

# Measuring individual well-being: A multidimensional index integrating subjective well-being and preferences

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CASE/202  
June 2017

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## **Editorial note**

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The author thanks Giles Atkinson, Frank Cowell, Conchita D'Ambrosio, Koen Decancq and Marc Fleurbaey for their valuable input and comments on earlier versions of this paper. Comments received from participants in seminars at the University of Antwerp, London School of Economics, and Winter School on Inequality and Social Welfare Theory (Alba di Canazei, Italy) are gratefully acknowledged. Remaining errors are the author's responsibility. Access to the British Household Panel Survey data was made available by the UK Data Archive. This work was supported by Doctoral Training Grant funding from the Economic and Social Research Council.

## **Abstract**

Policymakers have begun looking for measures to assess the well-being of their citizens beyond GDP per capita and disposable income levels. However, the multidimensional and subjective nature of human well-being makes defining such a measure challenging – when dealing with multiple dimensions of well-being, how can we reconcile the need for a consistent measure across individuals with the differences those individuals might place on the relative value of different dimensions (income versus health, for example)? This paper introduces the ‘preference index approach’, a multidimensional measure based on the ‘equivalence approach’ in social choice theory, assessing well-being in a way that reflects such interpersonal differences in preferences whilst retaining comparability among individuals. The framework is empirically illustrated with subjective well-being data from the British Household Panel Survey, using longitudinal life satisfaction regression to estimate different preference types between well-being dimensions. The empirical illustration estimates preferences of individuals by age group and education level, and finds an unexpected weaker preference for the health dimension within older groups. Across all groups, health is strongly prioritised over income. When preference heterogeneities are taken into account, the picture of well-being looks quite different than that painted by income, subjective well-being or standard multidimensional measures. The ‘preference index’ proposal challenges the popular assumption of a readily available cardinal well-being measure specified identically across individuals, and the common practice in composite indices of using population averages to seek an assessment. As such, the framework and empirical application of this preference-sensitive index of multidimensional well-being are new contributions.

**Key words:** Life satisfaction, multidimensional well-being, preferences, welfare economics

JEL number: D63, I31

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# 1 Introduction

The question of how to define multidimensional well-being has been gaining prominence in research and policy agendas in recent years. GDP centric growth policies that served post-war economies relatively well seven decades ago no longer point in a direction that captures the concerns of modern society, and the emerging consensus is that a multidimensional measure of progress is needed. The spotlight within research on well-being and living standards has noticeably shifted in response to these concerns, away from a traditionally unidimensional focus on mean incomes and towards more inclusive and multidimensional definitions of well-being. Although the idea of well-being as a multidimensional concept is not new, having been advocated several decades ago by Sen (1985, 1993), Stewart (1985) and Nussbaum (2000) among many others, it has recently grown in prominence and popularity. This has owed much to the high-profile Stiglitz-Sen-Fitoussi Commission report of 2008, the establishment of the OECD's Your Better Life Index and the independent initiatives of several governments to incorporate subjective and multidimensional well-being into their national accounts (the UK, Canada and Bhutan, for example).

Among economists, the most well-known conceptualisation of multidimensional well-being is Sen's capability approach (Sen, 1985), according to which an individual's capabilities reflect the combinations of functionings that she can attain. Sen defines functionings as "the things that he or she manages to do or be in leading a life" (Sen, 1999, p. 31), and multidimensional well-being is measured in terms of an individual's capability to attain these valuable functionings. At a practical level, the capability approach is often associated with the UNDP Human Development Index (HDI) – an example of a multidimensional index, comprised of population-level indicators of health, education and income. Despite the many criticisms levelled at the HDI since its original conception in 1990 and revised form in 2010 (in particular see McGillivray and White (1993); Noorbakhsh (1998); Sagar and Najam (1998); Ravallion (2011, 2012)), it is still by far the most famous and widely cited composite index of multidimensional well-being and is used extensively in policy and research.<sup>1</sup> As an application of the capability approach, however, the HDI has been criticised as being "a pale reflection of the general and ambitious methodology proposed by the capability perspective" (Fleurbaey and Blanchet, 2013, p. xiv).

More broadly, objections have been raised against the composite index approach in general. One objection is that such measures reflect only average population performance, without revealing anything about more detailed inequalities among individuals. Indeed a vast majority of composite indices of well-being that have been proposed simply add up population-level average indicators (Yang, 2014), which fails to differentiate between groups of individuals with cumulative disadvantages concentrated in multiple dimensions of well-being, such as poor health, low income, lack of education etc., and groups for whom disadvantages are spread over individuals more sparsely. Data limitations

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<sup>1</sup>At the time of writing, a Google search of "Human Development Index" returns over 1,800,000 results. In comparison, "index of well-being" and "well-being index" jointly return 483,000 results, and "multidimensional well-being" returns just 6,040 results. The same searches on Google Scholar return similar proportions of results for each.

can make such information about joint attainments in multiple dimensions difficult to obtain. However, the theory underpinning composite multidimensional indices often fails to consider this issue at all, reflecting a more fundamental weakness. To overcome this weakness, a method must be used that first summarises individual situations before aggregating to the population level, whereas the overwhelming approach in the literature on composite indices is to first aggregate by taking population averages in each dimension and then sum these population-level averages. Following from this, another objection is that there is no clear theoretical framework for how to aggregate dimensions at this population level. As a consequence, the implied trade-offs resulting from such measures are accused of being arbitrary and may not in fact represent the priorities of anyone in the population.

Despite the theoretical weaknesses, the development of new composite indices of social performance has proliferated in recent years. Bandura (2006) provides a comprehensive inventory of over 400 country-level indices covering a range of socio-economic themes. A more recent inventory by the UNDP (Yang, 2014) details 101 international composite measures of well-being and social performance. This proliferation has in part been facilitated by improved data resources, and has led to new research priorities incorporating population heterogeneity and non-income dimensions of well-being that contribute to quality of life. With this has come doubt on the reliability and relevance of data on average economic outcomes.

At the same time as the explosion in multidimensional measures of objective performance, there has been increasing interest in using subjective well-being (SWB) to assess social performance (Diener, 1994; Helliwell, 2003; Layard, 2005; Conceição and Bandura, 2008; Diener et al., 2009; Graham, 2011; MacKerron, 2012). Proponents of SWB argue that direct measures of ‘happiness’ or life satisfaction should be used as a barometer of social progress. The argument goes that happiness is the ultimate goal that individuals and societies strive for, and such measures are therefore a catch-all for everything that multidimensional measures of well-being attempt to aggregate, whilst avoiding the thorny issues surrounding conceptual and mathematical construction that the latter approach entails. On the other hand, however, raw SWB scores come with a different set of problems. The known effects of adaptation to different circumstances and different tastes are not reflected in such measures – recognised by Sen (1985) as “physical condition neglect”. Recent developments in the study of SWB covariates has meant that there is now a method that attempts to correct for this omission (Ferrer-i Carbonell and Frijters, 2004), and indeed such a method is incorporated in this paper. The decision to correct for such adaptation and tastes in fact exactly implies taking a more objective, resource-based perspective on measuring well-being. As such, the approach to well-being measurement developed in this paper is compatible with the aim of SWB research to unpack the components of a good life. The key difference is that while SWB advocates take evidence of links between life satisfaction and these components as supporting SWB as a direct measure of performance, the perspective taken here is that a measure based on the objective components themselves can provide fairer interpersonal comparisons, which is essential for such a performance measure. The problem of physical condition neglect can be explicitly corrected for by taking this approach, while still providing scope for subjective information to be incorporated by way of the aggregation procedure and weighting structure of the final measure. This alternative approach offers

a way for the SWB approach to inform the more resource-based approach associated with Sen (1999) which places emphasis on objective attainments, and lies at the heart of the proposed approach.

With the exception of broad surveys of well-being measurement,<sup>2</sup> research in SWB, social choice and multidimensional indices of well-being have tended to evolve as somewhat separate areas, with specific proposals within each area often made in isolation of the context of the others. This paper draws together important aspects of each of these areas, with the view that designing a widely accepted measure of well-being requires issues across disciplines to be addressed in a complementary way. Specifically, popular practice in the measurement of well-being makes two common simplifying assumptions: (1) there exists a readily available “measure of well-being which is capable of being expressed on a cardinal ratio scale” and (2) “the individual well-being functions are identical across individuals” (Dolan and Tsuchiya, 2009). This paper unpacks these simplifications by putting individuals’ own preferences centre stage, and proposes that the standard notion of multidimensional well-being indices can be modified to combine the intuitive idea of an index as a type of summary statistic with recent literature in social choice theory on well-being measurement that respects individual preferences.

The resulting index is not so far removed from many of the multidimensional alternatives to per capita GDP that have failed to gain support on theoretical grounds. Despite this similarity, it can in fact be seen as an application of a theoretical approach that has been rigorously defended. Namely, the proposed index can be seen as a close relative of the equivalent income approach developed by Fleurbaey (2005, 2011), itself an original application of the equivalence approach developed by Pazner and Schmeidler (1978). Related to this approach, Decancq et al. (2014) have derived a class of preference-sensitive multidimensional poverty indices and Decancq and Neumann (2016) include a similar approach to the one proposed here as an intermediate stage in the so-called “extended preference approach” (Adler, 2014). Consumer preferences have also long been used in the calculation of money-metric consumption-based welfare and poverty measures (Samuelson, 1974; Deaton, 1980). Proposals of composite indices of multidimensional well-being have so far, however, ignored this related literature on preference heterogeneity in welfare measurement.

For the sake of clarity, the approach developed in this paper will be referred to as the ‘preference index approach’. It aims to bridge the gap in theory between the theoretically weak ‘representative agent’ approach of typical multidimensional indices and the individualistic, preference-centred equivalence approach of social choice theory. The purpose of this paper is to make explicit this theoretical link, which has hitherto gone unrecognised, and to illustrate the proposed approach with an empirical application. In this sense, it is an attempt at addressing “the frequent gap between foundations and applied measures, between concepts and statistics” (Fleurbaey, 2008, p. 1), as well as gaps between literatures that have often evolved rather separately. It will be seen that the preference index approach results in an individual-level well-being measure akin to the specification of Maasoumi (1986) for the first step in his two-step procedure for multidimensional inequality measurement. The crucial difference is that in this paper

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<sup>2</sup>Fleurbaey and Blanchet (2013) provide such a survey with an explicit and comprehensive discussion of the overarching theoretical connections between different approaches.

an explicit derivation is given for the aggregation rule with the help of the equivalent income framework, and that an empirical strategy is presented for how to measure heterogeneous parameter values for different individuals.

The original contribution of equivalent income is in its use of individual-specific preferences to define well-being. The preference index approach borrows from the contribution of equivalent income in that respect. However, contrary to the equivalence approach and equivalent income, it dispenses with a money-metric representation of well-being. Rather, it takes as its reference of variation the dimension-neutral unit space. It should be noted at the outset that the departure from a monetary measure is not due to abhorrence for monetising aspects of life. That is to say, no objection is made to using money as a numeraire for making relative comparisons between dimensions of well-being. It has been noted that “[the] situation is not fundamentally different when none of the aggregated variables are monetary. Aggregation always implies assuming some more or less important substitution possibilities between the items that are aggregated” (Fleurbaey and Blanchet, 2013, p. 14). The rationale is rather that it results in a measure of well-being that is not contingent on a reference level in each dimension from which comparisons are made. This is a separate issue from the numeraire issue, and does have a bearing on making interpersonal comparisons if individuals have different preferences (*i.e.* their indifference curves cross). Additionally, in value systems where income has no value in well-being, none of the things that do have value can be measured in terms of trade-offs with income. For example, consider the notion of pure “Buddhist” preferences under which income plays no role in the individual’s definition of a good life – any attempt at implementing a monetary measure of well-being then breaks down since money is unable to capture any trade-offs between dimensions of life. Therefore, abandoning money as a well-being metric enables a wider array of value systems to be accommodated.

The essential premise of the preference index approach is to use ordinal and non-comparable information about individual preferences to construct an interpersonally comparable index of well-being. In brief, the procedures in the proposed method can be broken down in the following stages:

1. Mapping out individuals’ indifference curves, each of which represents her preferences over dimensions of well-being.
2. Projecting any given individual’s actual bundle of multidimensional well-being attainment onto an equivalent bundle along the individual-specific indifference curve, so that equivalent bundles of all individuals lie along a reference path in the multidimensional space.
3. Assigning individual index values to bundles on the reference path (analogous to the inverse of the distance function put forward by Deaton (1979)). Evaluation of bundles along the path provides interpersonal comparability between individuals with different preferences and different levels of attainment in dimensions of well-being.

The first step is an empirical question of eliciting preferences, whereas the other steps involve normative judgements in some form. Since the equivalence approach under-

pins the rationale for the preference index as a whole, an introduction to the equivalence approach and how it relates to the proposed method is given in Section 2. The key theoretical argument is that a synthetic index of well-being can be composed in a way that is consistent with welfare economic theory, incorporating considerations of heterogeneous preferences, fairness in evaluation across individuals, and dimension-wise correlations in distribution. Section 4 provides an empirical illustration of steps 1, 2, and 3, and the rich analysis possibilities it allows. One such analysis is a comparison of the preferences of different individuals, and how the incorporation of these preferences paints a different picture of well-being from other welfare measures. Section 5 concludes.

## 2 The Equivalence Approach

This section provides an overview of the equivalence approach and its conceptual role in the definition of the proposed preference-sensitive index. In its basic form in the context of a two-agent two-good exchange economy model, the equivalence approach defines fair allocations to be all the Pareto efficient allocations such that each individual is indifferent between her actual bundle and an egalitarian distribution of goods, *i.e.* each individual getting an identical bundle that is some fraction of the social endowment.<sup>3</sup> Pazner and Schmeidler (1978) coin the term Pareto-efficient and egalitarian-equivalent allocations (PEEEAs) to describe this resulting set of allocations. The egalitarian distribution can be seen as a fair hypothetical world to which actual distributions of bundles are compared. In this way PEEEs are identified which are equally as good as this hypothetical egalitarian distribution, but in which individuals may not necessarily have identical bundles due to differing marginal rates of substitution between goods from individual to individual.

Following a modified line of reasoning in relation to the equivalence approach, the preference index approach proposed here amounts to comparing individuals in a hypothetical world in which they are just as satisfied as in their actual situation, but in which their bundle of attainments are all situated somewhere along a defined reference path. In this approach the path takes the form of a ray extending from the vector of minimum attainable values at the origin to the vector of maximum attainable values in each dimension. Figure 1 provides a two-dimensional representation, where  $OB$  is the ray as defined. This ray represents fractions of the maximum attainment bundle, and is analogous to the fractions of the social endowment in the original equivalence approach. The key difference is that the original equivalence approach prescribes identical fractions across individuals in order to identify PEEEs, whereas the purpose of the preference index approach here is to use differences in these fractions across individuals to compare their well-being. In other words, whereas the original approach looks for egalitarian distributions of bundles in the hypothetical world, the preference index approach uses the hypothetical world as a tool for comparing different bundles under different preferences.

This hypothetical world is constructed so that all individuals are indifferent between

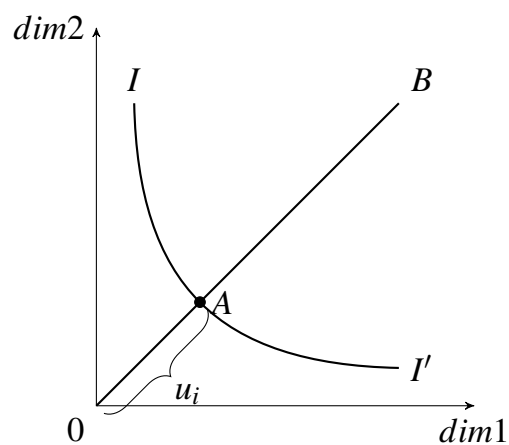
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<sup>3</sup>Note that such an egalitarian distribution need not be feasible, *i.e.* the fractions of the social endowment can sum to greater than one, since this distribution is only a hypothetical one to which bundles are being compared.



their actual situations and their equivalent situations on the ray in the hypothetical world, by moving along indifference curves. In this hypothetical world, bundles can be compared in terms of their distance from the origin along the ray, where there is no ambiguity in evaluation since attainments in all (normalised) dimensions are equalised across dimensions for a given individual. This “equally distributed equivalent” is then used as the individual well-being index measure. In Figure 1,  $OB$  is the ray as defined,  $O$  is the origin defining the minimum attainment bundle and  $B$  is the maximum attainment bundle. The distance  $OA$ , labelled  $u_i$ , is individual  $i$ 's index value for any bundle on indifference curve  $I'$ , which is equivalent to the hypothetical bundle  $A$ . Pazner and Schmeidler (1978) prove that the concept carries over to the case of any finite number of dimensions.

**Figure 1: Simple illustration of the equivalence approach**



As noted, a main difference between the original equivalence approach and the preference index approach is that the objective of the former is a fair allocation rule, whereas that of the latter is a rule for making comparisons in potentially unfair allocations. Another difference is that since this application of the equivalence approach is to well-being attainment rather than goods allocation in a closed economy, the element of rivalry disappears. This is because the resources that enable well-being attainment are not explicitly modelled as being scarce, although it should be recognised that this is not entirely realistic. In the preference index model there is no longer a social endowment of goods to be divided among agents; instead there is a maximum level of attainment in each dimension of well-being, and it is assumed that attainment of one individual is not constrained by the number of other individuals or the attainment levels of those other individuals.

Comparing the preference index approach to the equivalent income approach developed by Fleurbaey in a series of papers (Fleurbaey, 2005, 2011; Decancq et al., 2015), this one is based on a different extension to the original equivalence approach. The equivalent income approach also looks to evaluate and compare different bundles such that each individual is indifferent between the actual bundle and a bundle on a reference path. However, whereas the preference index approach introduced here compares situations to fractions of the maximum attainment bundle as the reference path, the equivalent income approach requires reference values of each non-income dimension to be defined, and optionally different values for each individual. In terms of Figure 1, whereas the

diagonal ray  $OB$  from the origin is the relevant multidimensional reference to which individual situations are compared and evaluated, in order to evaluate situations using the equivalent income approach a reference level must be fixed for each non-income dimension. This is visualised as a horizontal (or vertical) path extending perpendicularly from the chosen reference value on each non-income axis. An individual's well-being is then found by computing income minus the cumulative amount of income he or she would be willing to give up to attain the reference value of each other dimension (Decancq et al. (2015), for example, choose the reference value of perfect health). The resulting equivalent income measure is therefore an adjusted-income measure. The measure proposed here, on the other hand, is a composite index measure, which is not reliant on a monetary dimension such as income in order to be defined.

The argument behind using dimension-wise reference levels under the equivalent income approach is that, for each non-income dimension and each individual, there exists some optimal level of attainment for which it is ethically defensible to compare the situations of individuals, irrespective of their preferences. Again taking the example of perfect health as the reference level for the health dimension as in Decancq et al. (2014), the argument would be that trade-offs between health and other dimensions are irrelevant when individuals are in perfect health. Equivalent income is then defined as each individual's actual income adjusted down for the loss in well-being associated with a less-than-perfect level of health. It can be interpreted as the individual's actual income minus her willingness-to-pay (or to give up income) to reach perfect health from her actual health status. The same applies for reaching the optimal reference levels in the other well-being dimensions. Intuitively this can be understood as having a hypothetical multidimensional baseline situation of optimal attainments that individuals reach by giving up income, whereby the equivalent income is defined as the remaining income upon reaching this hypothetical "optimal" situation.

The rationale for the preference index approach makes two counter-arguments against this equivalent income approach. First, if our objective is to obtain a well-being measure that is generalisable to all societies, then preferences should be considered that place no weight on income in an individual's definition of well-being. Under such pure "Buddhist" preferences, any attempt at implementing a monetary measure of well-being then breaks down, since income is unable to capture the trade-offs between dimensions of life. Therefore, abandoning money as a well-being metric allows an approach to well-being measurement that is not reliant on a particular dimension (namely income) being present in the definition of well-being.

Second, it is not clear that taking perfect health, or a chosen "optimal" reference value in each non-income dimension for each individual, is the most convincing hypothetical baseline situation. This implies the extreme view that income as the slack variable should be reduced to the full extent of attaining this situation of optimality in the other dimensions. The preference index approach instead defines the hypothetical baseline situation to be where an individual's attainments are equally distributed across all the well-being dimensions. The corresponding willingness-to-pay interpretation is that the preference index is characterised by an individual's willingness to sacrifice attainment in higher-attaining dimensions in order to raise attainments in the lower-attaining dimensions to a hypothetical situation of equally distributed attainment across all dimensions.

The ethical argument is that the same ratio across all dimensions relative to maximum attainment in all dimensions is an unambiguous position from which to evaluate an individual's well-being, since her measure of well-being is simply the common degree of attainment across dimensions. This does not depend on income being present in the well-being definition. It also does not imply an extreme hypothetical situation for making comparisons in which one dimension, income, is used to compensate for all deviations below an optimal level in each of the other dimensions.

### 3 The Preference Index Approach

#### 3.1 Theoretical framework

Consider a simple framework in which each individual  $i$  considers  $m$  dimensions of life that matter for her well-being. Attainment in dimension  $k$  for individual  $i$  is given by a positive real number  $x_{ik}$ , and the personal attainment bundle of individual  $i$  is an  $m$ -dimensional vector  $x_i = (x_{i1}, x_{i2}, \dots, x_{im})$ . Attainment bundles are defined along a normalised scale such that  $x_{ik} = \frac{\tilde{x}_{ik} - x_k^{\min}}{x_k^{\max} - x_k^{\min}}$ , where  $\tilde{x}_{ik}$  is the raw attainment value in dimension  $k$ ,  $x_k^{\min}$  is the minimum value and  $x_k^{\max}$  the maximum value. Each individual  $i$  has well-defined preferences over personal attainment bundles  $x_i$  belonging to the potential attainment set  $X \subseteq \mathbb{R}_+^m$ . Let  $R_i$  denote individual  $i$ 's complete preference ordering over the set  $X$ . Preferences are assumed to be complete and transitive. When  $i$  prefers bundle  $x_i$  at least as much as bundle  $x'_i$ , this is denoted by  $x_i R_i x'_i$ . Strict preference is denoted by  $x_i P_i x'_i$  and indifference by  $x_i I_i x'_i$ . With these definitions, the minimum and maximum attainment bundles in the potential attainment set  $X \subseteq \mathbb{R}_+^m$  are normalised to  $\phi(x_{\min}, R_i) = 0$  and  $\phi(x_{\max}, R_i) = 1$ , respectively, for all  $R_i$ . Note that here,  $x$  is assumed to be cardinal. In practice, some empirical literature has treated ordinal data as cardinal for tractability and model flexibility (see, for example, Allan (1976) and Labovitz (1970), and Harwell and Gatti (2001) for a discussion in the context of educational data), or because this can provide additional insights into useful relationships (Moses et al., 1984). In the later empirical application that follows, the education dimension will be treated in this manner.

#### 3.2 A preference-sensitive multidimensional well-being index

Given this framework, an individual-level index of well-being,  $\phi(x_i, R_i)$ , can be specified according to her preference ordering  $R_i$  over  $m$ -dimensional bundles  $x_i$ , where  $\phi$  is increasing, continuous and concave in  $x_i$ . Making the simplifying restriction to the domain of homothetic  $R_i$ , i.e.  $x_i R_i x'_i \Leftrightarrow \alpha x_i R_i \alpha x'_i$ , we have that  $\phi(x_i, R_i)$  will be homogeneous and ordinally equivalent to:

$$\phi(x_i, R_i) = \begin{cases} \left( \sum_{k=1}^m w_{ik} x_{ik}^{\rho} \right)^{\frac{1}{\rho}} & \rho < 1, \rho \neq 0 \\ \prod_{k=1}^m x_{ik}^{w_{ik}} & \rho = 0. \end{cases} \quad (1)$$

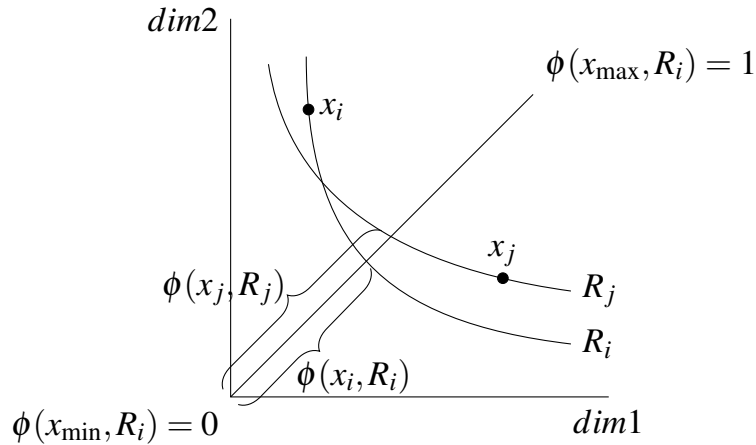
for dimensions  $k = 1, \dots, m$ , where  $w_{ik}$  captures the relative weights given by individual  $i$  to each of the dimensions.  $\phi(x_i, R_i)$  can therefore be represented by a generalised mean, a linearly homogeneous constant elasticity of substitution (CES) function. It is quasi-concave if and only if  $\rho \leq 1$ , with elasticity of substitution greater than one if and only if  $\rho \geq 0$  and less than one if and only if  $\rho \leq 0$ , where elasticity  $\sigma = \frac{1}{1-\rho}$ . Importantly, the constant elasticity assumption will later be relaxed to investigate what repercussions this has empirically.

A graphical representation demonstrates how such a specification captures differences in preferences between dimensions of well-being using the equivalence approach. In Figure 2, the indifference curves of the individuals  $i$  and  $j$  cross due to differences between their preference orderings  $R_i$  and  $R_j$  over bundles of two-dimensional attainments. Their situations at  $x_i$  and  $x_j$  cannot therefore be unambiguously compared, as would be the case if their indifference curves did not cross (the individual on the higher indifference curve would always be considered as faring better than the individual on the lower indifference curve). Instead, we have here an ambiguous situation where  $i$ 's indifference curve is higher in the portion of the graph where bundle  $x_i$  is situated, whereas  $j$ 's indifference curve is higher in the portion where bundle  $x_j$  is situated.

A choice must therefore be made for a reference path along which to compare individual situations, as described in Section 2. The intersection points between the reference path and indifference curves give hypothetical attainment bundles which would be deemed equally as good by both individuals as their respective bundles  $x_i$  and  $x_j$ . Choosing the ray through the minimum and maximum attainment bundles as in Figure 2, this reference path equates to fractions of the maximum attainment bundle, and is given exactly by Equation 1. Interpersonal comparisons can be made along this ray between individuals with heterogeneous preferences, and it is deemed that  $\phi(x_j, R_j) > \phi(x_i, R_i)$ .

Comparing this approach to the typical feature of composite well-being indices where the same index is used to aggregate dimensions of well-being for all individuals, this approach allows the individuals' own preferences to be used as a compelling way of aggregating dimensions. Importantly, this means that different views of trade-offs between dimensions of well-being can be respected when evaluating the well-being of individuals, thereby avoiding a single prescribed or paternalistic definition of well-being which may have no consensus among the population. On the other hand, however, the implementation of the approach uses a measure that is not so far removed in its general mathematical structure from the familiar normalisation and mean functional forms typical of a majority of composite indices Yang (2014). The practical advantage of this is that it does not alienate well-being measurement practitioners who are vested in the simple aggregation methods of these existing measures, whilst bringing an important advancement in theoretical basis.

**Figure 2: Restricted Transfer and inter-preference comparison**



The rest of the paper lays out the procedures for empirically deriving these individual indexes of well-being, with an illustration using data from the British Household Panel Survey.

## 4 Multidimensional Well-being in the UK

### 4.1 Methodological discussion

To empirically demonstrate the preference index approach outlined in the preceding sections, this section estimates preferences using a life satisfaction regression approach with micro level data from twelve waves of the British Household Panel Survey (BHPS). The BHPS is a representative sample of individuals aged over 16 in the UK. New entries and attrition means that the panel is unbalanced, with an average of 6 panels per individual. Wave 7 in 1996 marked the introduction of an additional self-completion questionnaire to the BHPS, asking individuals to indicate on a scale from 1 to 7 (very dissatisfied to very satisfied respectively) their satisfaction with various domains of life and life overall. Therefore, data from 1996 to the final wave in 2009 is used, excluding 2001 which omitted this life satisfaction question. This encompasses all waves of the BHPS containing the variables necessary for the analysis. Three dimensions of well-being are chosen for the analysis: equivalised household income, health and education. These three chosen objective policy outcomes appear to be widely accepted in both theory and in practice, and are frequently used in multidimensional applications to evaluating well-being. The UNDP Human Development Index perhaps set the precedent for incorporating education and health into comparisons of living standards (Stanton, 2007), recognising that these areas cannot be fully captured by measures of solely economic resources such as income. Inspired by this, a large body of work has grown out of this framework for measuring multidimensional well-being outcomes (Yang, 2014), and through this body of work “the international community has identified a strong and shared view on the key dimensions of human well-being” (Dietz et al., 2007, p. 32). Following in this vein, focusing on the chosen outcomes helps to frame the analysis

consistently with this literature.

## Income

Equivalised household income is used, calculated by taking the BHPS variable for total annual household income from all sources, and dividing by the square root of number of household members. This adjusts household income to account for economies of scale and household size as resources are spread among additional household members, and makes household income comparable at the individual level. Although other more complex equivalisation scales are available, the derivation of all such scales depends on the assumptions made and judgements about needs, which are open to debate. The square root is the preferred equivalence scale of researchers for the Luxembourg Income Study, Eurostat, and more recently the OECD and many other individual countries (Chanfreau and Burchardt, 2008; OECD, 2013), and is used here due to its popularity and wide comparability. Including equivalised incomes  $>£120,000$  produced significant outliers, whilst including equivalised incomes  $<£100$  produced bunching of values below this value, which is likely the result of reporting errors since this figure should include benefit payments, for which  $<£100$  per person per annum is implausibly low. Therefore, individuals with equivalised incomes  $>£120,000$  and  $<£100$  are excluded from the analysis. The remaining equivalised household incomes are normalised to a  $[0, 1]$  unit scale using the following commonly used min-max goalpost approach (Lugo, 2005; UNDP, 2013), where  $x_{it}$  is the original equivalised income value,  $x_{\min}$  is the minimum equivalised income £100,  $x_{\max}$  is the maximum equivalised income £120,000, and  $\hat{x}_{it}$  is the normalised value:

$$\hat{x}_{it} = \frac{x_{it} - x_{\min}}{x_{\max} - x_{\min}} \quad (2)$$

## Health

For health, a composite indicator is derived using BHPS variables for the following health indicators: whether an individual has been a hospital inpatient in the last year, whether an individual has problems with limbs, with chest or breathing, with heart or blood pressure, with stomach or digestion, with diabetes, with migraines, and with anxiety or depression. The composite measure is derived based on predicted values of the linear index from an ordered logit model of subjective health satisfaction. The weights in the composite measure are the rescaled coefficients of the logit regression, similar to the approach taken in Decancq et al. (2014) and van Doorslaer and Jones (2003), with the rescaling used to normalise the composite measure between 0 and 1. Subjective health satisfaction is not used as a direct measure of health since this risks endogeneity with the SWB items, as discussed by Ferrer-i Carbonell and Frijters (2004).

## Education

Although education has appeared in many lists of basic well-being dimensions and on many policy agendas, the effect of educational attainment on SWB has been a subject of contention (Dolan et al., 2008; Michalos, 2008). MacKerron (2012, p. 721) concluded in his survey of the “happiness economics” literature that “the impact of education varies between studies: in some it has no significant effect, whereas in others highest [SWB] is variously associated with lower, higher, and intermediate levels of education.” Although good education is often upheld as decisive in life, it seems that “empirical evidence remains quite divided and ambiguous when it comes to answers about... what people value in education.” (Gibbons et al., 2009, p. 1). This is echoed in the findings of Decancq et al. (2015), who using Russian data observe an insignificant relationship between educational attainment and the life satisfaction component of SWB. Nevertheless, the inclusion of this association in the analysis will be of particular interest.

For the education dimension, a known problem with the indicator of highest education qualification, though commonly used, is that it confounds effects of prior education that have manifested themselves indirectly later in the life course, either through positive income effects or negative aspiration effects. For example, while some evidence points to a small positive association between education and life satisfaction (Veenhoven, 1996; Frey and Stutzer, 2002; Oswald and Powdthavee, 2007), contradictory findings in other studies have been suggested to be the result of raised aspirations that are unfulfilled or by the higher educated taking on more high-stress occupations (Stutzer, 2004; Ferrante, 2007; Sebates and Hammond, 2008). As mentioned in Section 4.1, the empirical evidence on education and life satisfaction is therefore quite mixed. In addition, since there is little variation in education level over the years, the education variable of highest education qualification provides limited information under the individual fixed effects model used in the following analysis. Therefore, for the education dimension an alternative variable is exploited for the SWB regression – the dummy variable indicating whether an individual has obtained a new qualification in the last year. Since this variable narrows the time frame under consideration to one year earlier as opposed to over the entire life course so far, the indirect life course effects through income and aspirations are removed. The estimated education dummy coefficients for each preference are then used to derive the education measure, by assigning the coefficient value to each additional qualification level an individual has attained and summing these values.

In relation to the definition of  $x$  in Section 3, we therefore treat all three indicators as cardinal variables, though it should be acknowledged that the treatment of education is not as satisfactory as for the other dimensions due to the small number of education levels. To aid interpretation, analysis is conducted using normalised variables so that results that follow are interpretable with respect to a normalised  $[0, 1]$  unit scale consistent with the Normalisation axiom.

## 4.2 A life satisfaction approach to estimating preferences

The proposed index of well-being requires that an ordinal representation of indifference curves is first estimated, in order to derive the individual indexes. This involves assuming that for each individual there is a stable mapping from dimension attainments to the latent variable that determines reported life satisfaction, and that this applies in all years of the survey. This implies that an individual's rank according to her individual well-being index will correspond to her rank according to life satisfaction, and therefore the  $q$ -th quantile of the distribution of individual well-being will correspond to the  $q$ -th quantile of the distribution of life satisfaction (van Doorslaer and Jones, 2003).

More concretely let the following model be defined for life satisfaction,  $S_{it}$ , which is the outcome of attainment in dimensions of well-being and individual characteristics. This is

$$S_{it} = \alpha_i + \beta'X_{it} + \delta'Z_{it} + u_{it} \quad (3)$$

$S_{it}$  is the self-reported life satisfaction of individual  $i$  in year  $t$ .  $X_{it}$  is the vector of attainment in the  $\ell$  well-being dimensions of interest, in this case income, health and education.  $Z_{it}$  contains observed socio-demographic variables such as age, employment and marital status. These components of the model comprise a standard life satisfaction regression.

The empirical strategy further exploits the panel nature of the data to estimate an ordered logistic model of life satisfaction with individual fixed effects and individual-specific thresholds. This “fixed effect ordered logit” was developed in Ferrer-i Carbonell and Frijters (2004) and is further discussed in Frijters et al. (2006) and Jones and Schurer (2011). In practice, the model is estimated as a modification of the Chamberlain (1980) binary conditional fixed-effects logit model, with the modification allowing for an individual-specific rather than common life satisfaction threshold for each individual. This results in a much smaller loss of information compared to the original Chamberlain model since all individuals with any variation in satisfaction over time can be included, not just those with variation crossing over a fixed threshold. The resulting model results in a loss of only 8% of the observations due to the fixed-effect specification. A Hausman test confirms that fixed effects rather than random effects are appropriate, in line with a finding in the SWB literature that most panel studies examining determinants of life satisfaction have rejected the random effects assumption *i.e.*, the unobservable individual effects have been found in fact to be correlated with the explanatory variables (Frijters et al., 2006).

$$S_{it}^* = \alpha_i + \gamma_t + (\beta + \Lambda D_{it})' \Phi(X_{it}) + \delta'Z_{it} + u_{it} \quad (4)$$

The full model is given by (4), which further expands (3) to allow estimation of heterogeneous preferences.  $S_{it}^*$  is the latent life satisfaction variable such that reported life satisfaction  $S_{it} = q$  for  $q = 1, 2, \dots, 7$  if  $S_{it}^*$  falls between thresholds  $\eta_{q-1}$  and  $\eta_q$ , where the  $\eta_q$  are individual-specific.  $\alpha_i$  and  $\gamma_t$  capture unobserved individual and time fixed effects respectively, such as personality traits or aggregate shocks to the population.  $D_{it}$  is a vector of dummy variables to allow the estimation of heterogeneity in different parti-



tions of the population. In theory one could conceive of using ever finer partitions to the extent of estimating heterogeneity at the individual level, however given the current data this is not possible. Furthermore it is arguably more useful from a policy perspective to learn about group-level rather than individual-level preferences, since policy-making can usually only be targeted at particular population sub-groups as identified by some socio-demographic characteristic.  $\Phi$  is a function to be estimated, capturing the degree of elasticity of substitution between dimensions.

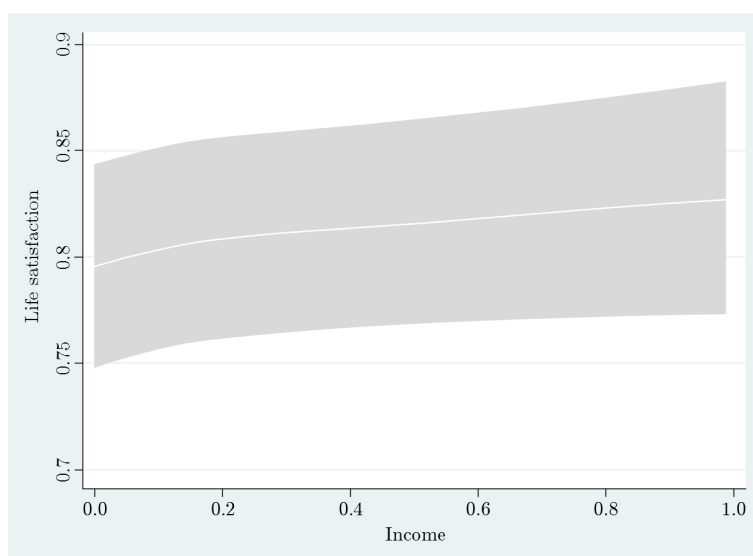
In order to pin down a suitable  $\Phi$ , a generalised additive model (GAM) of (4) is first fitted using spline functions for the dimension variables. This allows for capturing flexible functional forms, using plots of the resulting relationships to give an initial idea of function curvatures. Note that splines cannot be fitted to the education indicator since it is a dummy variable, and must enter the model linearly. In a second step, the fit of this non-parametric model is compared to a fully parametric model for which an optimal power transformation is found, with the restricting assumption that there is a common transformation parameter for each dimension. Such a parametric specification allows the closest CES representation of the ordinal preferences to be determined, helping to pin down the more tractable index specification proposed in Section 3. The third step is then to search for the best-fitting parametric specification allowing the transformation parameter for each dimension to vary independently. This is done by searching over a fine  $m$ -dimensional grid of values. In this case  $m = 2$  for the two continuous dimensions, income and health. By comparing the results of the latter two approaches, a picture can be obtained of how restrictive an assumption it is to impose CES preferences as opposed to allowing a more flexible and data-driven estimation of preference elasticities.

### **4.3 *Results and comparison with other measurement approaches***

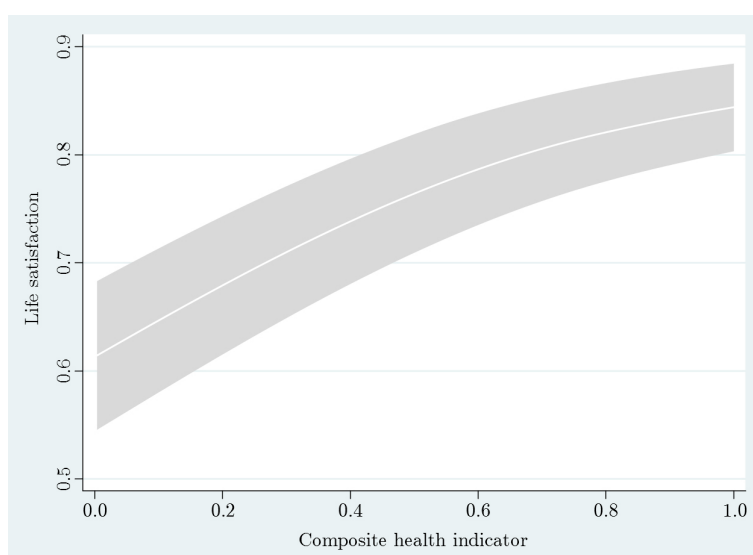
The analysis for the first step in this three-step approach, the GAM estimation, is as follows. The GAM spline plots, given in Figures 3 and 4, suggest that non-linear transformations are appropriate for both the income and composite health indicators. These spline plots allow smooth piecewise polynomial curves, or splines, to be fitted to the chosen well-being variables as opposed to confining to only linear functions as in standard linear models. Cubic splines are used, ensuring smooth joining at the knots where the curves join. It can be seen from Figures 3 and 4 that the health spline exhibits a more obvious non-linear relationship with life satisfaction compared to the income spline, though it cannot be judged simply by looking at the plots whether this is significant enough to warrant different transformation parameters for each variable. This is further examined in the second and third steps.

The second step is to compare the fit of this non-parametric model with fully parametric estimations imposing a common transformation parameter for each of the continuous dimensions. Model fit is compared using Akaike's Information Criterion (AIC), with lower AIC values indicating better fit. In the range  $[-2, 2]$  of Box-Cox power transformation parameters tested, a common parameter of 0.2 gives the best-fitting model as shown in Table 1. The fit of this model is compared to those under integer-value parameters of 0 and 1 in turn, to identify the closest naturally interpretable approximation

**Figure 3: Spline function for the income variable**



**Figure 4: Spline function for the health variable**



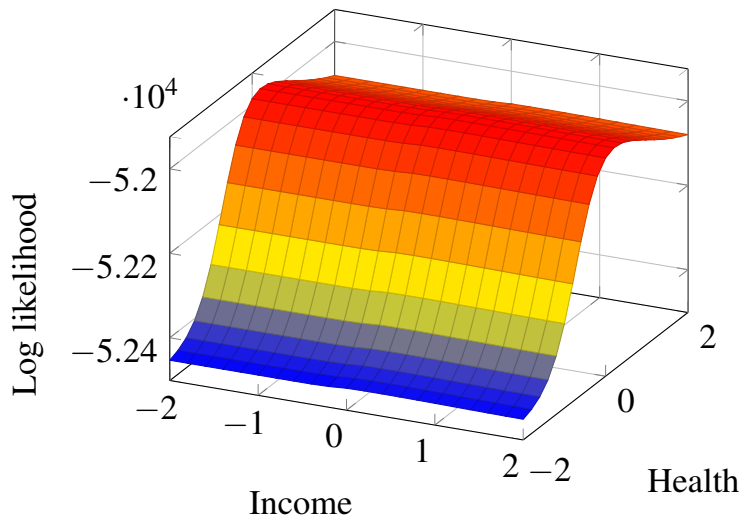
to the 0.2 optimum value. A value of 0 reduces to a logarithmic transformation whereas a value of 1 equates to a linear relationship. The AIC values reveal that 0 provides a much closer approximation, which additionally gives a very palatable and tractable interpretation as the natural log transformation or equivalently Cobb-Douglas preferences or a weighted geometric mean of these two dimensions.

The third step is to see how restrictive this common-parameter assumption is in contrast to dropping the restriction and allowing for more flexible representation of the data. To do this a two-dimensional grid search is performed over 0.2 increments in the range  $[-2, 2]$  for each dimension. The log-likelihood function is shown in Figure 5. Interestingly the likelihood-maximising values are again 0.2 simultaneously for both dimensions even without imposing the CES restriction, matching those obtained in the previous step. It may be concluded therefore that in this case the more tractable CES assumption has not imposed any restrictions on the model compared to the flexible GAM

**Table 1: Model fit for different curvatures of the well-being dimensions**

Transformation parameter	Observations	Degrees of freedom	AIC
Cubic spline	117358	31	104073.8
1	117358	29	104088.4
0.2	117358	29	104002.4
0	117358	29	104020.7

estimation. As discussed in the previous paragraph, given the closest integer approximation of 0 with its tractable logarithmic interpretation, in what follows this integer approximation will be used for the substitution elasticities of both the continuous dimensions, health and income.

**Figure 5: Log likelihood for two-dimensional grid search of transformation parameters**

Following the preferred specification (4), the estimation results first without preference heterogeneity  $\Lambda D'_{it} X_{it}$  are presented in the first column of Table 2 as a comparative “representative agent” approach. The second column reports the results when  $\Lambda D'_{it} X_{it}$  interactions that gave significant effects were included in the regression. The pseudo  $R^2$  values for both models are small, but in line with other fixed-effects studies of SWB (Graham et al., 2004, for example). With the exception of the age variables,<sup>4</sup> the socio-economic control variables were originally coded as categorical variables with each ranging from four to ten categories. For clarity of exposition, it was found that these variables could be reduced to two-category dummy variables without much loss of interpretation or change in magnitude of the dimension variable coefficients. It is the results using the simplified variables that are presented in Table 2.

<sup>4</sup>The age<sup>2</sup> variable is continuous and the age categories variable contains 5 categories (age cannot be included as a continuous variable as it would be perfectly collinear with year).

**Table 2: Satisfaction regression (standard errors in parentheses)**

Satisfaction	Homogeneous model	Heterogeneous model
<i>Equivalised income</i>	0.038*** (0.015)	0.044*** (0.016)
<i>Health</i>	0.544*** (0.018)	0.518*** (0.019)
<i>Education</i>	0.044* (0.026)	-0.009 (0.036)
<i>Young × income</i>		-0.044*** (0.016)
<i>Higher educated × income</i>		0.051** (0.024)
<i>Young × health</i>		0.131*** (0.040)
<i>Young × education</i>		0.124** (0.052)
Unemployed	-0.600*** (0.035)	-0.604*** (0.036)
Couple	0.314*** (0.041)	0.316*** (0.042)
Separated	-0.242*** (0.057)	-0.236*** (0.057)
Urban	-0.103** (0.041)	-0.112*** (0.041)
Age <sup>2</sup>	0.000** (0.000)	0.000 (0.000)
Age categories	yes	yes
Social status class	yes	yes
Individual fixed effects	yes	yes
Year	yes	yes
<i>N</i>	117,353	116,267
Pseudo R <sup>2</sup>	0.0195	0.0196

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Inspecting the other interaction coefficients it can be seen that the young care less about income, and the higher educated care more about income. To test how these results depend on the precise definition of the dummy partition, a sensitivity analysis of the “young” dummy is carried out (unreported). The results of this sensitivity analysis indicate that the estimated age-related preferences for income start to turn from caring less to caring more at around 44 years, and for education these preferences turn from caring to not caring also at around 44 years. This is around the age when adults raising young children may also need to start caring for ageing parents – a combination which significantly increases the financial burden of supporting a family. It is therefore plausible that income becomes a priority at this stage, whilst the relative importance of accumulating additional qualifications falls. Interestingly, for the interaction of age and health, it appears that older people care less about health than younger people. This may be less counterintuitive than at first sight. In a Taiwan panel study by Collins et al. (2007) of 3,363 older persons, the authors find similar results suggesting that higher life satisfaction and optimism may indicate the presence of adaptive coping mechanisms, and that this may in turn contribute to better health practices and to better physiological functioning in the longer term. In this analysis, the sensitivity analysis indicates that age-related preferences over health begin to turn towards caring less after the age of 68.

Comparing this health finding with comparable analysis in Decancq et al. (2015), they find the opposite using Russian data – there is a larger weight of health in the preferences of the old. Far from being a problematic inconsistency, these contrasting findings highlight the central argument for taking account of heterogeneous preferences. The implication is that older people living in the UK are less concerned about health relative to younger people, whereas in Russia older people are relatively more concerned about health. Examining the underlying fundamentals of health care and ageing in these two countries provides some insight to this result. Russia’s social programmes and care for the elderly are plagued by meagre pensions and poor healthcare services; in the UK on the other hand, the existence of a high quality National Health Service and state and occupational pensions provide assurance for the health of the elderly. Russian sociologist Gennady Tikhonov captures the general sentiment, that “The difference between Russia and the West is that in our country old age is considered to be a time of loss and reminiscence, whereas in the West it’s a time for new possibilities” (RT News, 2011). This seems to resonate with the observation of Deaton (2008) that whereas in the United States and Britain, health satisfaction actually improves with age after 50, in the the former Soviet Union health satisfaction falls very rapidly in the elderly. This is a difference that this preference-sensitive approach is able to capture.

Table 3 shows coefficients after a simple linear rescaling to give a clearer idea of the relative importance of each dimension. The coefficients in the table sum horizontally to one, however this rescaling can be chosen arbitrarily since the index treats preferences as ordinal and therefore only the *relative* weights are required. For all preference types income receives the lowest weight, though with some variation across groups. This result is consistent with the assertion of Deaton (2008, p. 54) that “many studies comparing people within countries have found only a small effect of income on life satisfaction relative to other life circumstances”, citing as examples Helliwell (2003) and Blanchflower and Oswald (2004).

**Table 3: Preferences**

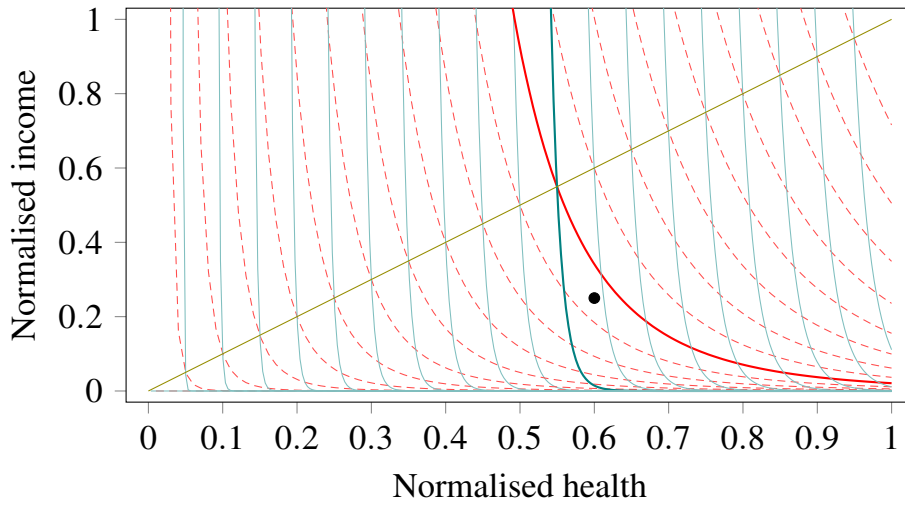
Preference type	Income	Health	Education
Young, lower educ	0.001	0.839	0.160
Young, higher educ	0.062	0.788	0.150
Older, lower educ	0.064	0.756	0.180
Older, higher educ	0.129	0.703	0.168
Representative agent	0.060	0.869	0.071
HDI approach	1/3	1/3	1/3
Income	1	0	0
Life satisfaction	-	-	-

Health, on the other hand, receives a very high weight. Again this squares with similar findings in the literature on health and SWB, for example those of Campbell et al. (1976) that health was rated by subjects in the US as the most important factor for happiness. Interestingly however, other studies on the statistical association between *objective* health and SWB have tended to find that the relationship is a relatively weak one (Brief et al., 1993).

Calculating the marginal rate of substitution between income and health under representative agent preferences using the weights in Table 3, an individual with mean attainment in income and health would be willing to give up £2,130 in equivalised household income to improve her health attainment by 1 point on the health scale. This improvement roughly equates to eliminating an average of one problem from the BHPS list of health problems: limbs, chest or breathing, heart or blood pressure, stomach or digestion, diabetes, migraines, or anxiety or depression. For comparison, in their critical study of willingness-to-pay as a measure of health state preferences, O'Brien and Viramontes (1994, Table 3) find a willingness-to-pay of C\$165 per month, or C\$1,980 per year, for a therapy offering healthy lung functioning for individuals with household income between C\$20,000 and C\$39,999. The review of willingness-to-pay and health-status by Reed Johnson et al. (1997) finds estimates ranging from \$1.18 per day, or \$430.70 per year, for a mild cough, to \$164.99 per day, or \$60,221.35 per year, for severe angina. Clearly there is wide a range of estimates in the health literature for a spectrum of health conditions and severities, and the estimate implied here by the preference index application to health falls in a very reasonable position within that range.

Note that the education coefficient for the young group is more relevant as a measure of the estimated education effect, since people tend to obtain educational qualifications when young, and so the direct effect of education is not confounded with the effect of income later in life which will tend to run in tandem. Again however, the caveat applies as to whether this can be interpreted as the value of the education itself or simply a positive collegiate experience.

**Figure 6: Indifference curves of an older higher educated individual (dashed indifference curves) and younger lower educated individual (solid indifference curves)**



**Table 4: Crosstabulation of different measures**

Quintiles of income	Quintiles of preference-sensitive measure				
	1	2	3	4	5
1	0.33	0.23	0.21	0.12	0.11
2	0.28	0.22	0.21	0.17	0.12
3	0.18	0.21	0.20	0.24	0.17
4	0.12	0.19	0.19	0.25	0.25
5	0.08	0.15	0.19	0.23	0.35

Figure 6 illustrates two groups of indifference curves – the older higher educated and the younger lower educated. To illustrate the point empirically that taking account of heterogeneous preferences is important when measuring well-being, consider an individual situated at the attainment bundle marked by the black circle. If this individual were an older higher educated person (with the dashed indifference curves), this would be a position of lower preference satisfaction than if the individual were a younger lower educated person (with the steeper, solid indifference curves) situated at the same bundle. In stark contrast to conventional measures of well-being, with the preference index it is possible that two individuals with identical attainment can have differing ideas about their degree of well-being.

To get a better idea of how the picture of well-being using the preference index measure corresponds with a number of other popular measures of welfare, some comparisons are presented in the following tables. Table 4 contains a cross-tabulation of quintiles

**Table 5: Average characteristics of the least well-off in 2008/9**

	Preference sensitive (1)	Representative agent (2)	HDI approach (3)	Income (4)	Life satisfaction* (5)
< 60% of median attainment (%)	19.3	22.0	12.1	12.1	3.1
Equivalised income (£)	16,536	17,269	10,903	6,507	17,480
Health (0-1 scale)	0.24	0.26	0.32	0.65	0.42
Life satisfaction (1-7)	4.72	4.76	4.71	5.09	1.62
Male (%)	36.0	36.6	35.0	37.4	40.0
Young (%)	10.0	11.0	11.2	30.7	24.4
Higher educated (%)	12.1	13.2	2.5	10.1	15.9
Urban (%)	71.4	70.7	72.2	69.3	73.6
Unemployed (%)	18.1	17.1	22.9	16.5	34.8

\* Median life satisfaction was 5, so figures are for those who responded 3 or lower.



of the preference index with quintiles of income as the sole well-being measure. It is immediately obvious on inspection of the diagonal that there is limited agreement between the two measures on the rankings of individual well-being positions. Table 5 expands the number of measures compared to include the homogeneous-preference “representative agent” index (2), the United Nations’ Human Development Index (HDI) measure (3), and the raw life satisfaction measure (5), focusing on the policy-relevant problem of identifying the least well-off. This is defined as those individuals with < 60% of median attainment according to each measure. Let those identified as least well-off according to the preference index measure be referred to as the ‘preference poor’.

In terms of dimension attainments, those identified as preference poor suffer from much worse health and somewhat lower life satisfaction than the solely income poor, whereas income does not seem to have such a bearing on preference-sensitive well-being since the preference poor have relatively high incomes. The preference index measure is more in line with the other multidimensional measures (2) and (3) and also with the raw satisfaction measure (5) though to a slightly lesser extent. Interestingly, all measures considered paint a similar socio-demographic picture of the average least well-off member of society – these tend to be older, lower educated female workers living in urban places. This is not to say that the measures necessarily identify the *same* individuals, only that the majority of individuals identified possess these similar characteristics.

## 5 Conclusion

The main objective of this paper was to formulate a multidimensional measure of well-being that is generalisable to other dimensions, useful from a policy perspective, and that reduces sacrifices in the representation of interpersonal preference heterogeneities. The end goal was not to prescribe a definitive well-being measure, nor to make definitive conclusions about quality of life. However, the empirical illustration did demonstrate some of the interesting analysis possibilities that the proposed approach provides.

First, the theoretical ‘equivalence approach’ (Pazner and Schmeidler, 1978; Fleurbaey and Maniquet, 2011) underpinning the proposed preference index was introduced, as well as how the preference index approach differs from other implementations of the equivalence approach. The preference index was then axiomatically presented, drawing from existing work in welfare economic theory and incorporating considerations of interpersonal heterogeneity, fairness in evaluating different situations, and dimension-wise correlations in the distribution of well-being. An empirical illustration was then presented of how the preference index approach could be implemented and used for types of analysis that traditional measures cannot offer. In the chosen method of operationalising the approach, generalised additive modelling was first used to flexibly model the relationships between life satisfaction and dimensions of well-being. This non-parametric model was then compared to a fully parametric CES model, and a parametric model allowing differing elasticities between dimensions. It was found that CES in fact gave the closest parametric representation of preferences between dimensions, meaning that the CES form of the preference index specification was not restrictive in

this case. The parameters of the resulting model pointed to a weighted geometric mean functional form. Interaction and individual fixed effects were further used to uncover the differing weights and therefore differing preferences between heterogeneous types of individuals, according to the equivalence approach.

A comparison of preferences was illustrated by separating individuals and their preferences according to age group and education level. Among other results, an interesting finding was that the older group had weaker preferences for health compared to the younger group. It was also shown how consideration of this kind of preference heterogeneity potentially changes our understanding of well-being in society compared with unidimensional measures such as income and SWB, and other composite measures. The preference index measure was able to reflect strong subjective preferences for good health across all individuals compared to relatively weak preferences for income. This was reflected in the wide disparity with income, compared to lesser disparities with the raw life satisfaction measure of SWB and other composite measures in terms of identification of the least well-off in society.

It is argued that this preference index approach, based on the work of Fleurbaey and others, is superior to its composite index predecessors because it is grounded in economic theory rather than using aggregation procedures for which there is no convincing theoretical basis. The main feature of the preference index measure illustrated in this paper is its ability to take account of preferences within the population over the various dimensions of life, while at the same time not losing some of the features of typical composite indices such as a normalised scale and mean-family functional form. These similarities with the simple aggregation methods of existing composite index measures have the advantage of familiarity to well-being measurement practitioners, whilst bringing an important advancement in theoretical basis.

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