Psychological utility functions for income are S-shaped: Evidence from UK adults

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Abstract

Do people's psychological valuations of income obey everywhere-diminishing marginal utility, or are they S-shaped, as proposed by the Desperation Threshold Model and found in some prior research? We ran a pre-registered study with UK adults (N = 150, Prolific) where participants rated the value to them of 41 different monthly incomes (£1–£8000; random order). Comparing the fit of different classes of function, the most frequent best fit was sigmoid (59% of respondents; quadratic 37%; linear 5%). Generalized Additive Models corroborated the S-shape: the mean first derivative rose at low incomes and fell at higher incomes, while the mean second derivative was positive at low incomes and negative thereafter, with the inflection around £1,600/month. Exact question wording did not appear to affect the shape. The midpoint of the S-shape increased with respondents' own income and the typical income of people they know. Thus, in this population, directly elicited psychological utility functions for income appear to be S-shaped, consistent with earlier findings and the Desperation Threshold Model: marginal utility increases up to a basic-needs threshold and decreases beyond it. Because the inflection lies at an income level actually experience by millions of Britons, these findings have potentially important implications for understanding real-world behaviour.

Introduction

The value people derive from an extra unit of money is not necessarily constant. Subjective wellbeing, life satisfaction, and measures of mental and general health show diminishing marginal returns, meaning that the benefit of an extra dollar decreases as someone's income increases (Backlund et al., 1996; Kahneman & Deaton, 2010; Nettle et al., 2025; Nettle & Dickins, 2022). Rational actor models of decision making assume that people understand this, at some level. For example, people are often risk averse (meaning that they prefer $100 for sure to a 50% chance of $250). This is classically explained by assuming that they have a utility function that is concave, and hence derive greater expected utility from the sure $100, even though the expected monetary payoff is smaller. The claim that marginal utility is everywhere concave across the range relevant to decision making is so standard that it carries the title of a law: Gossen's first law (Gossen, 1983).

Recently, we presented the Desperation Threshold Model, which unifies a number of convergent ideas scattered in previous literature (de Courson et al., 2025b). The model claims that the typical utility function for one's overall amount of monetary resources is not everywhere concave. Rather, the model posits an S-shape, like a sigmoid. The reasoning behind this claim is as follows. People have basic needs that it is dire not to be able to meet. These are not fully divisible. For example, someone's rent might be $1000, and they cannot obtain half the benefit of their apartment by paying $500. They must pay the full $1000 or be evicted. Thus, at the low-resources end of the utility function (when they have less than $1000), the marginal benefit of an extra dollar is small: even with it, they still cannot make rent. This is true until around the $1000th dollar. Here, the utility function is very steep, or even vertical. They go from being evicted from their apartment, to living in it, a dramatically better situation. Above the threshold level ($1000 in our example), more money would perhaps be valued, but a gain would not be nearly as good as failing to satisfy basic needs (losing the apartment) would be bad. Thus, the Desperation Threshold Model predicts a signature pattern of risk proneness at extremely low incomes, and maximal risk aversion at low but adequate incomes.

There is some evidence for patterns of risk attitude consistent with this S-shaped utility function. In particular, de Courson et al. (2025a) found, in UK and French adults, some evidence of a V-shaped relationship between financial resources and risk attitude: as financially resources reduced, people became more risk averse, until an extremely low level of resources (around the bottom 5% of the distribution), when they became more risk prone again. There is diverse other empirical evidence, from different settings and measuring both resources and risk attitude in different ways, consistent with this non-monotonic association between resources and risk (see de Courson et al., 2025b for review).

Such findings are consistent with the Desperation Threshold Model's proposed S-shaped utility function. However, the grounding of the model is not fully satisfying. On the one hand, the S-shaped utility function is *inferred from* patterns of risk attitude. On the other hand, the S-shape is invoked as an *explanation* for those very patterns of risk attitude. This is a limitation of purely revealed-preference interpretations of utility functions: their shape is inferred from choices, and yet also proffered as an explanation for those choices. But, if a utility function or something like it is driving choices, it must have some psychological instantiation independently of and prior to risky choices. The aim of this study is to test directly whether these psychological utility functions for income are S-shaped, using a method that does not depend on inference from choices under risk. We have people state what the value to them would be of different possible incomes that they might receive, and fit functions through their individual sets of ratings.

Our study builds on the *individual welfare function* paradigm that began with Bernard Van Praag (Van Praag, 1971). This paradigm directly estimated psychological utility functions of income, by using survey data in which respondents stated what levels of income they would consider 'very bad', 'bad', very insufficient', 'insufficient', 'barely sufficient', 'sufficient', 'amply sufficient', 'good', or 'excellent'. The 'very bad' income level was assumed to carry a utility of zero, and the 'excellent' a utility of 1. The intervening seven descriptors were assumed to divide up the region of the utility scale between the extremes of 0 and 1 evenly. This paradigm generated considerable empirical activity in the 1970s and 1980s (for review, see Kapteyn & Wansbeek, 1985). The general finding was that psychological utility functions of income are S-shaped, with a switch from increasing marginal returns to decreasing marginal returns at around the point where people consider that they would be able to 'make ends meet' (Kapteyn & Wansbeek, 1985; Van Praag, 1971). We note that authors in this paradigm had already foreshadowed the basic idea of the Desperation Threshold Model: "increasing marginal utility at the lower income range seems quite a plausible property….If income is below subsistence level, each extra dollar brings one closer to the point where survival is possible and hence each extra dollar carries a higher marginal utility" (Kapteyn & Wansbeek, 1985, p. 342).

The individual welfare function paradigm has some obvious limitations. The shape of individual functions was estimated from just nine points. This means that the resolution is very poor: though sigmoid functions often fitted well, the difference in fit from logarithmic or even linear functions was small (van Herwaarden & Kapteyn, 1981). Moreover, strong assumptions were imposed by the researchers: that ‘very bad’ is the worst income the respondent can imagine, equivalent to zero utility; and that the difference between, for example ‘insufficient’ and ‘barely sufficient’ is the same numerical increment in utility as the difference between ‘good’ and ‘excellent’. Here, we develop and present an improved paradigm where the shape of psychological utility functions for income is estimated with much finer resolution (41 points per respondent); and the respondents provide a direct numerical value of how much they would value each outcome, rather than choosing verbal labels that the researcher later converts arbitrarily into numbers. Our research is consistent with the ‘feelings integers’ approach in social science, which has shown that people are well capable of expressing their valuations and attitudes on numerical scales, yielding variables that are reliable guides to future outcomes (Kaiser & Oswald, 2022).

In our pre-registered study, we presented 150 UK-resident adult participants with 41 different monthly incomes, in random order, and asked them to rate each one on a scale of 0-100. In three different groups of 50 participants, the rating prompt was either: ‘How satisfied would you be with this income?’; ‘How well would you be able to manage….?’; or ‘How well would you be able to live….?’. The range of incomes spanned the lowest possible income (£1) through to an income in the >95% percentile of UK incomes.

We pre-registered the following research questions:

> RQ1. What is the typical shape of the best-fitting individual psychological utility function? In our pre-registered analysis, we addressed this by comparing the model fit for each respondent of linear, logarithmic, quadratic, or sigmoid functions. Only the sigmoid function has the S-shape assumed by the Desperation Threshold Model. In a non-pre-registered alternative analysis, we fitted Generalized Additive Models (GAMs) to each respondent’s data. GAMs provide a flexible data-driven non-linear fit with few constraints on the functional form. Each respondent’s fitted GAM can be examined for evidence of S-shape.

RQ2. Do the parameters of the best-fitting psychological utility function as established in RQ1 differ according to whether the rating question concerns satisfaction, managing or living well?

RQ3. Which individual variables predict parameters of the best-fitting psychological utility function? In particular, we were interested in whether the shape of the psychological utility function of income is strongly driven by one's own actual income, or the typical income of other people that the respondent knows.

Methods

Preregistration, data and code

The study was pre-registered at: https://osf.io/ewmxf. Data and code are available at: https://osf.io/r2mb9/.

Participants and sample size

Participants were UK-resident adults recruited from the online platform Prolific. Prolific and similar services provide convenience samples, in the sense that participation is limited to those who have decided to sign up and respond to the study call, but their demographic diversity is fairly broad. Research using Prolific has been validated by comparison with other sampling methods for a number of known findings in psychological and behavioural science (Coppock, 2019; Peer et al., 2022). The Prolific pool is mainly non-student. It over-represents younger and more educated adults compared to the UK population (see Radkani et al., 2023). Participants were recompensed £2.50 for taking part. The study has been approved by the IRB of the Paris School of Economics (no. 2025-008).

Without prior evidence on required sample size, we set our target recruitment to 50 respondents per rating question, for 150 overall. We balanced the numbers of men and women.

Procedure

Participants were presented with 41 different monthly incomes between £1 and £8000, in random order. The incomes spanned the range evenly at an average interval of £200. To inject some variation in the numbers and encourage the respondent to pay close attention to them, we varied the exact difference between adjacent income values by ± £60 (i.e. the actual difference was always between £140 and £260).

For each income, each respondent provided a 0-100 rating via a slider. Participants were randomized to one of the following response question options and received the same option for all 41 trials:

- [Satisfaction] How satisfied would you be with this income? (Totally unsatisfied ~ Totally satisfied)
- [Manage] How well would you be able to manage with this income? (Not at all ~ Very easily)
- [Live well] How well could you live with this income? (Could not make it at all ~ Could live comfortably)

Prior to the first trial, participants read the following instructions:

> In this study, we want you to rate [the satisfaction you would feel with/the extent to which you could manage on/how well you could live on] different levels of monthly income. By income, we mean the number of actual pounds you would receive each month into your bank account; that is, your income after tax and deductions.
>
> We will present you with different levels of monthly income, some of which you might have experienced already, some others not. The values that will be presented to you are in the range of incomes typically experienced in the general British population.
>
> For each monthly income that we present to you, please think about [how satisfied you would be/how well you would be able to manage/how well you could live], if this were to be your current monthly income. In other words: how well do you judge you would be able to cater to your needs and live a comfortable life? You will express this using a scale from 0 to 100.
>
> You should reason 'all else equal'. That is, don't assume that you would have to do different work to gain the different salaries. Each time, you will use the mouse to move the rating bar and press the spacebar when you are happy with your answer. There are 41 trials.

Individual measures

At the end of the 41 trials, asked the participants the following questions:

- Age
- Gender
- Number of adults in household
- Number of children in household
- Your own usual monthly take-home income
- What a typical monthly take-home income is amongst people you know

To capture the aspects of household size that are relevant to financial needs, we calculated a household size score of 1, plus 0.5 for every additional adult, plus 0.3 for every child.

Analysis strategy

RQ1. We pre-registered the following analysis. For each participant, we fitted the following functions to their 41 data points, with the income as the predictor and the response as the outcome:

- Null model. Intercept only.
- Linear function: $Response = \beta_0 + \beta_1 Income$
- Logarithmic function: $Response = \beta_0 + \beta_1 log(Income)$
- Quadratic function: $Response = \beta_0 + \beta_1 Income + \beta_2 Income^2$
- Sigmoid function. $Response = \frac{A}{1+e^{-s(Income-\mu)}}$

In the sigmoid function, A, s, and μ are parameters estimated from the data. A is the upper asymptote, s is a parameter that controls the steepness, and μ is the parameter determining where satisfaction crosses 50/100. The null and linear models were included as controls and we expected them to be relatively poor fits. The key comparison in terms of our research question was whether the sigmoid function (which is S-shaped) outperformed the two always-concave functions, logarithmic and quadratic.

For each participant, we compared the AICs of the five functions, and ‘called’ the respondent in terms of the function with the lowest AIC for their data. In addition, we calculated average AICs across all participants for each of the five function classes. For each participant, we saved the parameter estimates from the class of function that was modally best-fitting. In the event that the modally best-fitting function was sigmoid, we pre-registered to compute for each respondent the interval over which the second derivative was positive (increasing marginal returns) versus negative (decreasing marginal returns).

In addition to our pre-registered analysis, we fitted Generalized Additive Models (GAMs) to the data from each participant using R package ‘mgcv’. GAMs provide flexible, data driven, semi-parametric fits with minimal restrictions on the functional form of the relationship. We tested whether the fitted GAMs were S-shaped by numerically computing their first and second derivatives using R package ‘gratia’. If the relationship is S-shaped: the first derivative of the fitted GAM will first increase then decrease as the income increases; and the second derivative will be positive at lower incomes and negative at higher incomes. We used the GAMs for visualizing the individual functions, as they provide the fits most faithful to the raw data.

RQ2. We compared the parameter values of the modally best-fitting class of model by response question, using a multivariate analysis of variance (MANOVA), and follow up univariate models.

RQ3. For each respondent, we saved the parameter values of the modally best-fitting class of models. We then used AIC-based model selection and model averaging to identify the best model for predicting these parameter values. The set of predictors was: age, gender, own income, own income equivalized for household size, typical income amongst people they know, and whether they have children. We performed this analysis with the response questions pooled, as pre-registered for the case where RQ2 revealed no substantive differences according to response question.

Results

Description of sample

Demographic characteristics of the sample are shown in table 1.

Table 1. Demographic characteristics of sample. Means and standard deviations are shown for continuous variables, and frequencies for gender.

Age	41.7 (13.5)
Gender	
Man	75 (50%)
Woman	74 (49.3%)
Missing	1 (0.7%)
Adults in household	2.08 (0.85)
Children in household	0.77 (1.05)
Own usual monthly income (£)	2570 (1460)
Typical monthly income (£)	3020 (1520)

Function fitting: pre-registered analysis

Respondents' responses were systematically related to the income proposed, meaning that the non-null models fitted well and explained almost all of the variance (Figure 1, which shows the first 20 participants as an illustration). Comparing the AICs of five model forms for each respondent, the best fitting was the sigmoid function for 88 participants (59%), the quadratic for 55 (37%) and the linear for 7 (0.05%). The sigmoid was the most frequent winner, and the quadratic the second, for each rating question, as well as overall. In terms of average AIC, the rank order was the same for all three response questions and overall (Table 2): from worst fit to best, null > logarithmic > linear > quadratic > sigmoid. Thus, for each response question, the sigmoid was the model providing the best fit on average, and the best-fitting model for the majority of respondents.

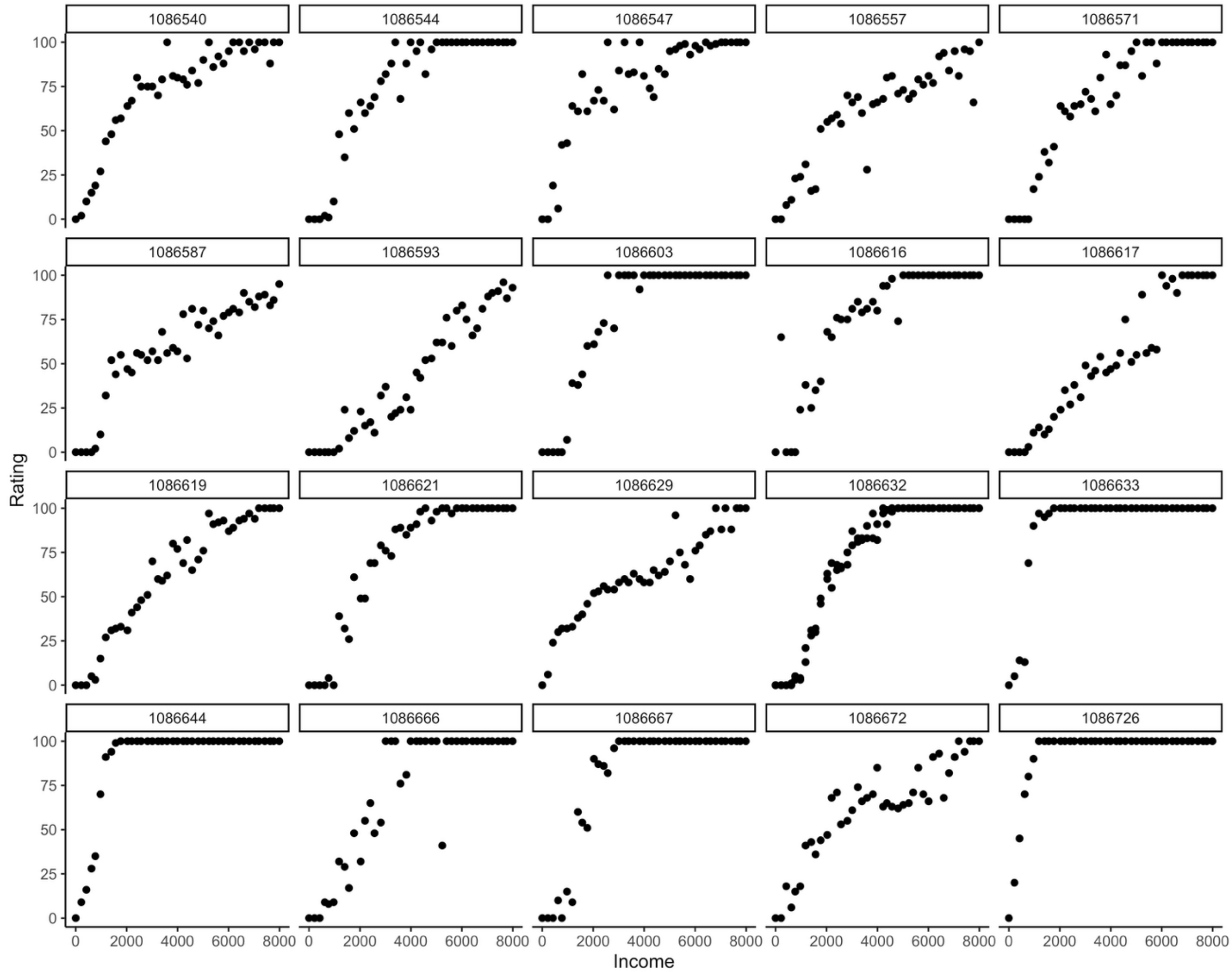

Figure 1. Data from the first 20 participants.

Table 2. Mean AIC values for each class of function fit, per response question. Respondent counts of ‘winners’ (best-fitting functions) for each participant are shown in the order Sigmoid/Quadratic/Linear.

Question	**Null**	**Linear**	**Logarithmic**	**Quadratic**	**Sigmoid**	**Winner**
Satisfaction	430.83	351.07	398.78	316.48	302.99	34 / 12 / 5
Manage	407.26	345.21	375.02	311.51	283.65	29 / 22 / 0
Live	404.42	327.20	371.48	298.01	284.97	25 / 21 / 2

As the sigmoid was the best-fitting function class in most cases, we fitted a sigmoid function for all participants, and extracted its three parameter estimates. The mean across participants of the sigmoid asymptote parameter A was 95.35 (s.d. 9.68). Since this is close to 100, the average respondent asymptotes very close to complete satisfaction as income becomes large. The mean of the mid-point parameter μ was 2532 (s.d. 1035). This is the point on the income scale at which satisfaction with income reaches half of its asymptote. Finally, the average steepness parameter s was 0.0012 (s.d. 0.0021). Steepness and mid-point were negatively correlated across respondents ($r = -0.49$). Parameter values did not differ significantly by response question (MANOVA: $F(6, 292) = 1.34$, $p = 0.237$). (Similar parameter estimates and conclusions are reached using only the participants for whom the sigmoid function was the best fit).

GAM approach

For each respondent, we fitted a GAM of response against income. We then obtained numerical estimates of the first and second derivative of this GAM at every value of income. Figure 2 shows the GAMs for each participant and the participants pooled; the average first derivative against income, and the average second derivative against income. The first derivatives were always positive. They showed the signature S-shaped pattern of first increasing with income, then subsequently decreasing. Correspondingly, the second derivatives were positive at low incomes and negative at higher incomes. Thus, the GAM analysis confirms that the marginal psychological utility of income is increasing at low values of income and turns decreasing above a threshold level. The transition from positive to negative second derivative in this analysis was at an income of £1600. The transition estimated using the fitted sigmoids was at an even higher point: £2410.

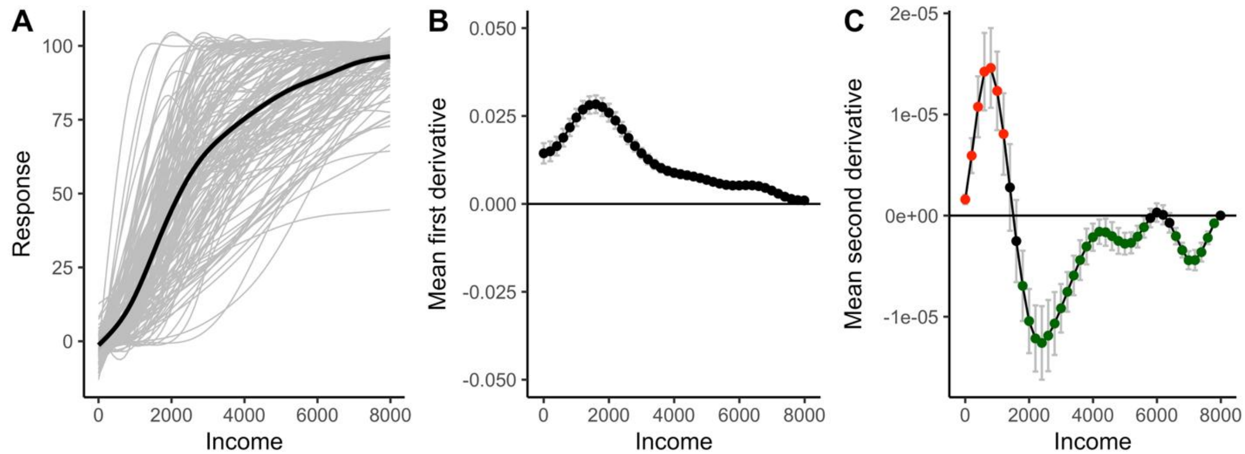

Figure 2. A. Fitted GAMs of response rating against income for every respondent (grey lines) and for all respondents pooled (black line) B. Mean first derivative (estimated numerically from fitted GAMs), across respondents. Error bars show the between-respondent 95% confidence interval. C. Mean second derivative (estimated numerically from fitted GAMs), across respondents. Error bars show 95% the between-respondent confidence intervals. The three response questions are pooled.

Individual variation in sigmoid parameters

To establish the best set of predictors of an individual's sigmoid parameters, we used AIC-based model selection from the set including all possible additive combinations of: own income, typical income amongst people they know, age, gender, and household size equivalence score. The best model for the asymptote A included typical income (negative) and age (positive); for the mid-point μ, own and typical income (both positive), and for the steepness s, own income alone (negative; table 3). The proportion of variance explained was strikingly higher for μ than the other parameters.

As the coefficients in table 2 show, the position of a person's sigmoid function was related to, but not completely determined by, the person's own income and the incomes of others they now. The mid-point parameter μ increased by 35p for every pound the person earns personally, and 12p for every pound increase in the incomes of people they know. To visualize this variability, we plotted separate sigmoids for the people in the lowest quartile and highest quartile of incomes (figure 3).

Table 3. Predictors of individual variation in the parameters of the sigmoid function. N=149 as one participant had a missing value for a variable included in the model selection.

	A			**μ**			**s**		
Predictors	*Estimate*	*SE*	*p*	*Estimate*	*SE*	*p*	*Estimate*	*SE*	*p*
Age	0.1374	0.0589	**0.021**						
Typical income	-0.0012	0.0005	**0.026**	0.1160	0.0598	0.054			
Own income				0.3516	0.0620	**<0.001**	-0.0003	0.0001	**<0.001**
Observations	149			149			149		
R^2 / R^2 adjusted	0.059 / 0.047			0.378 / 0.370			0.085 / 0.078		

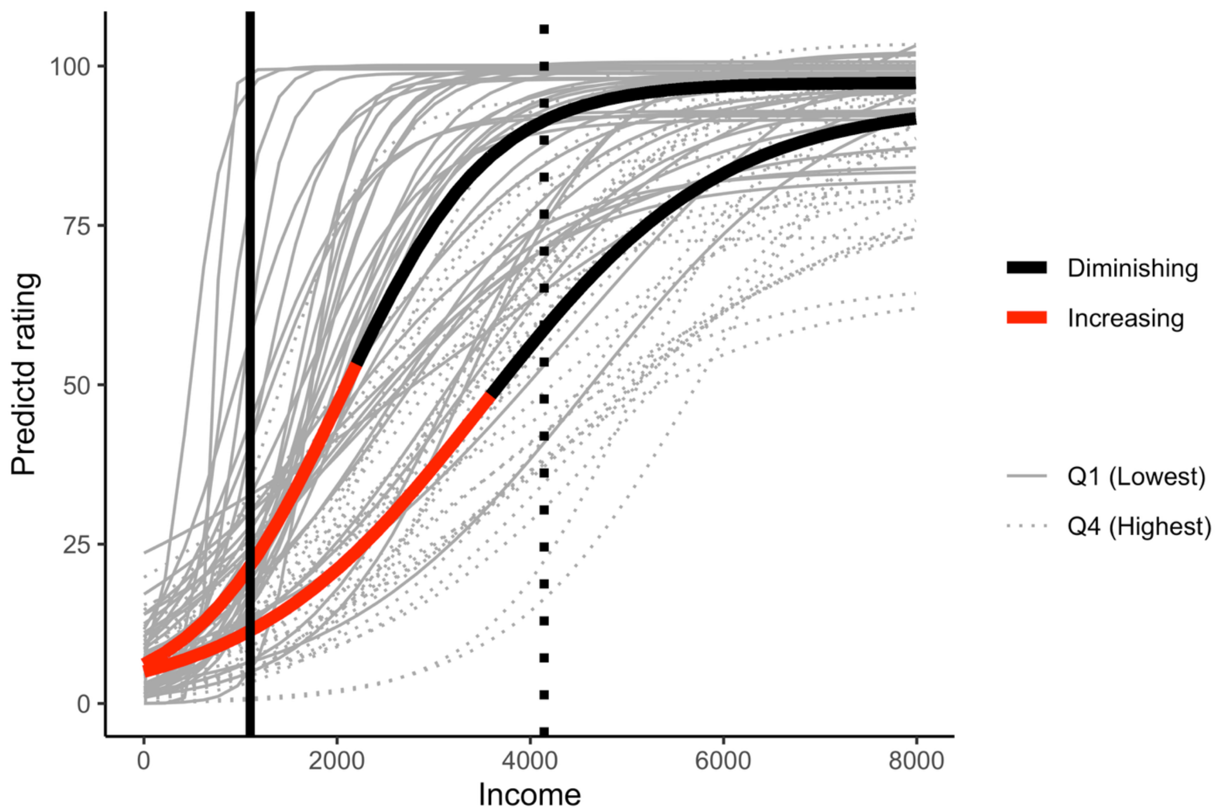

Figure 3. Fitted sigmoid functions participants in the lowest income quartile (solid) and the highest income quartile (dotted). The wider lines represent the average sigmoids for the two groups. The two vertical lines are the median incomes of the two groups.

As the figure shows, the positions of the typical sigmoids of the low- and high-income groups are much less far apart than their actual incomes. The low-income group switch from increasing to diminishing marginal returns well above their actual incomes, whereas the high-income group switch from increasing to diminishing marginal returms well below their actual incomes.

Discussion

Using a simple paradigm in which respondents rated how satisfied they would be with different incomes, or how well they could live on them, we found that the typical function linking satisfaction with income was S-shaped. This was clear from the fact that a sigmoid fit was superior to everywhere-concave alternatives for the majority of participants; and from the shape of flexible GAMs fitted to the data. The GAMs typically showed an increasing first derivative and positive second derivative at low incomes, and then a decreasing first derivative and negative second derivative at higher incomes. These are the hallmarks of, respectively, increasing marginal returns to additional income at low incomes, and decreasing marginal returns at high incomes. The exact wording of the response question used did not appear to make any substantial difference to the resulting shapes. People's individual functions were affected but not completely determined by their economic situations. Notably, the mid-point of the sigmoid function moved to higher incomes as the respondent's own income, or the incomes typical of the people they knew, became higher. However, the individual functions were not completely anchored on the status quo. Respondents with high incomes had a sigmoid mid-point well below their actual income, whereas respondents with low incomes had a sigmoid mid-point well above theirs.

Our empirical observations support the core assumption of the Desperation Threshold Model, that psychological utility functions for material resources are typically S-shaped (de Courson et al., 2025b). Moreover, the Desperation Threshold Model requires that the S-shape is not totally anchored on the person's current income, but rather reflects, at least to some extent, the actual cost of meeting basic needs. Our findings stand in contrast to the influential model of Rayo and Becker (2007), which predicts, on a priori efficiency grounds if utility is to track potential fitness gain, that psychological utility functions ought to re-centre continuously on the person's current status quo. Our results show that there is some movement with the status quo, but the re-centring is only partial. People on low incomes have a switch to diminishing returns at incomes considerably above their actual incomes, and people on high incomes have a switch to diminishing returns at incomes well below their own.

Our findings are also congruent with the findings of the individual welfare function literature (Kapteyn & Wansbeek, 1985; Van Praag, 1971), to which the present study makes considerable methodological improvements, notably a larger number of data points per individual, more robust fitting methods, and allowing the respondent to directly use a continuous numeric rating scale. They imply that the psychological utility of resource overall (as opposed to the consumption of any individual commodity) appears to violate Gossen's first law, the generalization that marginal utility is everywhere diminishing (Gossen, 1983). A possible rejoinder is that Gossen's law is primary a methodological claim: marginal utility is typically diminishing across the ranges that matter for real-world decision making, and so concave utility functions are a safe choice for modelling economic behaviour. The existence of a non-concave segment of the function at values of income that rarely occur does not violate the reasonableness of this assumption. However, it is not the case that incomes low enough to be in the increasing-returns segment documented in our study rarely occur. The point of transition to a negative second derivative is estimated around £1600 per month from our GAM functions (and this figure was even higher estimated from fitted sigmoids). The latest official UK Personal Incomes Survey puts this at around the 27th percentile of actual individual incomes (UK Government, 2025). Thus, a quarter of adults in the UK have incomes that, according to the present results, would put them in the segment where the marginal psychological value of extra income is increasing. This implies that, if we take the present results at face value, the S-shape could have important consequences for behaviour in the population.

Our study has several limitations. First, at present, we have only studied one convenience sample from the UK population. We have thus not established generalizability to the whole UK population, or any other population. This is clearly the next priority. Second, the measures are hypothetical, and respondents will not have experienced incomes in most of the range over which they provide ratings. Typical economic approaches to utility functions assume them to be revealed in patterns of (consequential) choice, rather than by self-report psychological measures. Our response to this is several-fold. Our respondents had no incentive to report any particular distorted pattern. Their responses were very systematically related to the incomes presented, despite those being presented in random order (see figure 1). Thus, we feel that people's ratings merit being taken seriously as expressions of the value they would attach to different incomes. More generally, if people make decisions by rationally responding to some set of valuations that they hold, they must be able to represent those valuations psychologically, in order to use them in computing their decisions. Those internal psychological valuations are worthy of study. People appear to be good at reporting internal psychological variables accurately, even on numeric scales (Kaiser & Oswald, 2022). Thus, we argue that the S-shaped functions observed here, even though based on hypothetical incomes, should be taken as potentially consequential, especially if doing so coheres with patterns of real-world behaviour at the individual and aggregate levels (de Courson et al., 2025b).

The key implications of the findings concern decisions under risk, where those decisions involve a possible gain in overall resources. Assuming everywhere-diminishing marginal returns predicts some degree of risk aversion regardless of personal situation. It also predicts greater risk aversion the lower one's income, a pattern that does indeed appear to hold across much of the income range in affluent populations (Dohmen et al., 2011; Guiso & Paiella, 2008). The present results, and the Desperation Threshold Model, predict a degree of risk proneness at very low incomes, coupled with risk aversion once incomes reach a threshold level. In particular, the increasing marginal returns imply that people with very levels of income ought to accept some risky options even when the expected return of those options is negative (because a lucky gain would be much better than the more likely loss would be bad). The Desperation Threshold Model leverages this prediction to explain observed features of high-poverty populations, such as increased rates of gambling and property crime, even though those behaviours generally have disadvantageous consequences. The current findings predict that institutions that increase the minimum possible income (e.g. welfare states, minimum incomes, negative income taxes) should reduce these kinds of risky behaviours, a contention for which there is a range of supporting evidence (see de Courson et al., 2025b for further discussion).

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