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The Diminishing of Marginal Utility of Income Under Latent Individual Specific Heterogeneity

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The diminishing of marginal utility of income under latent individual specific heterogeneity

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Abstract

Several questions in normative public economics can only be answered with reference to the diminishing marginal utility of income. Economists usually assume that the relation between income and its marginal utility can be described in terms of a constant elasticity. That is, a 1% increase in income lowers it's marginal utility by ρ%. As far as we know, only (Layard et al., 2008) determined this elasticity empirically, yet.

We employ the same structural model, where satisfaction data are used to estimate the rate of diminishing of the marginal utility of income. For theoretical as well as empirical reasons we analyze financial satisfaction instead of life satisfaction and equivalent income instead of household income. Additionally, since we use the German Socio-Economic Panel Study, we can account for individual-specific heterogeneity in the satisfaction equation and also in ρ, the rate of diminishing of the marginal utility of income, and we can account for auto-correlation in the residuals. These econometric specifications yield a fairly more precise estimation of $\rho = 1.3$, and indicate that the rate of diminishing of the marginal utility of income actually varies between individuals.

To analyze observable sources of heterogeneity, different sets of subsamples are constructed according to education and gender. These observable sources of heterogeneity play a minor role for the individual-specific variation in ρ.

The value added, in terms of theory, is the direct test of the hypothesis that the utility function is reference-dependent. Therefore ρ is estimated in two sets of subsamples, whereof the first set is constructed according to the median equivalent income in the society and the second set discriminates between observations with increased and decreased equivalent incomes.

Below both reference points the estimates for ρ are lower, above the reference points the marginal utility of income diminishes faster.

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1 Introduction

One of the best-known and widest-spread assumptions of economic theory is the diminishing of the marginal utility. Extra income rises utility, but the marginal utility of extra income is lower when the initial level of income is higher. This assumption has important policy implications, because it legitimizes the redistribution of income. Indeed, the implementing of this idea to policies requires even more, namely the rate of diminishing of the marginal utility when income increases.

Suppose that utility is inter-individual comparable, i.e. cardinal. All utility, direct as well as indirect utility, that a person draws out of her income y_{it} will be referred to as utility $u(y_{it})$. A marginal increase of income increases utility, and the marginal utility of an increase of a higher income is smaller than that of a lower income, i.e.

$$\frac{\partial u_{it}(y_{it})}{\partial y_{it}} > 0 \quad \text{and} \quad \frac{\partial^2 u_{it}(y_{it})}{\partial y_{it}^2} < 0. \tag{1}$$

Further it is assumed that the diminishing in Eq. (1) follows some regularity, i.e. that the marginal utility of an increase in income is ρ% lower when the increased income is 1% higher. This is the case for a utility function which follows the form[1]

$$u(y_{it}, \rho) = \begin{cases} \log(y_{it}), & \text{for } \rho = 1 \\ \frac{1}{1-\rho}(y_{it}^{1-\rho} - 1), & \text{else.} \end{cases} \tag{2}$$

With this utility function, the relation between the marginal utility of income for two individuals i and j depends only on the amount of their income and on the income elasticity of the marginal utility of income, ρ, independent of potentially additional scaling or slope parameters:

$$\frac{\partial u(y_{it})/\partial y_{it}}{\partial u(y_{jt})/\partial y_{jt}} = \left(\frac{y_{jt}}{y_{it}}\right)^{\rho} \tag{3}$$

Suppose, to further illustrate the meaning of ρ, that a tax should be implemented, which demands from everyone the same sacrifice in terms of losses of utility. If ρ equals zero, the

[1] The origin of this formulation is not unambiguous. The connection of both was made famous by Atkinson (1970).

marginal utility will not diminish when income increases and everyone would have to give the same absolute amount of income for the tax. The marginal utility of income would be independent of the amount of income. If ρ equals unity, the marginal utility will be inversely proportional to income. I.e., if i's income is ten times lower than the income of individual j, the marginal utility of i's income is ten times higher than that of j's income. Everyone would have to give the same fraction of income for the tax. For values of $\rho > 1$ the marginal utility diminishes more than proportional to increases in income, and the fraction of income that must be given for the tax increases with income. The higher the value of ρ the faster diminishes the marginal utility when income increases.

An other application that requires ρ, the income elasticity of the marginal utility of income, is the Atkinson measure of inequality, where ρ is interpreted as the inequality aversion within a population.

Despite it's theoretical and practical importance the income elasticity of the marginal utility is rarely estimated empirically. Layard et al. (2008) provide the only available microeconometric and direct[2] estimate of this rate, using data on life satisfaction and income. Therefore they combine six different datasets, three cross-national surveys and national surveys from the United States, Britain and Germany. Layard et al. (2008) provide estimates for the pooled sample of $n = 212,114$ observations as well as separate estimates for the different surveys. Especially the estimates for the two panel studies, the British Household Panel and the German Socio-Economic Panel Study, fail to be precise, despite the large number of observations. For the German data Layard et al. (2008) estimate $\rho = 1.26$ within a confidence interval of $[0.90, 1.63]$. Both the Atkinson measure of inequality and the just taxation application for rho yield very different results, depending on whether ρ is taken to lie below or above unity. For the Atkinson measure Jenkins (1997) analyzed the influence of ρ, and for the aforementioned taxation example the impact of ρ is already sketched.

In classical economic theory ρ is treated as to be constant, and as such Layard et al. (2008) estimate it. Indeed, Layard et al. (2008) estimate the rate of diminishing separately for men and women, and high and low educated individuals, as well as for singles and individuals

[2] Risk aversion is conceptually related and estimates of it are not that rare, but these yield knowledge on expected utility rather than ex post perceived utility (for more detailed argumentation see Layard et al., 2008).

in couples. But, they did not analyze whether the rate is the same above and below some reference income, which is a question coming up with the idea that the utility function is more concave above the reference point, and steep below the reference point (c.f. Kahneman and Tversky, 1979). Thereby the reference point does not need to be only the threshold that distinguishes losses from gains. The reference point can as well be the individual's aspiration, as Bogliacino and Ortoleva (2010) suggests, which could be the median income in our context.

But isn't there even more variation, since each individual is unique? Some people might value every increase in income equally, some might loose interest in extra money very fast. This does not need to be ignored, but can be accounted for in the econometric model. First, random effects estimations are run, to account for heterogeneity in the utility function. Second, the diminishing of the marginal utility itself is modeled as a random coefficient, in order to allow for individuality.

So, for theoretical as well as for econometrical reasons, we will reanalyze the income elasticity of the marginal utility of income.

In the subsequent section we will describe the data we use and the implementation of the theoretical concepts. Thereafter the econometric implementation and the estimation strategy will be presented. Thereafter, we present the results and conclude.

2 Data and Implementation

For our analysis we use Data of the German Socio-Economic Panel Study (SOEP)[3]. The SOEP is a longitudinal survey of individuals in randomly chosen households in the Federal Republic of Germany, which is run annually by the DIW in Berlin. It provides micro-data about demographic, economic, social and political topics, including a wide range of questions on subjective well-being. Thereof we use data from the years 2002 to 2010.

Since Frick et al. (2004) show that answers, especially on income questions, are unreliable in a respondent's first year in the panel study, these observations are excluded from the analysis.

[3]The data were made available by the German Socio-Economic Panel Study (SOEP) at the German Institute for Economic Research (DIW), Berlin. For details, see Wagner et al. (2007); Haisken-DeNew and Frick (2005).

Likewise the 1% at the top and at the bottom of the income distribution are excluded, in order to avoid influential outliers. We further constrain the sample so that only individuals with at least five consecutive observations in the same household remain in the analysis. This reduces the number of observations to $\sum_{i=1}^{n} t_i = 105798$ and the number of individuals to $n = 13939$. The sample means and variances of the analyzed variables are not much affected by this reduction (descriptive statistics of all variables of the original and the tightened sample are shown in the Appendix in Tables A.1 and A.2). Indeed, the deletion of observations with outstanding high income reduces the mean income, and the restriction that only individuals with at least five consecutive observations within the same household remain in the sample rises the mean age of the sample.

In order to analyze the marginal utility of income, we use data on financial satisfaction[4]. Data on subjective well-being are widely analyzed since the 1990ies. So the reliability and the interpersonal comparability of data of this kind is by and large confirmed in various studies (for an overview see Frijters and Ferrer-i-Carbonell, 2004; MacKerron, 2011).

The data on financial satisfaction in the SOEP are collected on a visual eleven-point scale, asking the subsequent question:

> How satisfied are you today with the following areas of your life?
> Please answer by using the following scale: 0 means "totally unhappy", 10 means "totally happy".
> How satisfied are you with your household income?

With the choice of financial satisfaction as the dependent variable, we leave the path of Layard et al. (2008), who use general life satisfaction for their analysis[5]. Choosing financial satisfaction as dependent variable for this kind of analysis is not only semantically appealing. This choice is also supported by the research of Van Praag et al. (2003), who find that financial satisfaction is only one of three domain satisfactions, which are about equally important determinants of the general life satisfaction. Further, the straightforward pairwise

[4]In the subsequent text the terms happiness, satisfaction and well-being are used interchangeable. Whenever we refer to financial satisfaction in especially, it is termed as such.

[5]Only once and for the purpose of comparison with the results of Layard et al. (2008), we analyze the relation between income and general life satisfaction.

correlations between log income and financial satisfaction (correlation coefficient of 0.45) on the one hand and between log income and general life satisfaction (correlation coefficient of 0.25) on the other hand indicate that the relation between income and financial satisfaction is, not surprisingly, stronger than that between income and life satisfaction, a fact that might improve the precision of the estimations.

The crucial explanatory variable is the monthly net household income, which is adjusted to units of constant purchasing power. Further, and in contrast to the analysis conducted by Layard et al. (2008), the household income is also adjusted to the varying needs of households of different size. This is done with an equivalence scale with a "family size elasticity of needs" (Buhmann et al., 1988) of 0.3, like the estimates of Schwarze (2003) suggest[6].

Indeed, financial satisfaction does not only depend on utility out of income, but also on other individual characteristics. These need to be considered when estimating the income elasticity of the marginal utility of income. First of all there are some influences on financial satisfaction that are confounded with income but do not actually reflect the utility of income. These are the position in the income distribution and the relative change of the individuals equivalent income since the last year. The first accounts for the role of inter-individual comparisons in the formation of income aspirations, the second accounts for the role of inter-temporal comparisons in the formation of income aspirations, since higher income aspirations c.p. reduce financial satisfaction (cf. Stutzer, 2004; Frey and Stutzer, 2005; Clark et al., 2008b; D'Ambrosio and Frick, 2012; Bottana and Truglia, 2011) . In addition, we control for the respondents age (and age squared), years of education, gender, working hours, the extend of working time mismatch, the respondent's self rated health status, her provenience (i.e. a variable that indicates if someone comes from one of the countries that sent Gastarbeiter to Germany), whether she is living in the Eastern part of Germany, whether she is without partner, currently unemployed, and whether she had ever been unemployed since the year 2002. Finally, fixed time effects are included to control for period effects.

[6]Already here can be mentioned that the subsequent estimates do not strongly depend on this choice, for extreme elasticities of zero or one the point estimates of ρ are somewhat lower. Using an equivalence scale with an elasticity of 0.5, which approximates the OECD equivalence scale, the point estimate of ρ is slightly higher than the estimate presented here in the subsequent section.

3 Econometric Model and Estimation Strategy

Since research on the determinants of financial satisfaction is well advanced, also the relation between income and (financial) satisfaction is analyzed yet (for an overview see Clark et al., 2008b). But most often income is introduced as log income, which means that ρ is assumed to equal unity. In the subsequent section we estimate this very parameter ρ, the income elasticity of the marginal utility of income.

Usually, economists interpret satisfaction data as ordinal, since answers are given in ordered categories. In contrast to this, Schwarz (1995) and Van Praag (1991) argue that respondents themselves interpret the given categories as being equidistant and try to maximize the information they transmit by their answers. Finally, Frijters and Ferrer-i-Carbonell (2004) show that for the estimation of the determinants of happiness the assumptions concerning the scale are of minor importance[7]. Hence, we assume cardinal comparability of the satisfaction answers and analyze financial satisfaction s_{it} of individual i at time t as depending on the aforementioned covariates subsumed in the vector x_{it} and the utility out of income, which clearly is unobservable, but supposed to follow the form given in Eq. (2). So, subsuming all explaining variables in $\tilde{X}_{it}(\rho)$ and $\beta = \{\beta_1, \beta_2\}$, the structural model is

$$s_{it} = \tilde{X}_{it}(\rho)\beta + \epsilon_{it} = \begin{cases} x'_{it}\beta_1 + \beta_2 \log(y_{it}) + \epsilon_{it}, & \text{if } \rho = 1 \\ x'_{it}\beta_1 + \beta_2 \frac{1}{1-\rho}(y_{it}^{1-\rho} - 1) + \epsilon_{it}, & \text{else.} \end{cases} \tag{4}$$

Further, statistical assumptions about unmeasured influences ϵ_{it} on financial satisfaction are necessary for the estimations. The easiest assumption is that the unobserved factors are time-varying, with an expectation of zero and uncorrelated to the observed determinants of financial satisfaction, i.e. ϵ_{it} is identically and independently distributed for $i = 1, \dots, n$, and $t = D_i, \dots, T_i$ with D_i and T_i denoting the first and last observation for individual i. This would lead to a straightforward ordinary least squares (OLS) estimation, which Layard et al. (2008) use.

Since panel data are available, measures to control for individual-specific unobserved het-

[7] In order to check the robustness of our results with regards to the boundedness of the scale of possible answers, we run estimations where we excluded observations with reported financial satisfaction of zero or ten, the upper and lower end of the scale. The estimates do neither change substantially nor statistically.

erogeneity in the utility function are at hand. We choose a random coefficient approach[8] to allow for individual specific latent heterogeneity, i.e.

$$s_{it} = \begin{cases} \tilde{X}(\pm\rho)_{it}^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}(\pm\rho)^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(i)/(ii)} \\ \tilde{X}(\pm\rho_i)_{it}^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}(\pm\rho_i)^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(iii)/(iv)} \end{cases} = \begin{cases} \tilde{X}_{it}^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}(\rho)^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(i)}, \\ \tilde{X}_{it}(\rho)^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(ii)}, \\ \tilde{X}_{it}^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}(\rho_i)^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(iii)}, \\ \tilde{X}_{it}(\rho_i)^{\text{ran}}\beta_i^{\text{ran}} + \tilde{X}_{it}^{\text{fix}}\beta^{\text{fix}} + \epsilon_{it}, & \text{(iv)}. \end{cases} \tag{5}$$

Hence several parameters are assumed to vary across individuals, thus capturing individual specific heterogeneity, while others are assumed to be constant across individuals. Individual specific parameters are specified as random coefficients, where for convenience a multivariate normal distribution is chosen, i.e.

$$(\beta_i^{\text{ran}}, \rho_i) = \theta_i \overset{\text{iid}}{\sim} \mathcal{N}(\tilde{\theta}, W). \tag{6}$$

While for cases (i) and (ii) the corresponding likelihood for the observed dependent and explanatory variables (data) is given as

$$\begin{aligned} L(\beta^{\text{fix}}, \tilde{\theta}, \rho; \text{data}) &= \prod_{i=1}^{N} \int_{\beta_i} (2\pi)^{-.5(T_i - D_i + 1)} |\Sigma_i|^{-.5} (2\pi)^{-k/2} |W|^{-.5} e^{-.5(\beta_i - \tilde{\beta})' W^{-1} (\beta_i - \tilde{\beta})} \\ &\quad e^{-.5(y_{i\cdot} - \tilde{X}_{it}(\pm\rho)^{\text{ran}}\beta_i^{\text{ran}} - \tilde{X}_{it}(\pm\rho)^{\text{fix}}\beta^{\text{fix}})' \Sigma_i^{-1} (y_{i\cdot} - \tilde{X}_{it}(\pm\rho)^{\text{ran}}\beta_i^{\text{ran}} - \tilde{X}_{it}(\pm\rho)^{\text{fix}}\beta^{\text{fix}})} d\beta_i \end{aligned} \tag{7}$$

and has a closed form solution as the normal distribution is chosen for mixing, i.e.

$$\begin{aligned} L(\beta^{\text{fix}}, \tilde{\theta}, \rho; \text{data}) &= \prod_{i=1}^{N} (2\pi)^{-.5(T_i - D_i + 1)} |\Sigma_i + \tilde{X}_{it}(\pm\rho)^{\text{ran}\prime} W^{-1} \tilde{X}_{it}(\pm\rho)^{\text{ran}}|^{-.5} \\ &\quad e^{-.5(y_{i\cdot} - \tilde{X}_{it}(\pm\rho)^{\text{ran}}\tilde{\beta} - \tilde{X}_{it}(\pm\rho)^{\text{fix}}\beta^{\text{fix}})' (\Sigma_i + \tilde{X}_{it}(\pm\rho)^{\text{ran}\prime} W^{-1} \tilde{X}_{it}(\pm\rho)^{\text{ran}})^{-1} (y_{i\cdot} - \tilde{X}_{it}(\pm\rho)^{\text{ran}}\tilde{\beta} - \tilde{X}_{it}(\pm\rho)^{\text{fix}}\beta^{\text{fix}})}. \end{aligned}$$

In cases (iii) and (iv), the consideration of an individual specific random ρ_i possibly in combination with a random β_{2i} coefficient renders the corresponding likelihood integral infeasible. In order to circumvent numerical integration, we instead utilize a first order Taylor approximation of the corresponding terms at the point $\tilde{\theta} = (\tilde{\beta}, \tilde{\rho})$, i.e.

$$\beta_{2i} \frac{1}{1 - \rho_i}(y_{it}^{1-\rho_i} - 1) \approx \tilde{\beta}_2 \frac{1}{1 - \tilde{\rho}}(y_{it}^{1-\tilde{\rho}} - 1) + \begin{pmatrix} \frac{1}{1-\tilde{\rho}}(y_{it}^{1-\tilde{\rho}} - 1) & \tilde{\beta}_2 \frac{-\log y_{it}^{1-\tilde{\rho}}(1-\tilde{\rho}) + (y_{it}^{1-\tilde{\rho}} - 1)}{(1-\tilde{\rho})^2} \end{pmatrix} \begin{pmatrix} \beta_{2i} - \tilde{\beta} \\ \rho_i - \tilde{\rho} \end{pmatrix} \tag{8}$$

[8] A fixed effects specification, i.e. a within estimation, which would be favorable (Frijters and Ferrer-i-Carbonell, 2004), is not possible because of the nonlinearity of the parameter ρ.

This linearization allows to provide the likelihood in either case in closed form, which is hence directly accessible to numerical optimization.

In addition, correlation in the latent factors are modeled as a moving average process, i.e.

$$\epsilon_{it} = \psi u_{it-1} + u_{it} \tag{9}$$

with corresponding individual covariance matrix Σ_i of dimension $T_i - D_i + 1 \times T_i - D_i + 1$. This may help to circumvent problems that arise if people adapt the satisfaction scale to the levels of satisfaction they perceived before. In this case, the autocorrelation coefficient will be negative. Whereas a positive autocorrelation coefficient would appear if individuals e.g. anticipate the level of satisfaction in the future and feel happy or unhappy in advance (cf. Caplin and Leahy, 2001; Clark et al., 2008a; Bottana and Truglia, 2011), or if satisfaction carries forward into the future.

Since there are arguments against a constant rate of diminishing of the marginal utility of income (cf. Kahneman and Tversky, 1979; Koszegi and Rabin, 2006, 2009), we in addition separate the sample according to two possible reference points, which may discriminate between differently concave utility functions. The first reference point that we account for is the income of others at the same time. We use the median income for this purpose, like Bogliacino and Ortoleva (2010) propose. Admittedly, more elaborate definitions of relevant others are imaginable, but since it is hard to find generally acceptable definitions of the reference group, and finally data on the relevant others, we decided for the whole society as the reference group. Two subsamples are retrieved, whereof the first contains individuals who's equivalent income is above the median of the income distribution. The second subsample contains individuals with incomes below the median of the income distribution. According to this assignment rule some observations of an individual become part of one subsample while the other observations of the same individual become part of the other subsample. In order to avoid identification problems, which could arise if for several individuals only one single observation is assigned to a subsample, single observations of an individual in a subsample are dropped. However, these subsamples are not suitable for the estimation of the auto-correlated error term, which is, though substantially weak, found to be statistically significant (cf. Model 2 in Table 1). If the estimates of ρ for these two subsamples (in Table 2) are equal, than the hypothesis can be rejected that the median income of the society is the reference point where above the marginal utility of income diminishes faster than below this reference point.

The second reference point is the individual's own equivalent income in the previous year. Kahneman and Tversky (1979) argue that the utility function for losses is not the same than for gains, but convex for losses and concave only for gains. Accordingly, we expect that the rate of diminishing of the marginal utility of income is smaller for decreasing incomes than for increasing incomes. In order to test this hypothesis, two alternative subsamples are retrieved that distinguish between observations with incomes that are higher than in the previous year and observations with incomes that are lower than in the previous year. Again, we cannot use the specification with the auto-regressive error term , in order to analyze whether the rate of diminishing of the marginal utility of decreasing incomes is the same as for increasing incomes, because the estimation of the autoregressive process requires consecutive data without lacks. So, we use the random effects model with the idiosyncratic error term to analyze the rate of the diminishing of the marginal utility for increasing and decreasing incomes, and keep in mind that the estimations lack in econometric precision and validity. We will discuss this with the results in the next section. If the estimates of ρ for these two subsamples (in Table 2) are equal, than the hypothesis can be rejected that the individuals own income in the previous year is the reference point where above the marginal utility of income diminishes faster than below this reference point. Whereas if the estimates are unequal, we get empirical confirmation of the hypothesis that the marginal utility of the last of 2000 Dollars not only depends on the absolute amount of income, but also on the income the individual was used to have.

4 Results

Model 1 in Table 1 presents the results of the estimation of a straightforward random effects estimation, with the nonlinear parameter rho (Eq. (5i)), and a straightforward idiosyncratic error term. Most of the estimates for the Model 1 in Table 1 meet our expectations. The significant gender effect, the regional differential in financial satisfaction, the u-shaped age effect and the negative effect of being unemployed are as expected and in line with other research on happiness respectively financial satisfaction (cf. D'Ambrosio and Frick, 2012;

Ferrer-i Carbonell, 2005; Van Praag et al., 2003; Winkelmann and Winkelmann, 1998). Years of education has no significant effect on financial satisfaction in our estimations. Senik (2005) explains such findings with the mediation of the education effect through status and income. The coefficient of main interest is the estimate for ρ, the income elasticity of the marginal utility of income, which is the very parameter that determines the concavity of the utility function. The estimate is somewhat higher than that of Layard et al. (2008) and significantly above unity, which is, as aforementioned, one crucial threshold. The significantly non-zero random effect indicates that the estimated constant varies between individuals, so the random effects model is appropriate and ignoring the random effect could lead to incorrect estimates. For the purpose of comparability we reestimated the model of Layard et al. (2008), i.e. with life satisfaction as dependent variable and unweighted household income as income measure (results not presented). The changes in the estimate of ρ that are caused by the variable selection and the sample restriction (age 30 to 55) nearly nullify: Life satisfaction instead of financial satisfaction and the unweighted household income instead of the equivalent income and the frugal set of covariates lower the estimates, whereas the restriction to best-agers strongly increases the estimate of ρ. The accounting for individual-specific heterogeneity in financial satisfaction noticeably increases the estimate of ρ. For the specification that Layard et al. (2008) choose (with life satisfaction and unweighted household income, the frugal covariable set and the age-restricted sample) our OLS-estimate is $\rho = 1.03$ and our random effects estimate is $\rho = 1.40$[9].

The estimates of Model 1 in Table 1 reveal only two surprising results. First, the estimated effect of having no partner is insignificant, whereas it is often found to be significantly positive (cf. D'Ambrosio and Frick, 2012; Van Praag et al., 2003). Since many other studies use a smaller range of covariates it is possible that the effect of having a partner is captured by, for example, the effects of health and working time mismatch. The second estimate which may surprise is the negative coefficient for income changes. Though it first looks like puzzling that financial satisfaction is lower when the relative change of income is higher. But in combination

[9] The fact that we could not exactly replicate the OLS point estimate, but only get an estimate within the 95%-confidence interval, which Layard et al. (2008) present, presumably stems from the different restriction that Layard et al. (2008) pose on the income variable. They did not just cut off the top and bottom percentil, but the observations with the highest and lowest residuals in an auxilliary income regression.

Table 1: Determinants of financial satisfaction

	Model 1		Model 2		Model 3	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Rel. income change	-0.224	(0.019)	-0.253	(0.019)	-0.2654	(0.0546)
Rank (income distribution)	0.416	(0.112)	0.399	(0.095)	0.9029	(1.3773)
Age	-0.060	(0.004)	-0.064	(0.003)	0.3763	(0.0371)
Age, squared	0.001	(0.000)	0.001	(0.000)	-0.0030	(0.0003)
Years of education	0.026	(0.005)	0.025	(0.005)	0.3131	(0.0514)
Hours worked this week	0.003	(0.001)	0.003	(0.001)	0.0071	(0.0057)
Neg. working time mismatch	-0.016	(0.002)	-0.016	(0.002)	-0.0126	(0.0095)
Pos. working time mismatch	-0.005	(0.001)	-0.005	(0.001)	-0.0109	(0.0094)
Female	0.204	(0.025)	0.205	(0.025)	0.8301	(0.1995)
Self rated bad health status	-0.408	(0.016)	-0.394	(0.016)	-0.2728	(0.0465)
Gastarbeiter	-0.358	(0.057)	-0.355	(0.030)	0.5347	(0.4302)
Without partner	0.027	(0.023)	0.019	(0.024)	0.4484	(0.1373)
Presently Unemployed	-0.666	(0.030)	-0.655	(0.031)	-0.5315	(0.0663)
Ever unemployed since 2002	-0.192	(0.030)	-0.212	(0.030)	-0.0635	(0.0621)
Region: East German	-0.522	(0.028)	-0.518	(0.028)	-0.2846	(0.1767)
Utility(y_{it},ρ)	19.404^a	(4.480)^b	12.994	(0.267)	0.0295	(0.0206)
ρ	1.332^a	(0.033)^b	1.277	(0.007)	1.3664	(0.0390)
$\sigma(\rho)$	-				0.2792	(0.0644)
Constant	-46.918	(8.320)	-33.901	(0.216)	-12.4135	(1.3653)
σ(Constant)	1.331^a	(0.009)^b	1.299	(0.009)	6.1938	(0.9655)
σ(e)	1.301^a	(0.003)^b	1.315	(0.003)	1.3123	(33.4044)
ψ	-		0.145	(0.004)	0.1607	(5.8123)

Note: Linear regression estimations, with random constant and fixed time effects. Model 2 and 3 with autoregressive error term. ^{a}) Coefficients are originally estimated in the log space. ^{b}) standard errors are obtained with the delta method.
Source: SOEP 2003 - 2010. $\sum_{i=1}^{n} t_i = 92007$.

with the result of D'Ambrosio and Frick (2012), who found that the effect of the last years income on actual satisfaction is positive, the negative coefficient for the relative change in income is reasonable. Since we control for the actual income, the relative change in income since last year is high for those who's income in the last year was low and the relative change is low for those who's last year's income was high.

Model 2 in Table 1 presents the results of the estimation of Eq. (5i) but this time with autocorrelated error term. The estimated moving average coefficient ψ is significantly above zero, i.e., given all the explanatory variables, the observed financial satisfaction is conditionally still not independent. A given level of financial satisfaction partly carries forward into the future, or future levels of satisfaction are anticipated. Whatever explanation might be true, the positive autocorrelation coefficient implies path dependence. Compared to the estimates in Model 1 in Table 1 the other estimated coefficients remain mostly unchanged. The estimate for ρ is slightly lower, but still within the confidence interval around the point estimate for ρ in Model 1. Since small changes in the coefficient ρ strongly affect the scaling of the transformed income variable $u(y_{it}, \rho)$ the noticeable decline in the income variable is not astonishing. This also applies for the decline in the constant.

Results for the random coefficient ρ are very preliminary and should not be interpreted.

Since we expect to find latent heterogeneity in the rate of diminishing of the marginal utility of income, the consequent question addresses observable sources of heterogeneity. Therefore, the sample was split into several sets of subsamples (Table 2). Separate estimations of ρ for men and women show that gender is no source of observable heterogeneity; the estimates for men ($\rho = 1.32$) and for women ($\rho = 1.34$) are almost identical. Likewise with estimations in two of the three education-homogeneous subsamples of low educated individuals (not more than 10 years of education), medium educated individuals (more than 10 up to 12 years of education), and highly educated individuals with 13 up to 18 years of education.

The estimate of ρ is the same for individuals with medium and individuals with low education ($\rho = 1.40$ and $\rho = 1.41$). Only for individuals with high education level (university-entrance diploma or more) the marginal utility of income diminishes with a lower rate of $\rho = 1.31$. The finding that the rate of diminishing for the best-educated is lower than that for lower educated individuals is especially astonishing, since the high educated individuals are expected to have high incomes (the pairwise correlation between log years of education and log equivalent income is r=0.4), and the diminishing of the marginal utility is faster for individuals in the upper part of the income distribution. The estimates for the median separated subsamples reveal some difference between the rate of diminishing of the marginal utility of income, but each point estimate falls within the confidence interval of the other subsample. Whereas the estimates of ρ for the observations with decreased and increased incomes differ much more.

Table 2: Estimates for ρ in different subsamples

		95% Confidence interval		
	Point estimate	lower bound	upper bound	Obs.
Gender-homogeneous subsamples				
Women	1.322	1.233	1.411	43304
Men	1.339	1.249	1.430	48703
Education-homogeneous subsamples				
Low	1.414	1.241	1.587	14194
Medium	1.402	1.298	1.506	52006
High	1.307	1.210	1.404	25807
Reference point: Median income in the society				
Below	.828	.542	1.114	37547
Above	1.108	.795	1.421	52841
Reference point: Individual's income last year				
Below	1.096	.997	1.195	28803
Above	1.418	1.355	1.481	60034

Note: Estimated with random constant, idiosyncratic error term, and fixed coefficient ρ.
Source: SOEP 2003 - 2010.

Interestingly, the estimates for the theory-driven subsamples differ more than those in the the aforementioned ad hoc subsamples. For both sets of subsamples the estimate of ρ for the observations above the reference point is higher than the estimate of ρ for the observations below the reference point. I.e. the marginal utility of income diminishes faster when individuals find themselves above the reference point. This may be interpreted as a confirmation of the reference point dependency of the utility function and as a confirmation, that the reference point could be the own income in the previous period, but also the income of others. Albeit, we should interpret these results with some caution, since they may partly be driven by the fact that, due to the assignment of observations instead of individuals to the subsample, the estimated random effect for one and the same individual in the different samples might not be the same, and we cannot account for the auto correlation of the error term.

A reestimation with subsamples, where all observations of one individual are assigned to, are at least for the reference-point-related subsamples inappropriate, since the assignment of observations of both sides of the reference point necessarily equalizes the estimates for the two subsamples, already for theoretical reasons.

5 Conclusion

Using a classical utility function and panel data on financial satisfaction, we estimated the rate of diminishing of the marginal utility of income. With our econometric specification we accounted for individual-specific random effects and auto-regressive error terms. Thereby we found that individual-specific unobserved heterogeneity influences the satisfaction answers, and that financial satisfaction is path dependent. Our estimates are fairly precise and indicate that the marginal utility of income diminishes faster than income increases ($\rho > 1$).

We also analyzed observable sources of heterogeneity in the rate of diminishing of the marginal utility of income, and found that men and women lose interest in extra income with an equal rate. For high educated individuals we found a slightly lower rate of diminishing of the marginal utility of income.

The hypothesis that the shape of the utility function depends on the reference point is not rejected, whereas the necessary assignment of observations of one and the same individual into two different subsamples remains unsatisfactory. Here, econometric validity and theoretic interest are in a trade-off relation, which we could not dissolve, yet.

Nevertheless, we yield results which demonstrate that the marginal utility of income diminishes, even faster than income increases.

References

Atkinson, A. B. (1970). On the measurement of inequality. *Journal of Economic Theory*, 2(3):244–263.

Bogliacino, F. and Ortoleva, P. (2010). Aspirations and growth: A model where the income of others acts as a reference point. *California Institute of Technology, Social Science Working Paper 1314R*.

Bottana, N. L. and Truglia, R. P. (2011). Deconstructing the hedonic treadmill: Is happiness autoregressive? *Journal of Socio-Economics*, 40(3):224236.

Buhmann, B., Rainwater, L., Schmaus, G., and Smeeding, T. M. (1988). Equivalence scales, well-being, inequality, and poverty: Sensitivity estimates across ten countries using the Luxembourg Income Study (LIS) database. *Review of Income and Wealth*, 34(2):115–142.

Caplin, A. and Leahy, J. (2001). Psychological expected utility theory and anticipatory feelings. *The Quarterly Journal of Economics*, 116(1):55–79.

Clark, A. E., Diener, E., Georgellis, Y., and Lucas, R. (2008a). Lags and leads in life satisfaction: A test of the baseline hypothesis. *The Economic Journal*, 118(529):F222–F243.

Clark, A. E., Frijters, P., and Shields, M. A. (2008b). Relative income, happiness, and utility: An explanation for the easterlin paradox and other puzzles. *The Economic Journal*, 118(529):F222–F243.

D'Ambrosio, C. and Frick, J. R. (2012). Individual well-being in a dynamic perspective. *Economica*, 79:p284–302.

Ferrer-i Carbonell, A. (2005). Income and well-being: An empirical analysis of the comparison income effect. *Journal of Public Economics*, 89(5-6):9971019.

Frey, B. S. and Stutzer, A. (2005). *Economics And Happiness: Framing the Analysis*, chapter Testing Theories of Happiness, pages 116–146. Oxford University Press.

Frick, J. R., Goebel, J., Schechtman, E., Wagner, G. G., and Yitzhaki, S. (2004). Using analysis of gini (AnoGi) for detecting whether two sub-samples represent the same universe: The soep experience. *Discussion Paper*, 1049.

Frijters, P. and Ferrer-i-Carbonell, A. (2004). How important is methodology for the estimates of the determinants of happiness? *The Economic Journal*, 114:641–659.

Haisken-DeNew, J. P. and Frick, J. R. (2005). DTC. Desktop companion to the German Socio-Economic Panel (SOEP). http://www.diw.de/documents/dokumentenarchiv/17/diw_01.c.38951.de/dtc.409713.pdf. (Access: 25/04/2011).

Jenkins, S. P. (1997). Trends in real income in britain: A microeconomic analysis. *Empirical Economics*, 22(4):483–500.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2):263–292.

Koszegi, B. and Rabin, M. (2006). A model of reference-dependent preferences. *The Quarterly Journal of Economics*, 121(4):1133–1165.

Koszegi, B. and Rabin, M. (2009). Reference-dependent consumption plans. *Journal of Economic Surveys*, 99(3):909–936.

Layard, R., Mayraz, G., and Nickell, S. J. (2008). The marginal utility of income. *Journal of Public Economics*, 92(8-9):1846–1857.

MacKerron, G. (2011). Happiness economics from 35000 feet. *Journal of Economic Surveys*.

Schwarz, N. (1995). What respondents learn from questionnaires: The survey interview and the logic of conversation. *International Statistical Review*, 63:153–177.

Schwarze, J. (2003). Using panel data on income satisfaction to estimate equivalence scale elasticity. *Review of Income and Wealth*, 49(3):359–372.

Senik, C. (2005). Income distribution and well-being: what can we learn from subjective data? *Journal of Economic Surveys*, 19(1):43–63.

Stutzer, A. (2004). The role of income aspirations in individual happiness. *Journal of Economic Behavior & Organization*, 54:89–109.

Van Praag, B. M. S. (1991). Ordinal and cardinal utility. an integration of the two dimension of the welfare concept. *Journal of Econometrics*, 50:69–89.

Van Praag, B. M. S., Frijters, P., and Ferrer-i-Carbonell, A. (2003). The anatomy of subjective well-being. *Journal of Economic Behavior & Organization*, 51:29–49.

Wagner, G. G., Frick, J. R., and Schupp, J. (2007). The German Socio-Economic Panel Study (SOEP) - scope, evolution and enhancements. *Schmollers Jahrbuch (Journal of Applied Social Science Studies)*, 127(1):139–169.

Winkelmann, L. and Winkelmann, R. (1998). Why are the unemployed so unhappy? evidence from panel data. *Economica*, 65(257):1–15.

A Appendix

Table A.1: Descriptives statistics for the original sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Financial Satisfaction	187633	6.332	2.289	0	10
Personal Equivalent Income	181510	2240.336	1567.315	0	89303.9
Monthly Net Household Income	181510	2820.506	2015.801	0	99999
No. of Persons in Household	192334	2.721	1.274	1	14
Current Age	192334	48.067	17.609	16	100
Years of Education	180787	12.163	2.700	7	18
Weekly Working Hours	187275	21.335	21.390	0	80
Neg. Working Time Mismatch	192334	.802	3.482	0	50
Pos. Working Time Mismatch	192334	2.577	5.528	0	50
Female	192334	.521	.500	0	1
Bad Health	192334	.171	.377	0	1
Gastarbeiter	192334	.045	.208	0	1
Without partner	192334	.204	.403	0	1
Unemployed	192334	.066	.249	0	1
Region: East Germany	192334	.240	.427	0	1

Source: SOEP 2002 - 2010.
Note: This sample still contains the upper and lower end of the income distribution.

Table A.2: Descriptives statistics for the analyzed sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Financial Satisfaction	105968	6.304	2.202	0	10
Personal Equivalent Income	105968	2090.559	977.664	408.563	6723.207
Rel. Income Change Since Last Year	92007	.057	.263	-.841	5.099
Monthly Net Household Income	105968	2603.913	1297.235	409	9500
No. of Persons in Household	105968	2.642	1.228	1	14
Current Age	105968	51.305	15.958	18	98
Years of Education	105968	12.074	2.634	7	18
Weekly Working Hours	105968	21.373	21.093	0	80
Neg. Working Time Mismatch	105968	.786	3.327	0	50
Pos. Working Time Mismatch	105968	2.585	5.345	0	50
Female	105968	.529	.499	0	1
Bad Health	105968	.187	.390	0	1
Gastarbeiter	105968	.050	.217	0	1
Without Partner	105968	.171	.376	0	1
Unemployed	105968	.063	.244	0	1
Ever Unemployed Since 2002	105968	.135	.342	0	1
Region: East Germany	105968	.266	.442	0	1

Source: SOEP 2002 - 2010.

Table A.3: Descriptive statistics for the reference point-specific subsamples

	Below Median		Above Median		Decreasing Incomes		Increasing Incomes	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Financial Satisfaction	5.415	2.262	6.926	1.930	6.060	2.290	6.409	2.147
Personal Equivalent Income	1334.066	377.156	2619.385	919.158	1908.381	884.572	2229.261	1019.63
Rel. Income Change Since Last Year	.055	.274	.059	.254	-.143	.133	.162	.253
Monthly Net Household Income	1597.944	547.751	3307.135	1203.127	2372.507	1156.349	2746.979	1355.882
No. of Persons in Household	2.350	1.184	2.846	1.217	2.687	1.213	2.608	1.228
Current Age	53.905	17.348	49.488	14.638	51.364	15.544	52.151	16.042
Years of Education	11.045	1.995	12.793	2.783	12.038	2.621	12.102	2.643
Weekly Working Hours	14.220	19.437	26.373	20.762	20.373	21.028	21.672	21.076
Neg. Working Time Mismatch	.922	3.778	.692	2.968	.858	3.555	.766	3.228
Pos. Working Time Mismatch	1.462	4.235	3.371	5.873	2.488	5.325	2.610	5.307
Female	.573	.495	.499	.500	.531	.499	.528	.499
Bad Health	.246	.431	.146	.353	.197	.398	.190	.392
Gastarbeiter	.074	.262	.032	.176	.055	.227	.047	.211
Without Partner	.262	.440	.107	.309	.164	.370	.174	.379
Unemployed	.116	.320	.027	.162	.089	.285	.049	.215
Ever Unemployed Since 2002	.219	.414	.077	.266	.166	.372	.135	.341
Region: East Germany	.369	.483	.194	.396	.268	.443	.267	.442
Number of observations	43599		62369		31704		60301	

Source: SOEP 2003 - 2010.

Table A.4: Determinants of financial satisfaction in the reference point-specific subsamples

	Reference point: median income				Reference point: own past income			
	Below		Above		Below		Above	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Rel. income change	-.205	(.037)	-.176	(.023)	-.361	(.078)	-.168	(.025)
Rank (income distribution)	.001	(.414)	.861	(.290)	.054	(.192)	.107	(.151)
Age	-.081	(.006)	-.056	(.005)	-.069	(.005)	-.064	(.005)
Age, squared	.001	(.000)	.001	(.000)	.001	(.000)	.001	(.000)
Years of education	-.009	(.009)	.037	(.005)	.011	(.006)	.024	(.005)
Hours worked this week	.003	(.001)	.000	(.001)	.000	(.001)	.000	(.001)
Neg. working time mismatch	-.015	(.002)	-.019	(.002)	-.021	(.003)	-.019	(.002)
Pos. working time mismatch	-.004	(.003)	-.005	(.001)	-.010	(.002)	-.003	(.002)
Female	.145	(.036)	.211	(.030)	.190	(.030)	.178	(.026)
Self rated bad health status	-.511	(.024)	-.364	(.020)	-.592	(.028)	-.459	(.019)
Gastarbeiter	-.266	(.072)	-.427	(.075)	-.266	(.066)	-.346	(.060)
Without Partner	.101	(.032)	-.063	(.032)	.032	(.035)	.030	(.026)
Presently Unemployed	-.657	(.042)	-.605	(.049)	-.729	(.051)	-.670	(.040)
Ever unemployed since 2002	-.244	(.043)	-.148	(.041)	-.352	(.046)	-.234	(.035)
Region: East German	-.509	(.038)	-.468	(.035)	-.499	(.033)	-.497	(.029)
Utility(y_{it},ρ)	.461	(.330)	3.579^a	$(6.326)^b$	5.028	(1.563)	40.220	(10.965)
ρ	.773	(.111)	1.150^a	$(.209)^b$	1.122	(.045)	1.408	(.038)
Constant	- 46.918	(1.894)	-9.713	(18.085)	- 17.469	(4.291)	- 86.978	(18.380)
σ(Constant)	1.389	(.012)	1.329^a	$(.013)^b$	1.296	(.013)	1.328	(.010)
σ(e)	1.415	(.006)	1.180^a	$(.005)^b$	1.381	(.007)	1.261	(.005)
Number of obs.	38527		53480		31704		60301	

Note: Linear regression estimations, with random constant and fixed time effects. ^{a}) Coefficients are originally estimated in the log space.

^{b}) standard errors are obtained with the delta method.

Source: SOEP 2003 - 2010.