\beta_1 y_t + \gamma_1 \Delta y + \eta y_{t-1} = (\beta_1 + \eta) y_t + (\gamma_1 - \eta) \Delta y = (\beta_1 + \eta) y_t - (\gamma_1 - \eta) y_{t-1}$.

Our estimate for current income thus combines the effect of current and past income, while the estimate for income change is biased downward by the value of η. This problem is of course not unique to our paper. Any model which seeks to estimate the effect of a variable along with the effect of a reference point (or the difference) implicitly assumes that the difference (or the reference point) does not have an effect on the dependent variable. For example, Clark and Oswald (1996) estimate the impact of current and past income on job satisfaction, and thus assume that income gains or losses have no effect. Ferrer-i Carbonell (2005) estimates the impact of own and reference income on LS and thus her parameters are combinations of the effect of own income, reference income, and the difference between the two. The difference matters since both reference income and the difference between own and reference income might have separate effects (e.g., the former through better local services, the latter through social comparison effects).

In (2) we include dummy variables for all but one of the different health categories, $H2$ to $H5$, as well as

[8] Their paper is not entirely clear on how they estimate or remove the fixed effect.

all genuine transitions TH from one health state to another, where J is the set of integers from one to five (one for each health state), and the indices j and k stand for the previous and current health status respectively. The current health state can be written as the sum of all transitions which lead to this state. We therefore omit the degenerate transitions ($j = k$). 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 labour force status, we also include dummies for being employed and unemployed, E, U, as well as all possible transitions TL from one labour force status to another, where L is the set $L = \{E, U, N\}$ and N stands for not being in the labor force. The indices l and m stand for the previous and current employment status respectively. For example, TL^{EU} is 1 if an individual was employed in the previous year, but is unemployed in the current year.

In the following subsections we discuss our hypotheses and how we are going to test them. Table 3 summarises the main hypotheses along with their results. To control the power of our tests we have formulated our hypotheses such that the features we are looking for are stated as alternative hypotheses.

4.1 Income, health and employment are goods

We first establish that the variables of interest are considered "goods" in terms of LS. The literature has firmly established that income, good health, and not being unemployed exert a positive influence on LS. We re-affirm these results for completeness. It is sensible to show that the variables of interest are desirable, before proceeding to tests regarding reference points or loss aversion.

For income to be a good, it needs to increase LS. Holding fixed the change in income Δy (and omitting the individual subscript) we have the following condition for income to be a good:

$$\frac{\partial ls}{\partial y} = \beta_1 + 2\beta_2 y_t > 0, \tag{5}$$

leading to the following hypothesis (we will refer to the hypotheses by their label in parentheses):

Hypotheses: (Y1) *Income is a good,*

$$\mathbf{H_{a,y_1}}: \quad \beta_1 + 2\beta_2 y_t > 0.$$

For health and labour force status we formulate the following hypotheses, assuming that a person has been in the same state in the previous year—that is, all transition dummies are zero:

Hypotheses: (H1) *Better health increases LS,*

$$\mathbf{H_{a,h}}: \quad \alpha_j - \alpha_k > 0 \quad \forall\, j > k.$$

(L1) *Being employed is better than being unemployed,*

$$\mathbf{H_{a,l}}: \quad \rho_E - \rho_U > 0.$$

4.2 Reference point

The reference point test in the context of PT 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 the reference point, then the coefficients on the current levels should be zero. We test whether income changes and health and employment status transitions have an influence on LS once income levels and health and employment states are controlled for. PT postulates a positive effect of "increases" of those goods. We therefore have for income gains:

$$\frac{\partial ls}{\partial \Delta y} = \gamma_1 + 2\gamma_2(\Delta y) > 0. \tag{6}$$

Suppose two persons have the same income. If the first has had the same income in the previous year, while the second person has arrived at their current income from a lower level, then equation 6 implies that the second person enjoys higher levels of LS.

For income increases to be a good in the loss domain, that is, a reduction of an income loss, we have

$$\frac{\partial ls}{\partial \Delta y} = \delta_1 + 2\delta_2(\Delta y) > 0. \tag{7}$$

Suppose two persons have the same income. If the first has had the same income in the previous year, while the second person has arrived at their current income from a higher level, then equation 7 implies that the second person enjoys lower levels of LS.

Similarly, for two people with the same health status, we should expect higher LS for the person who arrived at this status from a poorer health state, and lower LS for the person who arrived at this status from a better health state. Since someone whose health deteriorates is experiencing both a lower health state (estimated as α_j) *as well as* a health *loss* (estimated as α_{jk} with $j > k$) we would expect the two effects to result in lower LS than if the same health state had been experienced without a loss. If someone arrives at this health state after recovering from bad health, then we would expect their LS to be higher since they are experiencing a better health state *as well as* a health *gain*. It is possible that the LS effects of gains and losses are greater in magnitude than the level effects, in which case poorer health might result in higher LS, but this seems like a highly unlikely scenario and at any rate is not supported by our results. Note that with 5 health states we can have 20 potential transitions between health states, half of which are health improvements, and the other half health deteriorations.

For employment status the reasoning is analogous. An employed person should enjoy more LS than an unemployed person. But an unemployed person who recently lost their job should report lower LS than if they had been unemployed in the past, and an employed person who recently was unemployed should report higher LS than if they had been employed in the past.

For small gains in income (Δy approaching zero) we test:

Hypotheses: (RP1) *LS is increasing in changes in the gains domain,*

$$\mathbf{H_{a,y}}: \quad \gamma_1 > 0,$$

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

$$\mathbf{H_{a,l}}: \quad \rho_{UE} > 0,$$

Hypotheses: (RP2) *LS is increasing in changes in the loss domain,*

$$\mathbf{H_{a,y}}: \quad \delta_1 > 0,$$

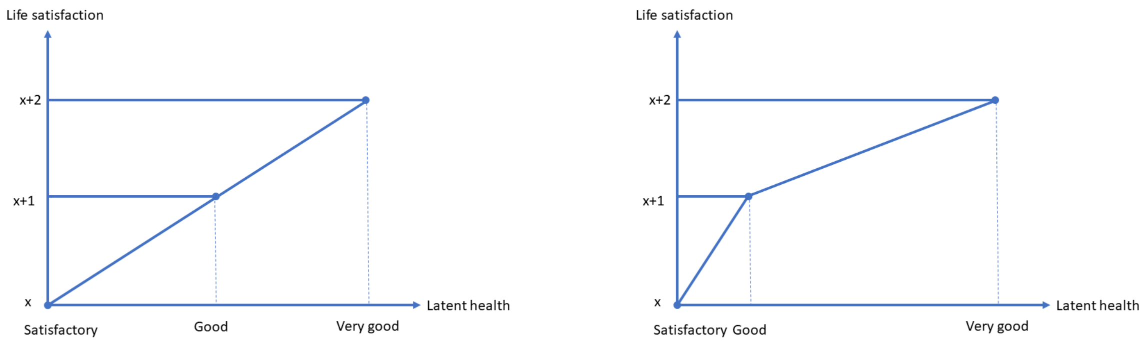
$$\mathbf{H_{a,h}}: \quad \alpha_{jk} < 0 \quad \forall j,k \quad \text{such that } j > k,$$

$$\mathbf{H_{a,l}}: \quad \rho_{EU} < 0,$$

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.

4.3 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 logit and assume that the latent variable has cardinal properties. We have estimated our model under both assumptions. We used the fixed effects OLS estimator for the cardinal, and the fixed effects ordinal logit (Blow-up and cluster, Baetschmann et al., 2015) for the ordinal specification. The two specifications yielded almost identical results. We produce a table of results for the ordinal model in the appendix, and proceed here with the cardinal model.



(a) Health variable is cardinal

(b) Health variable is only ordinal

Figure 1: The respondent reports life satisfaction ‘x’ in satisfactory health, ‘x+1’ in good health, and ‘x+2’ in very good health. In the left figure the health gain between Satisfactory and Good is the same as between Good and Very good. Life satisfaction is therefore linear in health. In the right figure the health gain between Satisfactory and Good is less than the health gain between Good and Very good. Life satisfaction is concave in health.

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 (see figure 1). 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 (left sub-figure in figure 1). But if the incremental gain in health between satisfactory and good is smaller than the gain in health between good and very good, the person would still exhibit diminishing marginal utility with respect to health (right sub-figure in figure 1). 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 health categories can be ordered, we do not assume that gains in health have ratio properties.

We test for diminishing marginal utility in *levels* and in *changes*. The two channels are not mutually exclusive but EUT supports the levels effect, while PT supports the changes effect. For income levels to have diminishing marginal effects on LS, the sufficient condition is $\beta_2 < 0$.

For income changes we can use equations 6 and 7. Taking derivatives with respect to Δy we obtain

$$\frac{\partial^2 ls}{\partial \Delta y^2} = \gamma_2, \qquad \frac{\partial^2 ls}{\partial \Delta y^2} = \delta_2.$$

Thus for LS to be concave in gains and convex in losses we require

$$\gamma_2 < 0, \qquad \delta_2 > 0.$$

The hypotheses are the following:

Hypotheses: (DMU1) *LS is concave in income levels,*

$$\mathbf{H_a}: \quad \beta_2 < 0.$$

(DMU2) *LS is concave in income gains,*

$$\mathbf{H_a}: \quad \gamma_2 < 0.$$

(DMU3) *LS is convex in income losses,*

$$\mathbf{H_a}: \quad \delta_2 > 0.$$

4.4 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 defined. 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 $\frac{\partial ls}{\partial \Delta y}$ in the gain domain to the same derivative in the loss domain. Loss aversion requires that the rate of change of LS for a decrease in y be greater than the rate of change in LS for a corresponding increase. From equations (6) and (7),

$$\delta_1 + 2(-\Delta y)\delta_2 > \gamma_1 + 2\Delta y \gamma_2, \quad \forall \Delta y \geq 0.$$

In particular, $\lim_{\Delta y \to 0}$ 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 $(\rho_E - \rho_U) + \rho_{UE}$, and 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 will 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.

The hypothesis on loss aversion is:

Hypothesis: (LA) *LS exhibits loss aversion in income, health and employment,*

$$\mathbf{H_{a,y}}: \quad \gamma_1 - \delta_1 < 0,$$

$$\mathbf{H_{a,h}}: \quad \alpha_{kj} + \alpha_{jk} < 0 \quad \forall\, j > 1 \quad \text{and} \quad \forall\, k < j,$$

$$\mathbf{H_{a,l}}: \quad \rho_{UE} + \rho_{EU} < 0.$$

4.5 Endogeneity of self-assessed health

In section 3.2 we have touched upon the problem of endogeneity of self-assessed health. Since both LS and health are self-reported, the risk of endogeneity is very high. We would expect an omitted variable to correlate with both variables in the same direction. Whatever drives respondents to report better health also drives them to report higher LS. The bias on health's effect on LS is thus positive. But how would this affect our estimates for health state transitions? Consider a simplified measure of health gains constructed as $\mathbb{1}_{H_t > H_{t-1}}$ with H_t being current health, and H_{t-1} past health. If past health is exogenous or its endogeneity negligible compared to current health, then health gain effects will also be estimated with a positive bias since the omitted variable drives health and health gains in the same direction. On the other hand, health loss effects for health loss defined as $\mathbb{1}_{H_t < H_{t-1}}$ will be negatively biased.

Recall that our test for LS to increase in health gains is given by $\alpha_{jk} > 0$ for $j < k$ ($\mathbf{H_{a,h}}$ in **RP1**). Due to its positive bias estimated α_{jk} will exceed its true value and we might erroneously conclude that it is positive. Rejecting the hypothesis however would be achieved *despite* the upward bias. The case for health losses is analogous. Accepting $\alpha_{jk} < 0$ for $j > k$ can be driven by negative bias and need not imply that health loss truly negatively affects LS, but rejecting it is strong evidence that health loss does NOT negatively affect LS.

Unfortunately, the two biases do not combine to give us an unambiguous direction for the bias in testing loss aversion. Since both biases amplify the coefficients α_{jk} and α_{kj} in absolute value we would need to know which of the two coefficients is affected more. The loss aversion test is therefore not conclusive but only suggestive. However, our results for health reveal some interesting features which render the loss aversion test obsolete.

Table 3: Summary of hypotheses to be tested.

Code	Alternative hypothesis H_a	H_a supports:	p-value	p-value adjusted
Panel A: Level effects				
Y1	LS is increasing in income levels.	EUT	0.000	0.000
H1	LS is increasing in good health.	EUT	0.000	0.000
L1	LS is increasing in employment.	EUT	0.000	0.000
Panel B: Reference point				
RP1	LS is increasing in income changes in the gains domain.	PT	0.438	0.500
	LS is increasing in health gains in the gains domain.	PT	>0.351	0.500
	LS is increasing when one becomes employed.	PT	0.966	0.715
RP2	LS is increasing in income changes in the loss domain.	PT	0.000	0.005
	LS is increasing in health gains in the loss domain.	PT	>0.954	0.657
	LS decreases when one becomes unemployed.	PT	0.034	0.286
Panel C: Diminishing marginal utility				
DMU1	LS is concave in income levels.	EUT	0.000	0.000
DMU2	LS is concave in income changes in the domain of gains.	PT	0.152	0.332
DMU3	LS is convex in income changes in the domain of losses.	PT	0.002	0.005
Panel D: Loss aversion				
LA	LS exhibits loss aversion in income.	PT	0.028	0.055
	LS exhibits loss aversion in health.	PT	n.a.	n.a.
	LS exhibits loss aversion in (un)employment.	PT	0.005	0.010

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

5 Results

The exact results for our main econometric model from equation (1–4) can be found in table 8 in the appendix. The results are generally in line with what is known about LS. Having a partner, having children, not being unemployed, being in good health, and income are associated with higher levels of LS. 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.[9] Table 3 summarizes the hypotheses and test results on reference points, diminishing marginal utility, and loss aversion. Note that the second to last column reports the p-value for the hypothesis tested in isolation, and the rightmost column the Šidák-corrected p-value which adjusts for the testing of multiple hypotheses. We grouped the hypotheses in panel A, RP1 in panel B, RP2 in panel B, panel C, and panel D when making the correction. A Bonferroni correction resulted in the same inference. Regarding our tests on whether income, health and employment are goods in term of LS (panel A), we find that all of those variables are goods. The hypothesis of no income effect (Y1) is rejected at the 1% level for a wide range of income levels y_t (between 0 and 5,000 Euros –

[9]A Hausman test rejects the equality of coefficients from the random effects and fixed effects estimators.

99.8% of our sample) in favour of the alternative hypothesis of positive income effects. Hypothesis H1 (no health effects) is strongly rejected for all possible health states. L1 (no employment effect) is also strongly rejected. Quantitatively, our estimates imply that a person enjoys 0.27 more 'units' of LS with an income of 2,000 Euros than they do with an income of 1,000 Euros.[10] Better health implies higher LS by between 0.35 (between very good and good) and 1.26 units (between not so good and bad), and a person enjoys half a unit of LS more when they are employed rather than unemployed.

5.1 Reference point

From panel B of table 3 we see that none of the hypotheses in RP1 (gains relative to the reference point have no effect) can be rejected. For income, there is no statistical evidence that a gain has any effect on LS over and above the level effects. For employment, a transition from unemployment to employment actually carries a significant (for a one-sided test) negative sign. However, the results for the loss domain are in agreement with the properties of PT. An income increase in the loss domain—that is, making the loss smaller—increases LS. The transition from employment to unemployment reduces LS, controlling for employment status. A person who just became unemployed has lower LS than a person who was unemployed in the previous period and is still unemployed. Thus, the evidence is that losses hurt but gains do not help. The magnitudes of these relative effects are quite small. Removing a loss of 100 Euros increases LS by 0.03 points, adding a gain of the same amount leaves LS virtually unchanged. The transition effect from employment to unemployment is a reduction in LS by 0.05, only a tenth of the level effect difference between employment and unemployment.

For health we get a completely reversed, and unexpected, result. Since there are many different health improvement transitions we test each of them. To see whether health gains improve LS, we test the null hypothesis that a health gain coefficient is ≤ 0 against the alternative that it is positive. For health losses, we test the null hypothesis that a health loss coefficient is ≥ 0 against the alternative that it is negative. The p-value in the table is the smallest out of all p-values for those tests, that is, all tests for health gains had a p-value of at least 0.517. There is thus no support for the claim that health gains increase LS. Indeed, the results mask the fact that all but one of the tests supported a *negative* coefficient, despite the likely positive bias as explained in section 4.5. That is, someone whose health state is x as a result of a health improvement

[10] The within person standard deviation of LS is 1.14, so the LS difference between 2,000 and 1,000 Euros corresponds to a quarter of an LS standard deviation.

still enjoys lower LS than someone whose health state is and was x. This is contrary to our expectation as spelled out in the previous section. A health state in combination with experiencing a health gain results in *lower* LS than the health state alone. The reverse is true for health losses. All coefficients here are positive despite the likely negative bias. That is, a person whose health is x as a result of a health decrease still enjoys higher LS than someone whose health is and was x. A health state in combination with experiencing a health loss results in *higher* LS than the health state alone.

Taken together, the results reported in panels A and B do not lend exclusive support for or against EUT or PT. Rather, LS seems to be best described by a model which incorporates both level and change effects, and exhibits asymmetries between gains and losses, albeit with important differences to the value function in PT. However, level effects dominate transition effects in magnitude.

5.2 Diminishing marginal life satisfaction

Panel C presents the results for hypotheses DMU1 to DMU3. LS is concave in income levels. While it is clearly convex in the loss domain of income, the support for concavity in the gains domain is not strong. We cannot reject that it is flat or convex at the 10% significance level.

5.3 Loss aversion

The gradient for income losses close to the reference point is 0.26 while for income gains it is only 0.01. Loss aversion (panel D) is thus present at the 5% significance level for income. Loss aversion is also present for employment status. Given our results for reference points for health transitions, it makes no sense to test for loss aversion in health. Rather, if we test for "loss preference", that is, the LS increase after a drop in health exceeding the LS decrease after a symmetric health improvement, we find significant support at the 5% level for this phenomenon for six out of the ten possible health transitions.

5.4 Shape of LS function

The LS function for changes in income in a range of -200 to +200 Euros is depicted in figures 2 and 3. Figure 2 depicts the effect of income changes when current income is fixed (the change thus occurs through past income). This corresponds to a pure change effect (e.g., is driven by Δy only). The left panel shows the resulting LS function from our quadratic model, and the right panel from a LS specification as in Vendrik and Woltjer (2007). Standard errors for the latter specification do not have a closed form. We therefore did not produce confidence bands. The models have the same properties in the loss domain (increasing and convex), even though the LS function as implied by the quadratic model is much smoother. The two models look distinct in the gains domain. Our model implies more of a flat profile (we cannot reject that it is flat on statistical grounds, see section 5.2), whereas the Vendrik & Woltjer specification results in decreasing LS in income gains. Figure 3 shows the combined level and change effects (varying current income while holding past income fixed). Here, as the effect of current income dominates the loss and gain effects, the two profiles resemble each other much more. They have most of the characteristic features of Prospect Theory: the kink at the origin, a slight concavity in gains, convexity in losses, and a general stronger effect of losses than gains.

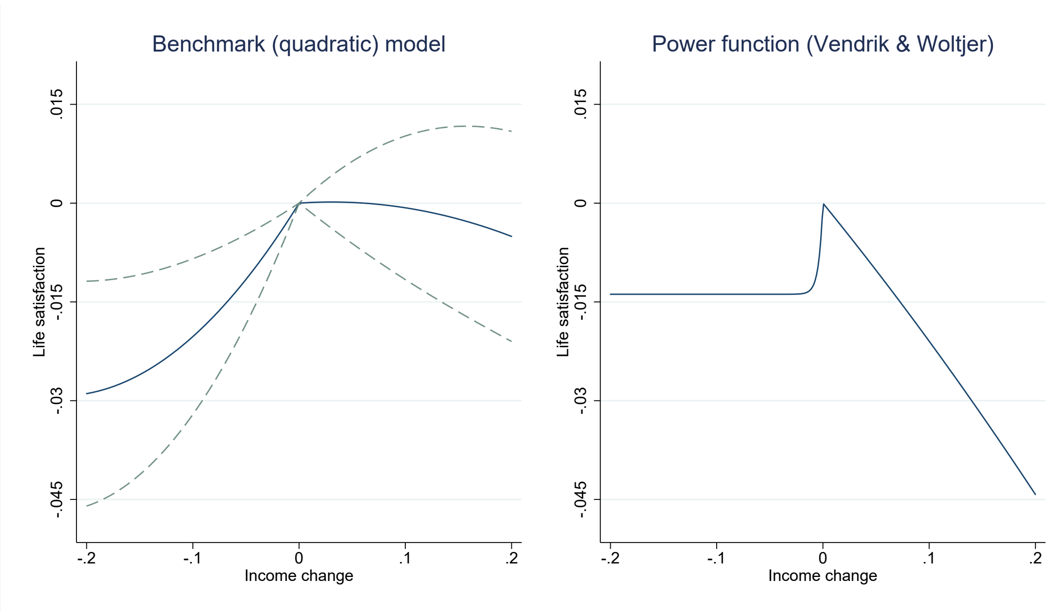


Figure 2: Life satisfaction as a function of income changes, with current income held fixed. The left-hand figure is our benchmark model. Dashed line is the 95% confidence interval for the change in life satisfaction. The right-hand figure is based on the power function specification as in Vendrik and Woltjer (2007). For the power function we did not compute confidence bands. Income changes are in 1,000s of Euro. The vertical axis is LS relative to no income change.

6 Discussion

The purpose of our analysis was to establish which features of the utility function in EUT and PT are displayed by reported current LS. The findings suggest that LS can be best described by EUT but also contains some features associated with PT. LS follows EUT in that higher income and better health levels are associ-

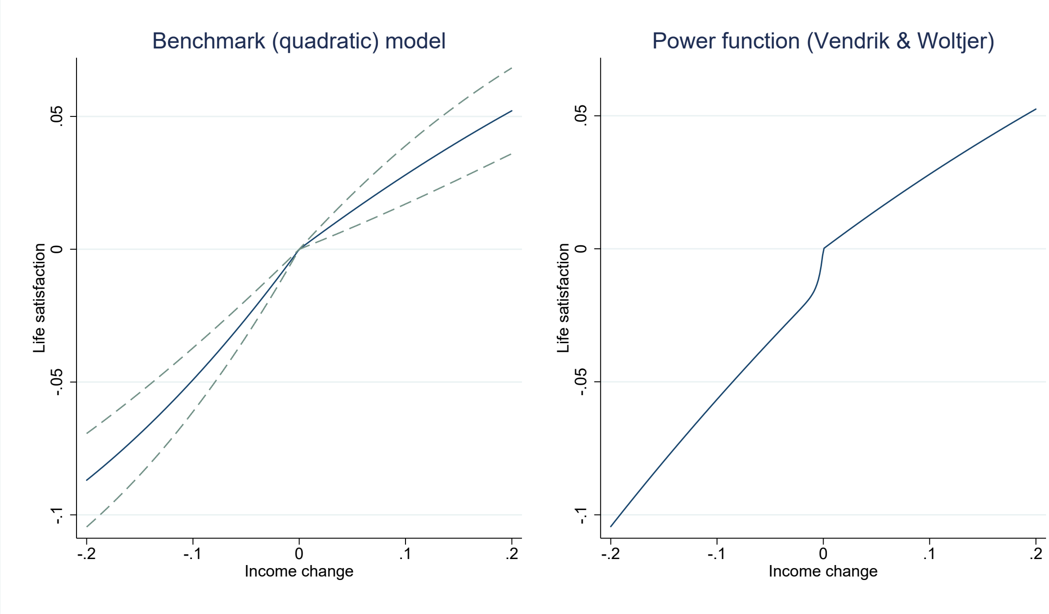


Figure 3: Life satisfaction as a function of income changes, with past income held fixed. The left-hand figure is our benchmark model. Dashed line is the 95% confidence interval for the change in life satisfaction. The right-hand figure is based on the power function specification as in Vendrik and Woltjer (2007). For the power function we did not compute confidence bands. Income changes are in 1,000s of Euro. The vertical axis is LS relative to no income change.

ated with higher LS. Individuals enjoy higher LS when employed rather than unemployed. Furthermore, LS is concave in income levels and thus exhibits diminishing marginal LS. In this section we discuss threats to the validity of our results and interpretations. In particular, we discuss the issue of measurement error, and other potential mechanisms that link self-assessed health with LS and to what extent they can explain our findings. We also offer some thoughts on the difference between reported and 'true' LS and their implications on our findings.

6.1 Measurement error

It is well known that measurement error in independent variables results in inconsistency of OLS and typically in a bias of the concerned coefficient towards zero. Fixed effects estimators can exacerbate this so-called attenuation bias and a number of methods have been proposed to deal with measurement error in panel data depending on what one assumes about the variance of the measurement error (Griliches and Hausman, 1986; Meijer et al., 2017).

In the present case measurement error enters in a number of ways. First, we have classical measurement error in all our variables: People might inaccurately report their incomes, their health, and their employment status. Bound et al. (1994) show that earned incomes are fairly accurately reported in the PSID, but biases are amplified by using income changes, which is a key variable in our model. Second and relatedly, ours is a dynamic panel model since the key variables enter both contemporaneously as well as with a one-period lag, further complicating the analysis of measurement error. Third, recall that our income variable is real equivalised household income, which almost certainly misspecifies how income and household composition interact in determining LS. Indeed, we are likely to misclassify some losses as gains and vice versa simply by assuming that individuals care about real income changes and have knowledge about year-on-year inflation. Forth, we have continuous measurement error in income, and measurement error in the form of misclassification for health and for employment. Card (1996) proposes an estimator which takes account of misclassification of union status. However, he relies on external information on misclassification probabilities.

The literature on subjective well-being seems to have largely ignored the problem of measurement error, and given the complexity of it in the present context we, too, do not explore this problem further.

6.2 Health transitions and life satisfaction

The results for the effects of health transitions on LS run against our expectations. The relationship between self-assessed health and life satisfaction is complex and perhaps our results are driven by a mechanism which we did not model. One possibility is that our results are driven by the endogeneity of self-assessed health and health state transitions. We have discussed this in section 4.5 and have argued that the resulting bias might explain positive effects of health gains and negative effects of health losses. However, we find the opposite *despite* the direction of the bias.

Can the phenomenon of adaptation explain our findings? To explore this we will look at two types of adaptation: People might adapt their health perceptions to their health state (e.g., reporting better health over time despite no change in their underlying health state), or they might adapt to how satisfied they are with their health (e.g., reporting better LS over time despite no change in self-assessed health). In the first case we assume that LS is determined by 'true' health, but self-assessed health is only a distorted signal of true health. Our goal is to estimate the parameters in a simplified model which can describe the above phenomenon:

$$LS = \beta_0 + \beta_h H + \beta_+ H^+ + \beta_- H^-$$

Here H^+ is a health gain and H^- a health loss dummy. Imagine an individual whose health deteriorates, resulting in a decrease in both self-assessed health and LS. For the moment let us assume that that $\beta_- = 0$ so that the change in LS is fully captured by β_h. In the next period the same person's health (and therefore LS) is unchanged. However, they *report* better health as they have adapted to their new health state. The model would imply a change in LS by $\beta_h + \beta_+$. What would β_+ need to be to reconcile higher reported health with no change in LS? We can fit the described data by choosing $\beta_+ = -\beta_h$: LS *should* increase by the level effect β_h. Since LS does not change, the change effect must offset the level effect. Next, imagine an individual whose health improves. They report better health and LS increases in accordance with β_h (we now disregard β_+). But in the next period they adapt to their health and report again their initial level of health. The coefficient β_h would imply lower LS but since their LS does not change β_- must be positive. Adaptation of one's health perception to some benchmark health might thus explain our finding of negative health gain and positive health loss effects.

Next consider the case where people report their health accurately, but they adapt to new health states in terms of their LS. Such a model might be described by

$$LS = \beta_0 + \beta_h H_t + \beta_1 H_{t-1}$$

and if $\beta_h > 0$ then adaptation would imply $\beta_1 < 0$. We can rewrite this as

$$LS = \beta_0 + (\beta_h + \beta_1)H_t - \beta_1(H_t - H_{t-1})$$

A health gain here implies a positive and a health loss a negative effect on LS. This form of adaptation would thus have the same testable implication as PT, but it goes against our findings. Interestingly, the two forms of adaptation result in opposite predictions for health gain and health loss coefficients.

Another driving force behind our results might be a form of progress bias (Campbell and Warren, 2015). If the respondent over-values their health gain—compared to their actual health improvement—loss aversion will not be detected using self-assessed health even if it is present in actual health. Another possibility is that actual health gains reflected by reported better health states do not correspond to equivalent health losses reflected by reported worse health states. For example, respondents might report better health states for small improvements in health, while they might report no change in health states for small health deterioration. Loss aversion, even if present, will not be detected in that case. Finally, the crude health reporting scores obscure important distinctions between acute and chronic health conditions. A change in health level to x might be associated with higher LS, as compared to being stable at x, because the second situation is more likely to be associated with a chronic condition, whereas the first situation is more likely to be associated with an acute, more easily curable, condition.

Since these explanations derive mainly from the subjectivity of self-assessed health, we have repeated our estimation with an alternative health variable which is based on less subjective measures of good health. We created a health index which is the sum of a dummy for not having visited a doctor in the previous three months, a dummy for not having any hospital visit in that year, and a variable categorising the extent to which health interferes with daily functions (0: substantially, 1: partially, 2: not at all). Our index ranges from 0 to 4, and we have used the same parametrisation as for our original health variable (dummies for all categories and transitions). The results were unchanged (not reported). As in our benchmark model health improvements decrease, and health decreases increase LS in most of the pair-wise health state comparisons. LS follows PT in that income gains, health improvements, and a transition from unemployment to employment are associated with higher LS. We also find that for income LS is convex in the losses domain. LS exhibits loss aversion with respect to income and to employment. Health changes on the other hand do not show the gain-loss asymmetric effects on LS, suggested by loss aversion.

6.3 Further considerations

One can argue that the validity of our findings will be compromised under certain conditions. Vendrik and Woltjer (2007) discuss the possibility that people might under-report LS for high values and over-report for low values. Related to this, they argue that the shape of the "true" LS function might be different from the shape of the reported LS function. The validity of these objections hinge on how one interprets LS. While some studies have used LS and other SWB measures as direct or proxy measures of utility, they have not discussed what exactly they mean by utility. Kahneman et al. (1997) provide a useful taxonomy. They distinguish utility by how it is inferred—decision utility vs. experienced utility—as well as by when and over what time period it is measured—instant, total, and recalled utility—, with important consequences for decision making (Dolan and Kahneman, 2008). Decision utility is the utility concept underlying modern economics, according to which utility is that theoretical construct that individuals maximise with their choices under a set of constraints. If LS is a measure of decision utility, then any distinction between reported and true LS is not meaningful, as long as reported LS can rationalise and in turn explain individuals' choices, just as different utility functions can rationalise observed choices. If however one wishes to use LS as a measure of experienced utility then issues of measurement, inter- and intra-personal comparability, and reporting behaviour become paramount.

The experienced utility interpretation can be supported by the view that LS is seen as a global evaluation of one's life. Schwarz and Strack (1999) argue that subjective well-being measures suffer from a myriad of context effects, however the LS question is asked to survey participants at the end of a lengthy interview and asks about life in general, well after a section which asks about satisfaction with different domains in life. This should minimise the probability that their answers will be biased due to attention focus or context effects. Perhaps a more serious argument against the experienced utility interpretation is the argument that LS is evaluated based on past and current, but also prospective experiences (Dolan and Kahneman, 2008).

Given that EUT and PT are theories of choice, the relevant utility concept in the current context is decision utility. However, LS is unlikely to perfectly overlap with decision utility. Benjamin et al. (2014) show that actual choices do not correspond to the options with the highest anticipated happiness in a context of residency choices of medical students. But even if realised choices would correspond to the highest anticipated LS, phenomena like adaptation (Loewenstein and Ubel, 2008) and projection bias (Loewenstein et al., 2003) will induce systematic differences between anticipated and realised LS.

How LS and other subjective well-being measures exactly relate to the different utility concepts is an exciting and open question but it is not the focus of this paper. We have established that L, as reported by survey respondents, shows many of the properties of utility functions stipulated by EUT and PT.

7 Robustness and extensions

7.1 Alternative estimators

The fixed effects estimator (often referred to as within estimator) and the first differences estimator are consistent under the same assumptions, and choosing one over the other is usually justified on efficiency grounds. However, recent work has highlighted that the difference in differences estimator with fixed effects does not generally identify the average treatment effect in long panels (Sun and Abraham, 2020; Goodman-Bacon, 2021; De Chaisemartin and d'Haultfoeuille, 2020). Importantly, in a panel spanning more than two time periods, observations which receive "treatment" in the middle of the sample period receive higher weights in the computation of the treatment parameter. The literature proposes estimators which address the problem of overweighting observations in the middle of the sampling period. However, they rely on assumptions which are too restrictive in our context (e.g., 'treatment' being irreversible). We therefore check the robustness of our results to the choice of fixed effects and first differences but do not employ any of the estimators proposed in this literature.

We repeated our estimations using the following procedure. We divide our panel into non-overlapping two-period panels, starting from 1996/97 to 2014/15 (we lose 1995 as we have an odd number of years in our panel). We perform the fixed effects estimator on each of our subpanels, and aggregate the estimates from each subsample by a weighted average where the weights are given by the size of the subsample. This procedure has the advantage of yielding the same results regardless of whether we use first differences or fixed effects, since the two estimators are equivalent for a panel of length two. The results from this are reported in table 10, column 2. In addition we run a fixed effects estimation (column 3) and a first difference estimation (column 4) on the combined two-period subsamples. Note that the combined sample yields more observations than just the sum of the observations across the subsamples. For example, the first difference estimator also adds the differences for 1997/98, 1999/2000, etc. to the combined sample. To simplify, we have also entered self-assessed health transitions simply as number of health gain or health loss increments.

There are two main differences between our benchmark results and the alternative estimators discussed above. First, the benchmark result and the fixed effects result on the restricted sample support the hypothesis that income losses hurt, while the two-period aggregator and the first difference estimators do not. Consequently, the latter estimators also do not support loss aversion in income. Second, the benchmark result and to a lesser degree the restricted sample fixed effects estimator find a negative effect of transitioning from employment to unemployment, while the two-period aggregator and the first difference estimators do not. Different estimation methods thus lead to different results, mainly for hypotheses relating to gains and losses. Since both the fixed effects and first difference estimators make the same assumptions for consistency, the differences between the two point to *some* type of misspecification (such as measurement error, see section 6.1). The fixed effects estimator is the common choice in the subjective well-being literature. For example, three of the papers cited in table 1 employ the fixed effects estimator. None uses first differences.

7.2 Social reference points

In this section we consider social reference points. Our aim is to understand whether reference points other than one's own past have explanatory power, and whether the evaluation of one's own standing relative to the reference point is asymmetric. If the value of one's own state variable is below the reference point, then this can be interpreted as a loss, and the marginal effect of the variable should be greater than when one is above the reference point. Quintana-Domeque and Wohlfart (2016) distinguishes between reference groups which are constructed along geographical and demographical dimensions. In addition, research on job satisfaction has also used reference points based on occupations or predicted values from Mincer-type equations. Clark et al. (2008b) provide an exhaustive discussion. Cheung and Lucas (2016), Jorgensen et al. (2010) and Luttmer (2005) use average incomes in geographic areas as reference income. Ferrer-i Carbonell (2005) and Vendrik and Woltjer (2007), using the same data we do, create reference groups based on age, education, and whether the respondent resides in East or West Germany. In a field experiment Card et al. (2012) assume that colleagues working in the same university department are the relevant reference group for job satisfaction, and Clark and Oswald (1996) use the predicted income from a Mincer-type regression as reference income. The latter two approaches are arguably more relevant for job than life satisfaction.

We follow the literature and construct reference values for our outcomes in five different specifications. The first specification uses the individuals' past state variables (as in our benchmark model). The next three specifications segment the population and calculate annual cell averages to serve as reference values. Cell averages are based on observations in the SOEP other than the household members for whom the average is being computed. For the second specification, we calculate reference values for each of the 16 German states, and, where applicable, separately for urban and rural locations. This results in 27 geographic areas. For the third specification we segment the population into five age, five education, and East-West cells as in Ferrer-i Carbonell (2005). The fourth specification uses only observations who are in full-time employment and segments this population by the first digit of the four-digit occupation code and by East and West Germany. For the last specification we use full-time employees to regress the natural logarithm of household income and health on age, age squared, a male dummy, years of education, years of education squared, the natural logarithm of annual hours worked, state dummies, year dummies, occupation dummies (based on the first digit of the four-digit occupation code), and household size dummies. We use the predicted values from those regressions as reference values. As in our main model, LS is then modelled as a function of a quadratic polynomial in income, as well as a quadratic polynomial of income relative to reference income, where parameters for relative income can differ below and above 0 (e.g., we replace $y_{i,t-1}$ by y_i^*, the reference of person i).

For ease of comparison between the different specifications, instead of using dummies for all health states and all pair-wise transitions, we use the original five-point health scale and define reference health either as the individual's past health score (specification 1), or the average health score of the corresponding reference group (specifications 2 to 4), or predicted health based on a regression of health on the same variables as the Mincer regression (specification 5). Finally, reference unemployment is either the past unemployment state of the individual, or the unemployment rate among their corresponding reference group. Where applicable, we also create an interaction term between unemployment and reference unemployment.

Table 4 presents results for our benchmark model and alternative specifications of reference groups. Panel A (top) for income reports the slopes of relative income when it is close to zero. Panel B (middle) for health is the effect of relative health on LS, and the panel C (bottom) summarises the effect of reference unemployment on LS. All models include level effects of income, health, and employment which are similar to the benchmark results, and we therefore omit them from the results table.[11] The benchmark model (column 1) echoes our earlier result. Income changes in the gains domain are neutral, but have positive slope (and are convex) in the loss domain. Income gains do not add to LS apart from level effects, but an income loss of 100 Euros reduces LS by 0.03 points. Current health increases LS, but holding current health fixed, health improvements reduce, and health deteriorations increase LS by 0.1 points (per health category). A person whose health is stable enjoys higher LS than someone with the same health state but who arrived at their health from a less healthy state. At the same time, among two equally healthy individuals, the one whose

[11] Results are not exactly the same because we do not dichotomise all possible health states and transitions, but use the original health variable.

Table 4: Results: Alternative reference points. Fixed-effects models

	Reference point				
	(1)	(2)	(3)	(4)	(5)
	Past self	Geographic cells	Demographic cells	Occupation cells	Mincer prediction
Panel A: Income					
Slope income gains	-0.005	-0.178***	-0.252***	-0.134***	-0.182***
	(0.072)	(0.051)	(0.032)	(0.042)	(0.056)
Slope income losses	0.295***	0.011	-0.034	-0.051	1.345
	(0.079)	(0.069)	(0.047)	(0.066)	(1.411)
Panel B: Health					
Health gains	-0.109***	-0.274***	-0.126***	-0.329***	-0.119
	(0.006)	(0.068)	(0.030)	(0.103)	(0.079)
Health losses	0.106***	0.129*	0.214***	-0.030	0.145*
	(0.007)	(0.068)	(0.031)	(0.103)	(0.079)
Panel C: Employment					
Reference unemployment	-0.105***	-1.130***	-0.507***		
	(0.019)	(0.254)	(0.118)		
Unemployed × Reference unemployment	0.098***	-1.699***	0.258		
	(0.032)	(0.513)	(0.229)		
R-squared	0.090	0.092	0.091	0.075	0.075

Robust standard errors in parentheses. Cell means exclude the value for the observation for whom the mean is calculated. The coefficients in row 2 and 3 are the slopes of income changes in the gains and loss domain respectively. Regressions include the same variables as in table 8 — including income, health state and employment status — except for pairwise health transitions. In column 1, health gains and losses quantify the effect of increasing and decreasing health respectively on LS over and above the level effects. In columns 2 to 5, health gains and losses quantify the slopes of health gains when health is above and below reference health respectively. The R-squared is the squared correlation between the de-meaned life satisfaction and predicted de-meaned life satisfaction. Stata reports this measure as R-squared within. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

health was better in the previous period enjoys higher LS. The effect of a gain is the same in magnitude as the effect of a loss. Past unemployment also exerts a negative effect on current LS, even if the person is not unemployed in the current period. However, past unemployment does not have any effect over and above the current unemployment effect if the person is still unemployed (the interaction term offsets the effect of past unemployment). This is consistent with the previous finding that people do not adapt to unemployment (Clark et al., 2008a).

For all other specifications we find that LS *decreases* in income gains and is neutral with respect to income losses, thus reversing the finding obtained with the reference point as the past self. For models 2 and 3, positive income effects are *suppressed* by around 0.02 LS points for a 100 Euros gains. We remind the reader of our discussion in section 4: Estimated gains and losses might be downward biased by independent effects of reference points.

For health, we find that, holding health state fixed, health gains above the reference point decrease, and health gains below the reference point increase LS. Since level effects are positive and greater in magnitude, this result implies that health gains increase LS more strongly when initial health is weak than when initial health is strong. Reference unemployment depresses LS in columns 2 and 3, suggesting the presence of negative externalities (for example through poorer public services). Interestingly, the regional negative externality is amplified through one's own unemployment. Both being unemployed, as well as living in a high unemployment region is bad, but being unemployed in a high unemployment region is particularly depressing. This finding contrasts with Clark (2003) who finds that the unemployed suffer *less* in terms of their well-being if regional unemployment is high. His paper is distinct in that he uses British data and uses health questionnaire to construct a measure of subjective well being.

Our benchmark model and the models based on geographic and demographic segmentation perform similarly well, while the specifications based on an occupational segmentation (column 4) and on a Mincer regression (column 5) perform worse in terms of the correlation of observed and predicted LS (R-squared), probably because the sample is conditioned on being employed, and unemployment explains an important part of the variation in LS in a sample containing both employed and unemployed observations.

Overall, our results in this section suggest that there is probably not one "right" reference point. Indeed, given the measurement error due to the strong discrepancy between what probably constitutes the right reference group and our aggregate measures, finding such strong and significant effects in most specifications is surprising. Furthermore, while relative measures and reference points exert important influences on LS, the effects do often not clearly align with predictions from PT, especially in the case of health. LS is a multidimensional construct, and our intuition suggests that it is evaluated against reference points in each of its dimensions, with varying weights.

7.3 Reference points in the past

To the extent that people use their own past as a reference point, the next natural question to ask is the time frame that people use. Intuitively, relatively recent experiences should have a higher weight in evaluating one's LS. For example, a pay rise can give rise to feelings of elevation, but these feelings might wear out quickly and it is unlikely that someone might still feel happy about a pay rise that happened a decade ago. This has led us to use the most recent past (the previous year) that is available to us as the relevant reference time. However, when evaluating one's LS, people might consider their experiences and achievements over longer periods of time, and perhaps different domains of life might affect one's LS over different time spans. We therefore re-estimated our model after replacing previous year's reference points with reference points from two years ago. That is, past year's income is replaced by income two years ago, and all health and employment transitions relate to current health and employment compared to health and employment two years ago. We then repeated this exercise for reference points from three years ago.

A priori, we would expect the associations between LS and the hypotheses which relate to reference points to be weaker. Since there will be considerable autocorrelation within our main independent variables, more distant lags will act as a proxy for the more recent past, resulting in more attenuated effects. Table 5 summarises the results for our benchmark model and the models which use two and three year lagged reference points. For easier interpretation we have included health in its original form (ranging from 1 to 5) and defined corresponding health gains and losses.[12] Our findings on level effects are, reassuringly, unchanged (Y1, H1, L1, DMU1). For income the results support our intuition: The tests which involve income losses become insignificant for two and three year lags (RP2, DMU3, LA1). Health results are

[12]Health gain is defined as $H_t - H_{t-1}$ if positive, and 0 else. Health loss is defined in analogously.

Table 5: P-values of hypotheses for reference points with different lags

Code	Alternative hypothesis H_a	H_a supports:	Previous Year	2-Year Lag	3-Year Lag
Panel A: Level effects					
Y1	LS is increasing in income levels.	EUT	0.000	0.000	0.000
H1	LS is increasing in good health.	EUT	0.000	0.000	0.000
L1	LS is increasing in employment.	EUT	0.000	0.000	0.000
Panel B: Reference point					
RP1	LS is increasing in income changes in the gains domain.	PT	0.480	0.901	0.887
	LS is increasing in health gains in the gains domain.	PT	1.000	1.000	1.000
	LS is increasing when one becomes employed.	PT	0.972	0.145	0.433
RP2	LS is increasing in income changes in the loss domain.	PT	0.000	0.335	0.869
	LS is increasing in health gains in the loss domain.	PT	1.000	1.000	1.000
	LS decreases when one becomes unemployed.	PT	0.053	0.009	0.000
Panel C: Diminishing marginal utility					
DMU1	LS is concave in income levels.	EUT	0.000	0.000	0.002
DMU2	LS is concave in income changes in the domain of gains.	PT	0.133	0.693	0.814
DMU3	LS is convex in income changes in the domain of losses.	PT	0.005	0.352	0.321
Panel D: Loss aversion					
LA	LS exhibits loss aversion in income.	PT	0.028	0.128	0.406
	LS exhibits loss aversion in health.	PT	n.a.	n.a.	n.a.
	LS exhibits loss aversion in (un)employment.	PT	0.007	0.083	0.001
R-squared			0.090	0.087	0.091

The last three columns report the p-values with the associated tests. The first p–value is from the model which uses the previous year as reference point. The second and third are from models which use responses from two and three years ago, respectively, as reference points. Health transitions are treated cardinally, that is the p-values for RP for health refer to unit changes in self-assessed health.

Table 6: Effects of change in equivalised real household income on life satisfaction

	Frequency	Real income gain 100 Euros	Real income loss 100 Euros
Decrease in nominal household income	35%	-0.074***	-0.007**
No change in nominal household income	14%	-0.030**	0.025
Increase in nominal household income	51%	+0.004	0.049***

Results based on the benchmark regression with the following differences: Quadratic terms for income gains and losses are omitted. Income gains and losses are interacted with a dummy for nominal household income gains, and one for nominal household income losses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

unchanged, perhaps due to the highly persistent nature of health. For unemployment the association between LS and employment transitions remains strong even after three years.

7.4 Changes in nominal income

Recall that our income variable is real equivalised household income (to avoid confusion with nominal income we will refer to real equivalised household income as y). It can thus change due to a number of reasons: changes in nominal income, inflation, and changes in household composition. Since the effect of changes in y on LS is likely to depend on the underlying cause we have estimated our model differentiating changes in y by whether they were accompanied by changes in nominal household income. Specifically, we create two dummy variables, one indicating whether there has been a nominal increase in (non-equivalised) household income, and the other indicating a nominal decrease. We interact our income (y) gain and income (y) loss variable with both of these dummies. To simplify the discussion, we also restrict all income loss and gain effects to be linear. That is, the quadratic terms in income changes are omitted. Our model thus estimates the effect of gains and losses in y when nominal income decreases, when it is unchanged, and when it increases. Note that all combinations are possible. Specifically, we can (and do) observe nominal income decreases despite an increase in y (e.g., children leaving the household).

Table 6 shows results from this regression. We see that gains in y which are accompanied with nominal income losses suppress LS by 0.074 points per 100 Euros. For losses in y the magnitude is only a tenth of that. Losses in y which come with nominal income gains (e.g., after child birth) *increase* LS by 0.049. An increase in y not accompanied by any change to nominal income (e.g., through a child leaving the household) *decrease* LS by 0.03 points. Losses in y without changes in nominal income (e.g., after child birth, inflation) have no significant effect on LS. The results highlight the importance of the underlying sources of income changes for their impact on LS and suggest directions for future research on the link between income and

LS.

8 Conclusion

We have analysed which characteristics of expected utility theory and prospect theory can be found in life satisfaction in an annual household panel. We found that LS exhibits features of both theories, in particular: LS resembles utility in EUT in that it increases in levels of income, health, and employment status, but it also shows features of utility in PT as it also increases in positive *changes* of those variables (except for health). Furthermore, LS exhibits loss aversion in income and in employment, but not in health. The main caveat here is our choice of reference point: the value of the variable of interest for *the same person*, at the time of the *previous interview*. It might be that different reference points will result in a rejection of EUT in favour of PT or vice versa. However, this is also true for the other models of the reference point, in the literature or analysed herein. Finding the correct model, or the best model for a specific type of data available, is an important goal for future work.

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Code availability (software application or custom code): The code used to obtain the results is available as supplementary material.

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Appendix: Further results

Table 7: P-values of hypotheses for different samples

Code	Alternative hypothesis H_a	H_a supports:	$\|\Delta y\| < 500$ Euros	$\|\Delta y\| < 1000$ Euros	$\|\Delta y\| < 1500$ Euros
Panel A: Level effects					
Y1	LS is increasing in income levels.	EUT	0.000	0.000	0.000
H1	LS is increasing in good health.	EUT	0.000	0.000	0.000
L1	LS is increasing in employment.	EUT	0.000	0.000	0.000
Panel B: Reference point					
RP1	LS is increasing in income changes in the gains domain.	PT	0.438	0.548	0.275
	LS is increasing in health gains in the gains domain.	PT	>0.351	>0.366	>0.353
	LS is increasing when one becomes employed.	PT	0.966	0.926	0.917
RP2	LS is increasing in income changes in the loss domain.	PT	0.000	0.000	0.000
	LS is increasing in health gains in the loss domain.	PT	>0.954	>0.960	>0.977
	LS decreases when one becomes unemployed.	PT	0.034	0.012	0.006
Panel C: Diminishing marginal utility					
DMU1	LS is concave in income levels.	EUT	0.000	0.000	0.000
DMU2	LS is concave in income changes in the domain of gains.	PT	0.152	0.089	0.000
DMU3	LS is convex in income changes in the domain of losses.	PT	0.002	0.005	0.001
Panel D: Loss aversion					
LA	LS exhibits loss aversion in income.	PT	0.028	0.028	0.040
	LS exhibits loss aversion in health.	PT	n.a.	n.a.	n.a.
	LS exhibits loss aversion in (un)employment.	PT	0.005	0.004	0.002

The last three columns report the p-values with the associated tests. The first *p*–value is from the sample that includes only observations whose income changed by less than 500 Euros. The second and third include only observations whose income changed by less than 1,000 and less than 1,500 Euros respectively. In the case of RP for health, we tested each possible transition between health states separately. The reported *p*–value is the lowest among the 10 tests.

Table 8: Determinants of life satisfaction

	(1) OLS	(2) Fixed effects
Household income (in 1,000 Euros) (β_1)	0.493***	0.288***
	(0.023)	(0.016)
(Household income)^2 (β_2)	-0.024***	-0.011***
	(0.005)	(0.002)
Income gain (γ_1)	-0.085	0.011
	(0.081)	(0.072)
(Income gain)^2 (γ_2)	-0.161	-0.182
	(0.202)	(0.177)
Income loss (δ_1)	0.184**	0.261***
	(0.089)	(0.079)
(Income loss)^2 (δ_2)	0.510**	0.580***
	(0.229)	(0.200)
Health:very good (α_5)	4.266***	2.739***
	(0.035)	(0.049)
Health:good (α_4)	3.528***	2.391***
	(0.032)	(0.045)
Health:satisfactory (α_3)	2.663***	1.917***
	(0.032)	(0.045)
Health:not so good (α_2)	1.727***	1.257***
	(0.034)	(0.044)
Employed (ρ_E)	-0.099***	0.025
	(0.009)	(0.015)
Unemployed (ρ_U)	-0.801***	-0.501***
	(0.022)	(0.027)
Male	-0.093***	
	(0.006)	
Partner	0.323***	0.251***
	(0.007)	(0.018)
Children	0.238***	0.070***
	(0.008)	(0.013)
Years of education	-0.015***	-0.014***
	(0.001)	(0.005)
Observations	302,777	302,777
Number of persons		49,606
R-squared	0.275	0.097

Robust standard errors in parentheses. Omitted categories are Health:bad, and not in labour force. Regressions include a full set of year fixed effects, dummies for five age categories, and transitions between all health and labor force states, and a dummy for not knowing the previous health state. 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 9: Summary of hypotheses to be tested - Fixed effects ordered logit model

Code	Alternative hypothesis H_a	H_a supports:	p-value
Panel A: Level effects			
Y1	LS is increasing in income levels.	EUT	0.000
H1	LS is increasing in good health.	EUT	0.000
L1	LS is increasing in employment.	EUT	0.000
Panel B: Reference point			
RP1	LS is increasing in income changes in the gains domain.	PT	0.464
	LS is increasing in health gains in the gains domain.	PT	$>$0.818
	LS is increasing when one becomes employed.	PT	0.965
RP2	LS is increasing in income changes in the loss domain.	PT	0.002
	LS is increasing in health gains in the loss domain.	PT	$>$0.999
	LS is decreasing when one becomes unemployed.	PT	0.010
Panel C: Diminishing marginal utility			
DMU1	LS is concave in income levels.	EUT	0.003
DMU2	LS is concave in income changes in the domain of gains.	PT	0.157
DMU3	LS is convex in income changes in the domain of losses.	PT	0.003
Panel D: Loss aversion			
LA	LS exhibits loss aversion in income.	PT	0.052
	LS exhibits loss aversion in health.	PT	n.a.
	LS exhibits loss aversion in (un)employment.	PT	0.002

Hypotheses tested and associated p-values. Estimation was carried out with the fixed effects ordered logit model as in Baetschmann et al. (2015). In the case of RP for health, we tested each possible transition between health states separately. The reported p–value is the lowest among the 10 tests.

Table 10: Main results by estimator type

Code	Alternative hypothesis H_a	(1) Benchmark	(2) Two-period aggregated	(3) Fixed Effects	(4) First Difference
Panel A: Level effects					
Y1	LS is increasing in income levels.	0.000	0.003	0.000	0.000
H1	LS is increasing in good health.	0.000	0.000	0.000	0.000
L1	LS is increasing in employment.	0.000	0.001	0.000	0.000
Panel B: Reference point					
RP1	LS is increasing in income changes in the gains domain.	0.445	0.389	0.740	0.137
	LS is increasing in health gains in the gains domain.	1.000	0.966	1.000	1.000
	LS is increasing when one becomes employed.	0.970	0.197	0.726	0.077
RP2	LS is increasing in income changes in the loss domain.	0.000	0.384	0.020	0.653
	LS is increasing in health gains in the loss domain.	1.000	0.972	1.000	1.000
	LS decreases when one becomes unemployed.	0.037	0.256	0.098	0.519
Panel C: Diminishing marginal utility					
DMU1	LS is concave in income levels.	0.000	0.026	0.000	0.000
DMU2	LS is concave in income changes in the domain of gains.	0.153	0.349	0.292	0.126
DMU3	LS is convex in income changes in the domain of losses.	0.002	0.267	0.011	0.013
Panel D: Loss Aversion					
LA	LS exhibits loss aversion in income.	0.000	0.489	0.056	0.854
	LS exhibits loss aversion in health.	n.a.	n.a.	n.a.	n.a.
	LS exhibits loss aversion in (un)employment.	0.005	0.500	0.081	0.834

Benchmark results are from a fixed effects estimator on the whole sample. Two period results are the weighted average of results from a fixed effects estimator on non-overlapping two-period samples. The fixed effects results are results from a fixed effects estimator on the sample of all individuals included in the two period sample. The first difference results are results from a first difference estimator on the sample of all individuals included in the two period sample. Health transitions are treated cardinally, that is the p-values for RP for health refer to unit changes in self-assessed health.