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A Step towards Valuing Utility the Marginal and Cardinal Way

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Abstract
Income has a direct impact on our utility as well as an indirect impact through the goods, services and life events it allows us to purchase. The indirect effect of income is not properly accounted for in existing research that uses measures of cardinal utility for economic analysis. We propose a new approach for appropriately attributing the full effects of income on utility and we show the implications of our approach using a longitudinal dataset that contains reports of subjective wellbeing (SWB). We show that income has a much greater effect on SWB when indirect effects are considered. These results have important implications for how we value the marginal benefits of non-market goods and we explore some of these issues in the paper.

JEL Classifications: A10; D6; D61; H41; I31
Keywords: subjective well-being; utility; happiness; multicollinearity; income; non-market goods

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1. Introduction

Economists have a long tradition of seeking to value the impact of goods, services and life events on utility. Marginalist theory has now become the cornerstone of much of this activity; indeed, it forms the basis of how economists evaluate individual and firm-level behaviour, it is at the core of Paretian welfare economics, and it is a general framework for allocating scarce resources across the economy. Marginal utility is the basis of marginalist theory. The early work of Jevons, Menger and Walras essentially had its roots in the hedonic tradition of Bentham. Over time, and with the contributions of Pareto, Slutsky and Hicks, marginalist theory moved away from cardinal utility to an ordinal approach that focussed on marginal rates of substitution and revealed preferences.

Recent work in economics, however, is reverting back to a cardinal concept of utility, as proxied by reports of subjective wellbeing (SWB). The work by economists on this subject goes back to Easterlin (1974) but readers are pointed towards more recent reviews of the burgeoning literature by Clark et al (2008), Dolan et al (2008) and Stiglitz et al (2009). If we assume, as many economists are now doing (see (Blanchflower & Oswald, 2008)), that SWB can be used as a proxy for underlying utility, then it is possible to estimate the marginal utility derived from a range of goods, services and life events and, further, to derive monetary values for these things through the estimation of *income compensations* (ICs). The IC represents the change in income required to hold utility constant given a change in another good. ICs have recently been estimated for a variety of market and non-market goods, such as employment (Blanchflower & Oswald, 2004; Clark & Oswald, 2002), air pollution (Levinson, 2009; Luechinger, 2009) and health (Ferrer-i-Carbonell & van Praag, 2002; Groot & van den Brink, 2006).

A major limitation of this work is that the 'new cardinalists' have yet to arrive at a satisfactory theory of marginal utility. In particular, the current SWB literature has failed to fully capture and isolate the true marginal utility of the variables of interest. If the SWB framework is to be used in marginal analysis, we must have a robust theoretical framework upon which empirical estimates of the impact of different variables on utility can be built. To provide monetary values for non-monetary effects on utility (e.g. for use in economic appraisal and cost-benefit analysis), we must establish a robust 'exchange rate' between income and specific goods, services and life events. In this paper, we focus on the key methodological issue of unpicking the direct and indirect effects of income on SWB.

The main challenge here is to fully understand the complex and dynamic relationships between SWB, income and other variables. Specifically, the studies to date have failed to properly account for the indirect effects of income e.g. income will impact upon health status which will then impact upon on SWB, thus increasing the relative contribution of income to SWB. Therefore, SWB studies have derived biased estimates of the marginal effects of income on SWB, which has resulted in biased (and usually exaggerated) monetary values for a range of goods, services and life events.

Our *Step Approach* (SA) recognises both the direct and indirect effects of income on SWB. It uses a set of auxiliary regressions that control for the relationships between income and the other control variables. The derived coefficient on income then represents *both* the direct and indirect marginal effects on SWB.

Empirical support for the SA comes from analysis of the British Household Panel Survey (BHPS), which is one of the most widely used panel datasets for research into SWB. Our analysis shows that employment, local area safety, caring, and debt burden should have lower ICs than those reported in the literature to date and those that would be obtained without using the SA- and the differences can be quite large. Employment, for example, is 'worth' around £12,000 per month (over and above the wage) under the traditional approach, whereas it is valued at around £4,000 per month using the SA. The impact of income increases when its direct and indirect effects are accounted for, and this reduces the amount of income required to compensate for a change in the variable of interest.

The SA has significant implications for welfare economics and for policy appraisal. For nearly a century, marginal theory has assessed marginal changes in utility from preferences. We build on this tradition to show how marginal changes in utility can be proxied by SWB. Our approach also allows us to more accurately establish monetary values for changes in goods, services and life events. In so doing, our approach allows us to derive more accurate estimates of cardinal utility for policy appraisal and cost-benefit analysis. By appropriately accounting for the relationships between the various determinants of SWB and income, the SA ensures that the ICs will be a better approximation of the 'true' value of the impact on utility of goods, services and life events.

The rest of the paper is organised as follows. Section 2 describes the theoretical framework and how, in principle, ICs should be arrived at. Section 3 shows how the literature to date has provided biased (and usually inflated) ICs. Section 4 presents the new empirical methodology for capturing the direct and indirect effects of income on cardinal utility. Section 5 uses panel data to test the SA and shows that all goods or life events have much lower monetary values to those implied by the literature to date. Section 6 concludes by providing some recommendations about how the SA could be used in welfare analysis.

2. SWB, Cardinal Utility, and Income Compensations

Under the assumption that SWB can serve as an empirical approximation of individual utility, the SWB approach essentially uses econometric techniques to estimate the marginal impacts on utility of a host of determinants, including income, health status and employment status. Monetary values for these determinants can be estimated from the marginal rate of substitution between income and a given determinant, controlling for the other determinants of SWB (Clark and Oswald, 2002).

The SWB approach has gained prominence in recent years, as more data on SWB and its determinants have become available, and as problems with revealed preferences (derived from market data) and stated preferences (hypothetical valuation contingent on a market) have persisted (Frey & Stutzer, 2002). We do not explore the problems with preference-based approaches further here (interested readers are referred to Kahneman & Tversky (2000), Ariely et al (2003), Glaeser et al (2005) and Sugden (2005)), but suffice to say that the SWB approach has been seen by some economists to be a possible additional, or potentially, alternative way to value non-market goods (see (Dolan & Kahneman, 2008; Deaton et al, 2009), in the context of valuing health states).

In the SWB framework, the monetary value (IC) of a good (Z) can be expressed as the level of income required to hold utility constant in the absence of the good:

$$u(y, Z') = u(y + IC, Z^0) \qquad (1)$$

where y is income and Z^0 and Z' are respectively the situations before and after the good is endowed, provided or consumed. For a ‘bad’ the IC is negative. Assuming that SWB is a good proxy for cardinal utility, we can estimate (1) empirically using a SWB function:

$$SWB_{it} = \alpha + \beta_1 y_{it} + \beta_2 Z_{it} + \beta_3 X_{it} + \varepsilon_{it} \qquad (2)$$

where X is a vector of other determinants of SWB, such as age and marital status. (1) therefore becomes:

$$(\alpha + \beta_1 y_{it} + \beta_2 Z_{it}' + \beta_3 X_{it} + \varepsilon_{it}) = (\alpha + \beta_1 (y_{it} + IC) + \beta_2 Z_{it}^0 + \beta_3 X_{it} + \varepsilon_{it}) \qquad (3)$$

Re-arranging (3) the IC (or monetary value) of Z can be expressed as:

$$IC = \frac{\beta_2 (Z_{it}' - Z_{it}^0)}{\beta_1} \qquad (4)$$

It is relatively straightforward to show that the income compensations required for some goods are not constrained by own income; indeed, in some circumstances the IC can technically approach infinity. This is because in the wellbeing or life satisfaction approach to valuation, it is actual changes in people’s ‘utility’ that we monetise, rather than deriving values from people’s statements or revealed behaviours which are naturally constrained by their income budgets. (see the Appendix for the formal derivation of this). A large IC is therefore not immediately problematic. The problem with existing IC estimates, as stated in Section 1 and as we shall show in Section 3, is that they do not correctly estimate the marginal utility of income. When deriving estimates of the monetary values of different goods, services and life events, it is essential that we account for the indirect effects of income. We can simplify the SWB function in equation (2) as:

$$SWB = f(y, Z, X) \qquad (5)$$

The indirect effects of income need to be explicitly acknowledged, and so (5) becomes:

$$SWB = f[y, Z, X(y,)] \qquad (6)$$

Here the X variables are to some extent a function of income. In this case, the good, *Z*, is assumed to be exogenous. Set up in this way, (6) captures the direct and indirect effects of income on SWB.

We can transform (6) into its empirical counterpart and estimate the IC since, from (4), we know that the IC is derived as the ratio of the marginal utilities of the good (*Z*) and income. In its empirical form the SWB function in (6) is as follows:

$$SWB_{it} = \alpha + \beta_1 y_{it} + \beta_2 Z_{it} + \beta_3 X_{it}(y_{it}) + \varepsilon_{it} \qquad (7)$$

From this the marginal utility of the good is:

$$\partial SWB_{it} / \partial Z_{it} = \beta_2 \qquad (8)$$

And the marginal utility of income is:

$$\partial SWB_{it} / \partial y_{it} = \beta_1 + \beta_3 \cdot \partial X_{it} / \partial y_{it} \qquad (9)$$

The IC thus becomes:

$$IC = \frac{\beta_2 (Z_{it}' - Z_{it}^0)}{(\beta_1 + \beta_3 \cdot \partial X_{it} / \partial y_{it})} \qquad (10)$$

3. Problems with existing Income Compensations

The above problems related to the indirect effects of income are of course eradicated if all of the explanatory variables are instrumented or randomly assigned in the dataset, but this has never been the case in the literature to date. As highlighted in (7) we assume that some explanatory variables are endogenously determined (by income) within the model.

The failure to properly account for the indirect effects of income on SWB is likely to have caused the very high IC estimates quoted in the literature to date. For example, Clark and Oswald (2002) estimate the IC required for someone to move from employment to unemployment (i.e. the value of work) to be approximately £23,000 per month in addition to the loss of the wage. Powdthavee (2008) derives very large values for social involvement: using the British Household Panel Survey he finds that SWB is associated with greater frequency of interaction with friends, relatives, and neighbours, and derives an IC of £85,000 per year for moving from 'seeing friends or relatives less than once a month' to 'seeing friends or relatives on most days'. Levinson (2009) and Luechinger (2009) both find that the ICs from SWB are orders of magnitude greater than (revealed and stated preference) willingness to pay values for environmental goods. Part of the reason for any divergence between preference-based methods and the SWB approach will be due to the fact that the indirect effects of income are more likely to be captured in preference methods. In stated preference surveys, well-informed respondents will state a value of a good based on the opportunity cost of the money foregone, ie, the consumption (indirect effects of income) they forego to pay for the good being surveyed. In revealed preference approaches house prices, for example, will also be determined by the opportunity cost of foregone consumption and so values for environmental amenities and other goods based on house price differentials will incorporate the indirect value of income to individuals. See the Appendix for a tabulation of all the main studies that derive values using SWB.

The large ICs are generally due to the fact that income has been shown to have a small effect on SWB (Carroll et al , 2009; Ferreira & Moro, 2009; Groot & van den Brink, 2006; Helliwell & Huang, 2005; Luechinger, 2009; Welsch, 2008b). In SWB regressions, income is usually proxied by the level of individual or family income. Income has an instrumental value in that it provides people with the ability to purchase goods, services and life events that increase their utility. If we control for many of the things that are 'purchased' by income, we strip out the instrumental value of income. The result is that the coefficient on income will be an underestimate of its true value and ICs will be overestimated.

This is essentially the problem of *bad control*, where variables of interest cannot have their full indirect effects (Angrist & Pischke, 2009). Consider the simplified SWB function in (2):

$$SWB_{it} = \alpha + \beta_1 y_{it} + \beta_2 X_{it} + \varepsilon_{it} \qquad (2)$$

Where, for ease of exposition, SWB is a function of income and *one* other variable X_{it}. The coefficient on income can be described as a function of sample variances and co-variances:

$$\beta_1 = \frac{\text{cov}(SWB, y)Var(X) - \text{cov}(y, X)\text{cov}(SWB, X)}{Var(y)Var(X) - \text{cov}(y, X)^2} \qquad (11)$$

Dividing through by *Var(X)*, we derive:

$$\beta_1 = \frac{\text{cov}(SWB, y) - \beta_{yX}\ \text{cov}(SWB, X)}{Var(y) - \beta_{yX}\ \text{cov}(y, X)} \qquad (12)$$

where β_{yX} is the regression coefficient obtained from regressing y_{it} on X_{it} in an auxiliary regression. If there is no relationship between y_{it} and X_{it}, then β_{yX} = 0 and we arrive back at the standard unbiased OLS estimator:

$$\beta_1 = \frac{\text{cov}(SWB, y)}{Var(y)} \qquad (13)$$

Our proposition is that income has a causal effect on the other determinants of SWB (e.g. health, Ettner (1996)) hence $\beta_{yX} \neq 0$; $\text{cov}(SWB, X) \neq 0$; $\text{cov}(y, X) \neq 0$, which as we can see from (12) clearly impacts on the estimate of the income coefficient (β_1) that we derive from OLS. In this case, we would like to include these effects in our estimate of the marginal utility of income, rather than have them excluded from the income coefficient as per (12) and the SA allows us to do this.

The literature has been remarkably silent on this matter. One exception is Ferrer-i-Carbonell and van Praag (2002), who acknowledge that income has indirect effects on SWB and, in estimating the IC for different health states using the German Socio-Economic Panel, assume that income impacts upon SWB through its effects on a set of domain satisfactions, including leisure, housing and job satisfaction. This approach does not, however, provide a full solution for two main reasons. First, income is excluded from the final SWB function and thus loses any direct value it may have in terms of status effects, erroneously reducing the impact of income on SWB. Second, the final SWB function does not include controls for many of the explanatory variables that have been shown to impact on SWB, such as age and marital status, thus biasing the model.

4. A New Framework for the Wellbeing Function

Without the option of fully instrumenting all explanatory variables in the model, we therefore need a framework that accounts for the direct and indirect effects of income. The SA seeks to do this. We have demonstrated that wellbeing can be defined using equation (6). Our approach can be used for valuing both exogenously and endogenously determined goods. We focus on the latter case here and assume that income is exogenous in the model and define SWB as:

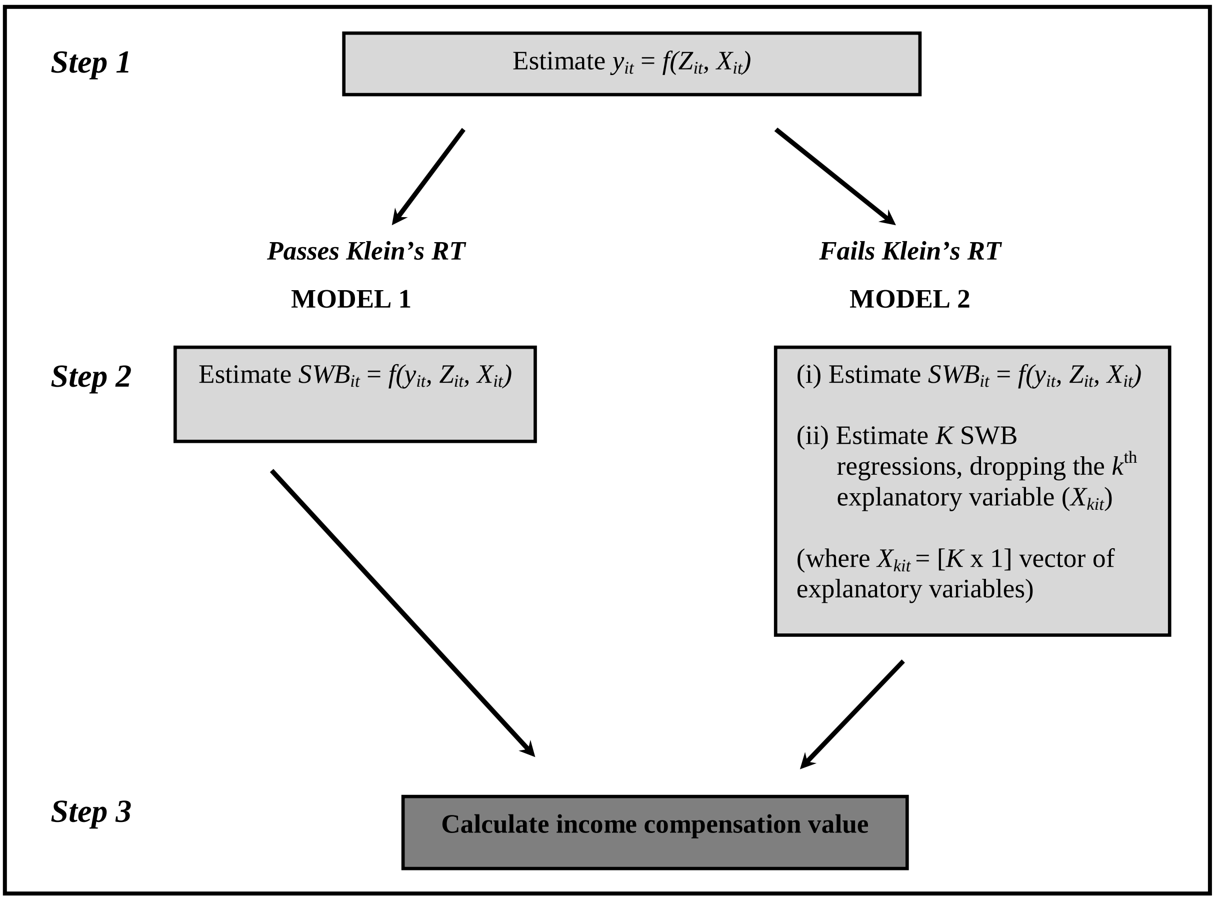
$$SWB = f[y, Z(y), X(y)] \qquad (14)$$

This derives the following IC for the estimated good (Z):

$$IC = \frac{\beta_2}{(\beta_1 + \beta_2 . \partial Z_{it} / \partial y_{it} + \beta_3 . \partial X_{it} / \partial y_{it})} \qquad (15)$$

We estimate (14) and (15) using the SA, whereby at different stages we control for $\partial X_{it} / \partial y_{it}$ and $\partial Z_{it} / \partial y_{it}$ in the coefficient on income, which makes the calculation of the IC in (15) simpler. This will ensure that the income coefficient represents the full direct and indirect instrumental value of income. We can then derive more accurate IC estimates for any good. The stages in the SA are summarised in Figure 1.

Figure 1: Decision process for estimating income compensations in the Step Approach



Step 1

The income coefficient should include the instrumental value of income to the individual. In *Step 1* we test for the existence of possible indirect effects by using *auxiliary regression* techniques that are often employed in empirical work to detect multicollinearity. The presence of indirect effects is essentially an issue of multicollinearity as the control variables will be correlated with income. In auxiliary regressions, the independent variables in a given function are regressed on each other to evaluate the relationships and correlations between the control variables. There is no strict test for multi-collinearity, but if the auxiliary model fails *Klein's Rule of Thumb* (when the R^2 in the auxiliary regression is larger than the R^2 in the original main regression (Gujarati, 2003)) then the regressand can be assumed to be collinear with the other explanatory variables and is usually dropped (Griffiths et al, 1993; Gujarati, 2003).

Rather than drop the correlated variable in question (here income), in *Step 2* we adapt the procedure to filter out the correlations. Klein's Rule of Thumb provides a test as to whether the specified SWB function is controlling for the potentially important indirect effects of income. In essence, the test tells us whether the magnitudes of β_{yX} and $\text{cov}(y, X)$ are large enough to result in the estimate of β_1 in (12) excluding many of the important indirect effects of income on SWB.

Step 2

Here, we regress SWB on income, the estimated good and the explanatory variables – as determined in *Step 1* **–** to derive the marginal utilities of these variables. The procedures from *Step 1* derive two possible estimation techniques for the SWB function depending on the level of correlation between income and the explanatory variables.

MODEL 1 is the model that is used as standard practice in the SWB literature as depicted in equation (12). Figure 1 suggests that to use **MODEL 1** there should be no correlations between income and the explanatory variables, which is a bold assumption to make.

If the auxiliary regression in *Step 1* fails Klein's Rule of Thumb, we assume that income is correlated with the other control variables. **MODEL 2** ensures that the full effects of income are captured. Here we first estimate a standard SWB function in (i) to derive the direct effects of income. Then in (ii) we estimate *K*+1 SWB regressions (one for each explanatory variable plus one for the variable of interest (Z)), where in turn we drop one of the control variables from the regressions. Dropping those control variables through which income has an indirect effect on SWB will result in an increase in the power of the income coefficient. In effect, this Step adds the relationships β_{yX}, $\text{cov}(SWB, X)$ and $\text{cov}(y, X)$ to the income coefficient β_1 in (12). Variables that in theory should not be affected by income (i.e. those variables with $\beta_{yX} \neq 0$ - for example age) and those that do not impact on SWB are not included in *Step 2.*

Aggregating the changes in the income coefficient for all *K*+1 specifications of the SWB function in (ii) provides an estimate of the *total* indirect effect of income on SWB. This method is preferred to estimating *K*+1 different regressions for each control variable (ie, a health function and a marriage function etc) because (a) it does not force any parametric restrictions on the effect of income on the other controls and the subsequent effect on well-being, and (b) it keeps the method simple as the full estimation process can be undertaken using only the variables from the original SWB function.

Step 3

The coefficients (i.e. marginal utilities) derived in the models are used to estimate the value or income compensation for any good. In **MODEL 1** there is no effect of income on the other control variables so we estimate the IC value using the coefficients on income and the good from a single SWB function, as is the current practice in the literature.

In **MODEL 2** there is a causal effect of income on the other control variables and we include this indirect effect in the coefficient on income. To do this, we add the total indirect effect from (ii) to the direct effect from (i). Referring back to the IC calculation in (15), through the SA, we essentially incorporate the impacts of $\beta_2 . \partial Z_{it} / \partial y_{it}$ and $\beta_3 . \partial X_{it} / \partial y_{it}$ in the coefficient on income. This makes the calculation of the IC in (15) more manageable as it reduces to:

$$IC = \frac{\beta_2}{\beta_1 *} \qquad (16)$$

This is the same as the standard IC calculation in (4), but the asterisked income coefficient (β_1*) incorporates the full direct and indirect effects of income. As stated above, β_1* is estimated by adding the income coefficient from (i) - which represents the direct effects, to the aggregated indirect effects of income from (ii).

Based on the SWB function in (14) and the IC estimate in (16), we have retained the full instrumental value of income. This has been done by re-assigning any impact of the control variables that should be accredited to income, thus allowing us to capture more precise estimates of the marginal utility of income and the resulting ICs.

5. Empirical Estimation

We test the SA using data from the BHPS. This is a nationally representative sample of British households, containing over 10,000 adult individuals, conducted between September and December of each year from 1991. Respondents are interviewed in successive waves, and all adult members of a household are interviewed. The sample has remained representative of the British population since the mid-1990s. We restrict our sample to 16 – 65 year olds and exclude full-time students, retirees and those unable to work due to disability. In the empirical analysis, we use the log of household equalised income. The SWB measure that we use is the life satisfaction question that has been well established in the field: *"How disatisfied or satisfied are you with your life overall?"*. Responses are on a scale from 1 (not at all satisfied) to 7 (completely satisfied). Life satisfaction was added in 1997 and so we analyse the period 1997-2009, excluding 2000 which did not include health status and 2001 which did not include life satisfaction.

We derive income compensations for: (i) Employment; (ii) Living in a safe area; (iii) Caring duties at home and (iv) Burdened with debt. Throughout we calculate ICs based on i) the standard method as set out in equations (1) to (4), and ii) the SA. In the model, we compare employed and self-employed to unemployed people. 'Living in a safe area' indicates whether the respondent feels that they live in an area where vandalism and crime are not a problem. 'Caring duties at home' signifies that the respondent looks after someone living with them who is sick, handicapped or elderly. Finally, we classify those 'Burdened with debt' as respondents who state that debt and interest repayments on loans are a financial burden on their household. Descriptive statistics of the variables are set out in Table 1.

We use equation (2) to estimate a general SWB function. We assume the existence of time-invariant unobserved determinants (λ_i) of wellbeing:

$$SWB_{it} = \alpha + \beta_1 y_{it} + \beta_2 Z_{it} + \beta_3 X_{it} + \lambda_i + \varepsilon_{it} \qquad (17)$$

We include the main explanatory variables that have been found to be important determinants of SWB in the literature (Blanchflower and Oswald, 2004; Dolan et al, 2008). Ferrer-i-Carbonell and Frijters (2004) show that assuming cardinality as opposed to ordinality for the SWB variable makes no difference to estimation results, and that allowing for fixed effects does change results substantially. Our preferred model is therefore an OLS regression with fixed effects. The results of this model are shown in Table 2. We also present a random effects model for information, but focus on the results of the fixed effects model. The coefficient on log of household income (β_1) is statistically significant at the 1% level and is estimated to be 0.03 in the fixed effects model.

Step 1

In Table 3 the following model, which we call the *income model* is estimated empirically:

$y_{it} = f(Z_{it}, X_{it})$

The overall R^2 of the income model (0.17) is far greater than the overall R^2 of the SWB function (0.08). Employing Klein's Rule of Thumb, this suggests that multi-collinearity with respect to income is a notable problem in the SWB function. The income coefficient derived in Table 2 is thus not a true measure of the marginal value of income because many of the indirect effects of income will be controlled for.

To motivate the discussion below, we first estimate a simple univariate equation; regressing SWB only on income for our sample:

$$SWB_{it} = \alpha + \beta_1 y_{it} + \varepsilon_{it} \qquad (18)$$

Since no other control variable is included in the model, β_1 will include all indirect effects of income on SWB. The regression in (18) will of course suffer from omitted variable bias and so will not represent the true value of income, but instead it will provide an upper-bound estimate of the coefficient on income. Estimating (18) we find that β_1 = 0.09 and that it is statistically significant at the 1% level. When we measure the direct and indirect effects of income in *Step 2*, we expect the income coefficient to lie somewhere between 0.03 and 0.09.

Step 2

The income model fails Klein's Rule of Thumb, which means that to derive IC values for (i) Employment; (ii) Living in a safe area; (iii) Caring duties at home and (v) Burdened with debt, it is necessary to use **MODEL 2.** We have already estimated part (i) of **MODEL 2** in Table 2**.** Table 4 sets out the results of part (ii) of **MODEL 2.** The two age variables and employment status are not dropped in the regressions because income cannot affect age and it is unlikely to affect employment status. Similarly, education is not dropped because current income is unlikely to affect levels of educational attainment [1]. For categorical variables (i.e., health status and marital status) we drop all related variables together. Therefore we estimate a total of five

[1] It should be noted that we keep education and employment status in the *income model* (*Step 2*) because we cannot fully rule out an effect of income on these variables.

regressions to derive the indirect effects of income. We report the income coefficient for each of these five SWB regressions in Table 4.

We find that income has a positive indirect impact on SWB through marital status and debt burden and there are small effects on SWB through living in a safe area and having caring duties. The indirect impact via health is negative, suggesting that increased income worsens health. Another possible explanation is that our health variable is not a full measure of health status and so any positive effects of income on health are already being picked up in the income coefficient.

The overall impact of dropping each of the variables is an increase in the income coefficient by 0.011. This is the aggregate indirect effect of income and is added to the direct effect income coefficient of 0.03 from regression (i) in Table 2. On including the indirect effects, the income coefficient increases by 40 per cent: we estimate that $\beta_1* = 0.041$. This result is consistent with our prediction that the income coefficient should lie between 0.03 and 0.09. The income coefficient of 0.041 is the value that will be used in the IC calculations in *Step 3.*

Step 3

We estimate IC values for (i) Employment; (ii) Living in a safe area; (iii) Caring duties at home and (iv) Burdened with debt using the Standard SWB approach and the SA. In Table 5, column (1) lists the coefficients used in the Standard approach and column (2) derives the IC estimates based on those coefficients. Columns (3) and (4) do the same for the SA. In the SA we use the coefficient on income from **MODEL 2** ($\beta_1* = 0.041$). All valuations/ICs are in UK £ per month figures.

The IC estimates derived using the Standard approach (column 2) all tend to be large. Our results using the Standard approach resonate the general finding in the literature; that ICs can be very high. Using the SA the overall trend is that IC valuations are significantly reduced; on average IC values fall by over 50 per cent. A key issue to note here is that although there is a general trend in the SWB literature that IC valuations are high, there is considerable variation in the coefficient estimates due to the use of different functional forms and datasets. Therefore, we do not seek to directly compare our results on variable coefficients to other papers but, rather, to show how using the SA changes the IC results for some key variables of interest: employment, living in a safe area, caring and debt.

First, consider employment. The employed in our sample are made up of full and part-time employees and self-employed. The comparison group for the employed is the unemployed. The IC estimate derived from the Standard approach is £12,000 p.m, which is considerably lower than Clark and Oswald's (2002) estimate of £23,000 p.m. As income is held constant and leisure time forgone is not held constant, the IC for employment is the net value of employment – it is the value of being in work over and above the wage income and the loss in leisure time. Using the SA we estimate the value of employment to be around £6,000 per month. The sample mean salary is around £17,300 per year.

Second, consider living in a safe area. We find that living in a safe area is valued at around £16,000 per year. This is an interesting finding, in that in our model we do not control for house prices. Those living in dangerous areas should therefore be benefitting from lower house prices and rents which should offset the adverse wellbeing impact of living in an unsafe neighbourhood. The value of living in a safe area that we estimate is therefore the value of this amenity over and above what is already captured in house prices. This is evidence of imperfections in the housing market and a strong argument for not using hedonic market (revealed preference) studies to value amenities such as safety – i.e. revealed preferences do not actually include the actual suffering caused by living in an unsafe area. Using revealed preference methods, Gibbons and Machin (2008) find that a one standard deviation decrease in the incidence of crime has a capitalised value of around £20,000 in London at year 2000 prices.

In separate analysis, which we do not show here, we estimated the value of living in a safe area for the sub-sample that lives in London and the surrounding Southeast area of England (a sample of London on its own was too small to provide statistically significant results) to be about £23,000 per annum (this would be in addition to the housing premium derived by Gibbons and Machin (2010)).

Third, consider providing residential care. There is a cost or burden to providing care at home for relatives. Under the Standard approach this cost is around £24,000 per month. Using the SA, the cost of caring is about £10,000 per month. This is still high because the caring coefficient will also include the negative effect of a family member being sick or disabled in addition to the task of caring itself.

Fourth, consider debt. We find that perceiving to be heavily burdened with debt has a negative impact on individual wellbeing. Under the standard approach this impact equates to a cost of about £37,000 per month. Using the SA, the cost of debt burden is about £14,000 per month. To put this in to some context, the average amount of debt in the UK (including mortgage loans) stands at around £53,000 per household. We have shown that there is a non-financial emotional or welfare loss to people who experience high levels of debt.

6. Conclusion

Measures of subjective wellbeing (SWB) are increasingly being used in economics. A key objective of this work is to derive monetary values for goods, services and life events. The success of this work will depend on having a robust estimate of the marginal impact of income on wellbeing so that marginal rates of substitution between income and the good in question can be estimated. The literature thus far has failed to take account of the indirect effects of income on wellbeing, thus resulting in implausibly high monetary value estimates for such things as employment and environmental amenities.

The SA proposed in this paper develops our ability to use cardinal utility for marginal analysis by allowing economists to estimate the full direct and indirect effects of income on SWB. In so doing, the approach provides a robust method for calculating the monetary value of any good, service or life event for use in cost-benefit analysis. The monetary value is expressed as the income compensation required to hold well-being constant for a change in the good in question. Income compensations estimated in this way allow us to reconnect economic appraisal with the foundations of utility theory – the utility derived from any state of the world. The approach developed here can be used by economists and policy-makers as a useful alternative way to estimate monetary values that do not rely on revealed or stated preferences.

Using the SA, we find that the income compensations for a range of non-market goods and life events fall substantially to arguably more plausible levels compared to the literature to date and the standard estimation approach. For example, the value placed on employment falls from around £12,000 per month to £6,000 per month and the cost of the burden of being in debt falls from around £37,000 per month to about £14,000 per month when using the SA. We feel that this represents a significant step towards using the SWB approach to valuation in a meaningful way in cost-benefit analysis and policy evaluation.

This is only the beginning, of course, and we need apply the SA to other datasets, with different variables and, particularly different measures of well-being (Kahneman and Riis, 2005; Dolan and Kahneman, 2008). Nonetheless, the Step Approach represents an important step towards valuing utility the marginal and cardinal way.

Table 1. Descriptive statistics

Variables	Descriptions	Mean	Std. Dev.
Life satisfaction	Life satisfaction score, coded on a seven-point scale so that 1 = very dissatisfied, 7 = completely satisfied	5.19	1.19
Annual household income	Annual equivalised gross household income	£28,121	£20,707
Employed	Employment status (Employed or Self-employed = 1)	0.78	0.41
Age	Age of respondent	38.93	12.02
High education	Educational attainment (Degree (undergraduate or Post-graduate) attained = 1)	0.16	0.37
Excellent/good health	Respondent assesses own health as 'excellent' or 'good'	0.76	0.43
Poor health	Respondent assesses own health as 'poor' or ' very poor'	0.06	0.23
Married	Marital status (Married = 1)	0.56	0.5
Divorced	Marital status (Divorced = 1)	0.05	0.23
Widowed	Marital status (Widowed = 1)	0.01	0.1
Separated	Marital status (Separated = 1)	0.02	0.14
Never married	Marital status (Never married = 1)	0.2	0.4
Caring duties at home	Respondent has caring duties at home	0.05	0.22
Living in safe area	Respondent does not live in an area where they perceive vandalism and crime to be a problem	0.83	0.38
Burdened with debt	Repayment of debt and associated interest is a 'heavy burden' or 'somewhat of a burden'	0.14	0.35

Table 2. SWB regressions

Dependent variable: Life satisfaction	Fixed effects		Random effects	
	Coefficient	S.E.	Coefficient	S.E.
Ln (Household income)	0.030***	0.008	0.050***	0.006
Employed	0.069***	0.012	0.109***	0.011
Age	-0.045***	0.004	-0.058***	0.003
Age^2	0.001***	0.000	0.001***	0.000
High education	0.078*	0.043	-0.030*	0.018
Excellent/good health vs. fair health	0.263***	0.010	0.360***	0.009
Poor health vs. fair health	-0.299***	0.017	-0.363***	0.016
Base case: Co-habiting couple				
Married	-0.020	0.017	0.062***	0.014
Divorced	-0.200***	0.029	-.0287***	0.023
Widowed	-0.404***	0.063	-0.331***	0.047
Separated	-0.416***	0.032	-0.463***	0.028
Never married	-0.179***	0.020	-0.238***	0.015
Caring duties at home	-0.088***	0.023	-0.122***	0.019
Living in safe area	0.029***	0.010	0.072***	0.009
Burdened with debt	-0.101***	0.011	-0.153***	0.010

Constant	5.73***	0.109	5.45***	0.083
N	18,276		18,276	
Overall R^2	0.08		0.12	

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively. ***Employed*** are compared with unemployed. ***Good health*** *and* ***Poor health*** are derived from the respondent's assessment of their health of the past year. ***High education*** indicates that the respondent has a university degree. All other variables are described in Section 5.1.

Table 3. *Step 1*: Income Model

Dependent variable: Ln (Household income)	**Coefficient**	**S.E.**
Employed	0.338***	0.006
High education	0.231***	0.022
Excellent/good health vs. fair health	-0.012**	0.005
Poor health vs. fair health	0.004	0.009
Base case: Co-habiting couple		
Married	0.0340	0.009
Divorced	-0.093***	0.014
Widowed	-0.108***	0.032
Separated	-0.164***	0.016
Never married	-0.234***	0.010
Caring duties at home	0.0254**	0.011
Living in safe area	0.017***	0.005
Burdened with debt	-0.033***	0.006
Constant	9.779***	0.011
Overall R^2	0.17	

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively.

Table 4. *Step 2*: Model 2

Variable dropped	**Income coefficient (β_1)**	**Change in income coefficient**
Health	0.0283	-0.0017
Marital status	0.0414	0.0114
Caring duties at home	0.0301	0.0001
Living in safe area	0.0301	0.0001
Burdened with debt	0.0307	0.0007
	Total indirect effect	**0.011**

Table 5. Comparison of Income Compensation estimates

	Standard LS approach		Step Approach	
	(1) Variable coefficient	(2) Income compensation (£ per month)	(3) Variable coefficient	(4) Income compensation (£ per month)
Ln Household income	*0.030****	N/A	*0.041****	N/A
Employment	*0.069****	£12,020	*0.069****	£5,800
Living in a safe area	*0.029****	£2,210	*0.029****	£1,370
Caring duties at home	*-0.088****	-£24,080	*-0.088****	-£10,000
Burdened with debt	*-0.100****	-£36,460	*-0.100****	-£14,000

Notes: ***, **, * represent significance at the 1%, 5% and 10% levels respectively. IC estimates are based on an average annual income of £16,000.

Appendix

A1. Proof that Income Compensations are not constrained by income

Assume that there is a non-excludable public good and that its provision is funded through taxation (the example and proofs also generalise to excludable private goods as commented on below but we focus on non-excludable public goods for ease of exposition). Under the theory of the efficient provision of public goods (Samuelson, 1955), tax becomes a parameter in the individual's utility-maximisation process:

$$\max_{x_i, z} u_i(x_i, Z) \qquad (A1)$$

$$s.t. \; px_i + t_i Z = y_i \qquad (A2)$$

$$where \quad u_z > 0; \; u_{zz} < 0 \qquad \forall Z$$

Here Z = the public good and t_i = tax paid by i (essentially the price of the public good). The standard results are attained. At the optimum:

$$MRS_{xZ} = u_Z^i / u_x^i = t_i \qquad (A3)$$

$$MRS_{Zx} = u_x^i / u_Z^i = p \qquad (A4)$$

Without any loss of generality, assume that x is a composite good and thus we can set $p = 1$. MRS_{xZ} then becomes $\partial u_i / \partial Z$ or u_Z^i which is simply the willingness to pay (WTP) for an increase in public good provision. Since the public good is non-excludable, obtaining an efficient allocation of public good provision requires that we sum the MRSs across individuals. In a two person economy the efficiency requirement is therefore:

$$MRS_{xZ}^i + MRS_{xZ}^{-i} = MRT_{xZ} \qquad (A5)$$

$$\Rightarrow u_Z^i + u_Z^{-i} = C \qquad (A6)$$

$$\Rightarrow t_i + t_{-i} = C \qquad (A7)$$

where C is the marginal cost of providing the public good. At the efficient level of public good provision (Z*), it is possible that $MRS^{i} \neq MRS^{-i}$ (this is different to the case for private goods, where at the optimum MRSs are equal across all individuals). From (*A3*), it is therefore possible that $t_i \neq t_{-i}$. The amount an individual pays in tax towards the public good is constrained by her income.

The efficient level of the public good (Z*) can be derived through a Lindahl equilibrium so that people pay a tax rate equal to their WTP for the *total level* of public good provision. This tax rate can differ between individuals. The Lindahl equilibrium requires that people are honest in their revelations of WTP for the public good (Mas-Colell, Whinston, & Green, 1995). Since the amount that individuals *can* pay (in taxation) is constrained by their incomes and a public good is provided up to the point when (*A5*) holds, and since $u_z > 0;\ u_{zz} < 0 \quad \forall Z$, an individual can make a small contribution to the public good but reap large benefits if others' WTPs are such that a large amount of the public good is provided. This is essentially the issue of cross-subsidisation in public goods and it would also be the case for goods provided under private insurance schemes in which cross-subsidisation occurs. It is possible, therefore, for the individual level IC required for a policy intervention to greatly exceed own income. We formalise this in *Proposition 1*.

Proposition 1. Suppose that $y \in [o,\infty)$ *and that society's willingness to pay for the non-excludable public good (Z) is such that* $\exists c(Z)$ *such that* $\sum MRS^{i}_{xZ} > c(Z)\ \forall Z$ *and that* $u^{i}_{Z} > 0;\ u^{i}_{ZZ} < 0$. *Then the level of IC is not constrained or upper-bounded.*

Proof 1.1. First we show that the level of IC can be greater than own income. Assume that $IC^{i}_{Z} \leq y_i$. *Since* $y \in [o,\infty)$ *and* $\sum MRS^{i}_{xZ} > c(Z)\ \forall Z$ *this implies that* $Z^{*} \in [0,\infty)$. *As* $u^{i}_{Z} > 0;\ u^{i}_{ZZ} < 0$ *however, then to ensure that* $IC^{i}_{Z^{*}} \leq y_i$ *it would imply that* $\exists K$ such that $Z^{*} \leq K$, *where K is some constraint on the level of public goods provided. But we know that* $Z^{*} \in [0,\infty)$ *and so* $\neg(IC^{i}_{Z} \leq y_i)$ *which implies (in this situation) that*
$IC^{i}_{Z} > y_i$ ■

Proof 1.2. Under some conditions the level of IC can approach infinity. Since $y \in [o,\infty)$ *and* $\exists c(Z)$ *such that* $\sum MRS^i_{xZ} > c(Z)$ $\forall Z$ *this implies that* $Z^* \in [0,\infty)$. *As* $u^i_Z > 0$; $u^i_{ZZ} < 0$, *then* $\underset{Z^* \to \infty}{Lim}\ IC_i(Z^*) = \infty$. ■

Table A1. Summary Table of the main income compensation studies

Author(s)	Country	Good evaluated	Income Compensation value
Blanchflower and Oswald (2004)	USA and UK	Various	Unemployment: $60,000 per annum
Carroll et al. (2009)	Australia	Droughts and some other life events	Drought (in Spring time) A$18,000 (deemed very large); Marriage A$67,000 p.a.; employment A$72,000 p.a.
Clark and Oswald (2002)	UK	Various	All ICs in per month values. Employment to unemployment: -£15,000 (GHQ) and -£23,000 (SWB); Health excellent to health good: -£10,000 (GHQ), -£12,000(SWB); Health excellent to health fair: -£32,000 (GHQ), -£41,000 (SWB).
Cohen (2008)	USA	Crime and Health	Crime: $49 p.a. for 10% increase in crime rates. IC for burglary is high compared to estimates of cost of burglary. Health: Good health to fair health: $161,060 pa.; Good health to poor health: $276,624 p.a.
Deaton et al. (2008)	Africa	Value of life	Small IC estimates for the value of life
Di Tella et al (2003)	USA and Europe	Various	ICs estimated for Macro-level unemployment and inflation
Dolan and Metcalfe (2008)	UK	Urban regeneration	Regeneration: £6,400 (instrumenting for income) - £19,000 (not instrumenting for income).
Ferrer-i-Carbonell and van Praag (2002)	Germany	Chronic diseases	Examples: IC of 59% of income for diabetes; 43% for arthritis; 18% for hearing problems
Ferriera and Moro (2009)	Ireland	Air quality and climate	Air pollution: €945 per microgram per cubic meter of PM10 (5% improvement from average) Climate: €15,585 for 1c temperature increase in Jan and €5,759 for 1c temperature increase in July.

Frey et al (2004b)	Paris, London, Northern Ireland	Terrorism	IC of 14% - 41% of income to reduce terrorist activity to lower levels (as experienced in other parts of the country).
Groot and van den Brink (2006)	UK	Cardiovascular disease	IC for heart disease: Average £49,564 (men) and £17,503 (women). £93,532 for 25 year old man and £1,808 for 75 year old man.
Helliwell and Huang (2005)	USA	Non-financial job characteristics	1 point fall in job satisfaction (on a 10 point scale) has IC of $30,000 - $55,000 p.a.
Levinson (2009)	USA	Air quality	$464 p.a. per microgram per cubic of PM10. The IC value is larger than for hedonic method.
Luechinger (2009)	Germany	Air quality	IC of €183-€313 for a 1 microgram per cubic meter reduction of SO_2. Compared to €6-€34 using a revealed preference method.
Luechinger and Raschky (2009)	Europe	Flooding	Prevention of flood: $6,500; Decrease of annual flood probability by its mean $190. This is similar to compensation found in Hedonic markets
Mackerron and Mourato (2009)	UK	Air quality in London	IC for 1% increase in NO_2 levels is 5.3% of income. Deemed unrealistically high compared to stated and revealed preference studies.
Oswald and Powdthavee (2008)	UK	Death of family members	Loss of mother: £20,000 p.a. (£10,000 with income instrumented); Loss of child: £41,000 p.a. (£34,000 with income instrumented); Loss of partner: £64,000 p.a. (£36,000 with income instrumented).
Powdthavee (2008)	UK	Social relationships	IC for seeing friends and relatives less than once a month to never £63,000; Marriage: £68,000 p.a.; Move from very poor health to excellent health £300,000; Unemployed £74,000 p.a. in addition to the wage.
Rehdanz and Maddison (2005)	Multi-country panel	Climate	List of ICs for 67 countries estimated
Stutzer and Frey(2005)	Germany	Commuting	Commute of 23 mins (sample mean): €242 p.m. (18.9% of average monthly wage).
van den Berg and Ferrer-i-Carbonell (2007)	Holland	Informal care	Caring: €8-€9 Euro per hour if recipient is family member. €7-€9 Euro per hour is recipient is not family member.
van Praag and Baarsma (2005)	Holland	Airport noise	IC for noise generated per flight of €253.

Welsch (2002)	Cross-country	Air pollution	IC of $70 per kiloton of nitrogen dioxide per capita.
Welsch (2006)	10 European countries	Air pollution	Reduction of total suspended particles $13-$211 p.a. per microgram per cubic meter. Comparable to values obtained from US property value models.
Welsch (2007)	International - 54 countries	Air pollution	IC in range of 'few hundred US dollars' per ton nitrogen dioxide for direct effect. The indirect pecuniary effect of air pollution on SWB is positive as it is an input to production, but it is smaller than the direct effect in absolute terms.
Welsch (2008a)	International - 21 countries with history of conflict	Civil conflict	IC around $108,000 per fatality due to conflict.
Welsch (2008b)	International	Corruption	1 point index increase in corruption on Transparency International 1-10 point scale (which is a relatively large change) has an IC of $900 per capita per year (including indirect pecuniary effects).

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