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Abstract: This paper uses life satisfaction data to calculate the extent to which individuals are willing to trade money for improvements in their health status. Using a large nationally representative survey in the UK, I show that the amount of extra equivalent household income to make someone with a health condition, as well off in terms of life satisfaction as someone without the health condition, ranges from a low of £4,235 per annum for impairments associated with asthma to a high of £31,283 for impairments associated with congestive heart failure. These values could be used as a basis for a cost-benefit analysis of health care interventions aimed at the medical conditions examined. Relative to previous work, I address a number of critical empirical challenges when it comes to using this compensating income variation approach for determining the monetary value of a health improvement. First, I address the issue of income endogeneity in life satisaction by instrumenting income with the educational status of respondents' parents. Second I control for the potentially confounding role of personality differences by including a measure of the Big Five personality traits in the micro-econometric analysis of life satisfaction.

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1. Introduction

Faced with ever increasing costs, policymakers need to make informed decisions about which types of health care interventions should be prioritised over others. In addition to considering the costs of such interventions, decision making about the allocation of resources in the health domain requires information about the value attached to health improvements. When it comes to assessing the value of health care interventions, there are a number of different economic methodologies used. The simpliest method commonly employed is cost-effectiveness analysis as the benefits are measured as a single unidimensional outcome, e.g. cases prevented, conditions diagnosed or life years gained. An important limitation is that this unidimensional approach may mean that other potentially important outcomes are ignored. In comparison to cost effectiveness analysis (CEA), cost utility analysis (CUA) considers a broader measure of health related outcomes such as quality adjusted life years (QALYs). QALYs are a generic measure of disease burden which reflects both the quality as well as quantity of life saved. The basic idea underlying the QALY is relatively simple: it assumes that a year lived in perfect health is worth 1 QALY and a year of life lived in a state of less than this perfect health is worth less than 1.

A variety of measures are used to elicit the weight associated with health states less that are less than perfect (i.e. less than one). The most common being the visual analogue scale (VAS), the standard gamble (SG) and the time tradeoff (TTO). The VAS requires respondents to rate health states on a scale (typically represented by a vertical "thermometer-type" line) with "worst" and "best" endpoints, usually represented by 0 and 100, respectively. While simple to use, it is subject to a number of biases such as context and spreading bias, and end-point aversion (Dolan 2000). As valuations derived from the VAS are elicited in a *choiceless* context, i.e. don't require individuals' to make trade-offs, health economists generally prefer the choice based SG and TTO methods. For the SG approach, respondents choose between a health state that is certain (for example, frequent asthma attacks) and a gamble with one better (for example, full health) and one worse (for example, death) outcome possible. With the TTO, respondents choose between living for a defined period of time in a specified poorer health state or living for a shorter period of time in full health. Some common criticisms of these choice based methods are that they can be relatively time-consuming and cognitively challenging for respondents (Dolan 2000; Tolley 2009). Another criticism relates to their failure to incorporate the patient's willingness to pay in decisions to finance new treatments.

In cost-benefit analysis, the benefits associated with heatlh care interventions are assessed by determining how much indiivudals themselves are willing to pay for the associated health care benefits. This approach has a number of advantages over CE and CUA analysis. First, it more easily allows a direct comparison of the benefits of a health care intervention with its costs. Second, by determining an individuals' willingness to pay (WTP) we can also measure potential benefits of health care other than just health gain. An additional advantage of this method is that it allows preferences for health to be considered alongside other non-health attributes, that the individuals values, i.e. allow a comparison between the value individuals place on improvements in health relative to other arguments in their utility function. One of the more common approaches for determining individuals willingness to pay (WTP) for use in cost-benefit analysis is contingent valuation (CV) which is a survey based and hypothetical technique for eliciting how much individuals are willing to pay for one health state relative to another. With contingent valuation, individual's are asked to place a specific monetary value on a hypothetical change from one health state to another or simply their WTP for the elimination of specified health risks. The validity and reliability of the contingent valuation method is, however, the subject of heated controversy, as it is argued that the methodology is susceptible to hypothetical bias and framing problems (Carson et al., 2001; Murphy et al., 2005; Lusk and Norwood, 2009). More specifically, respondents are usually confronted with hypothetical scenarios of which they often have no personal experience, meaning that they may find it difficult to fully understand and comprehend the actual scenario they are being asked to assess.

Another widely used approach for obtaining WTP for health outcomes is through using revealed preferences (RP), where people's preferences for health conditions are 'revealed' from observed behavior in the market. The hedonic pricing approach, using wages, is an example of such an approach where the amount that individuals need to be compensated for risks to health is ascertained by determining how wages differ in response to changing on the job health risks. One limitation with this approach arises from the issue of self-selection as, for example, workers who choose a certain occupation with high health risks are likely to be a select group for whom health risks weigh less heavily than the general population. One further pervasive problem with all revealed preference methods is that consumer decisions are based on perceived rather than objective perceptions. If adequate information on occupational risks is missing, then people's subjective assessment and objective measures may not correspond with each other very well, thus leading to biased estimates of individuals' willingness to pay for reductions in health risks.

More recently, the compensating income variation (CIV) approach has been proposed as an alternative to CV and revealed preferences for determining how much individuals are willing to pay for improvements in health. This method involves regressing a measure of life satisfaction on different health conditions, controlling for other personal characteristics such as income. The output from such a regression analysis can then be used to calculate how much individuals are willing to trade off income for better health, by estimating how much extra income an individual would require, to offset a given loss in life satisfaction arising from a health condition. In this paper, I use this approach to calculate the level of compensation that is required to make an individual indifferent between having and not having 15 different health conditions, using a large nationally representative survey in the UK. Since this approach does not rely on stated valuations, it is less prone to bias than CV, and since it involves a randomly selected representative sample of individuals it is not subject to problems of self-selection, commonly associated with revealed preferences. This paper builds on previous research that have used this approach for monetising the benefits of health outcomes by first accounting for endogeneity bias when estimating the effect of income on life satisfaction. Second, through the inclusion of measures of individual's personality traits, commonly not available in large scale surveys, I test for personality induced bias when estimating the effect of health on life satisfaction. I show that the amount of extra equivalent household income to make someone with a health condition, as well off in terms of life satisfaction as someone without the health condition, ranges from a low of £4,235 per annum for impairments associated with asthma to a high of £31,283 for impairments associated with coronary heart failure. These values could be used as a basis for a cost-benefit analysis of medical care expenditures on interventions aimed at the prevention or indeed treatment of the health conditions examined.

2. Life satisfaction and health

Traditionally, economists have viewed well-being as the ability to fulfill desires or satisfy preferences and have focused on increasing the choices available to people through, for example, raising incomes (Harsanyi 1982; Dolan and White 2007). In other disciplines such as psychology and sociology, there has been a significant focus on understanding the factors affecting subjective indicators of well-being such as how satisfied individuals are with their quality of life (or life satisfaction, happiness etc.) As Helliwell and Putnam (2004) note "A *prima facie* case can be made that the ultimate 'dependent variable' in social science should be human well-being, and in particular, well-being as defined by the individual herself, or 'subjective well-being'". Economists, have generally paid much less attention to the determinants of subjective as opposed to objective indicators of well-being, due to concerns as to whether subjective data can really serve as an adequate proxy measure of utility. Emerging interdisciplinary research has begun to address these concerns and increasingly suggests that self-rated questions about life satisfaction can be a valid approximation for individually experienced welfare or utility (see Dolan and White 2007 for a review of this work). Research in psychology has shown, for instance, that responses to questions about life satisfaction correspond with external reports on respondents by others (e.g. friends and partners). Self-reported life satisfaction has also been shown to be a good predictor of future behavior as if there are certain factors that reduce self-reported life satisfaction, individuals will make choices that remove those factors (Clark et al., 2008).

Starting from the premise that health is an important argument in an individual's utility function, we can estimate the welfare change associated with a change in health, if we can determine the compensating change in one of the remaining arguments in an individual's utility function, that leaves utility unchanged. One of these remaining arguments is income and as such it is possible to measure the extent to which an individual is willing to sacrifice income to experience one health state relative to another. This is the central idea behind the compensating income variation approach adopted in this study to monetise health conditions. This method involves regressing life satisfaction on various health conditions, income and a variety of control variables. The resulting partial correlations between the specified health conditions and life satisfaction and income and life satisfaction, capture the marginal utility of health and income respectively. We can use these partial correlations to estimate how much individuals are willing to trade off money (in our case equivalent household income[1]) for improvements in health. It obviates some of the major difficulties inherent in revealed and stated preference methods. For example, this approach uses information on the entire population, thereby avoiding problems of self-selection bias associated with the hedonic wage approach. It further has the advantage that it does not require that respondents evaluate hypothetical situations as in stated preferences methods (e.g. contingent valuation).

There is growing acceptance and subsequent use of this compensating income variation approach in the economics literature. It has been used, for example, to place a monetary value on airport noise (van Praag and Baarsma, 2005), flood disasters (Luechinger and Raschky, 2009), terrorism (Frey et al., 2009), weather and climate (Maddison and Rehdanz, 2011) and air pollution (Luechinger, 2009; Levinson, 2012). Looking specifically at research relating to health conditions, a number of recent studies have also applied this technique in estimating how much extra income an individual would need to be 'compensated' for cardiovascular disease (Groot and Maasen van den Brink, 2006 & 2007; Latif, 2012), headaches/migraines (Groot and Maasen van den Brink, 2004), chronic pain (McNamee and Mendolia, 2014) and disability (Cullinan et al., 2011; Cullinan et al., 2013; Hancock et al. (2013). A smaller number of studies have also used this approach in valuing a range of different health conditions (Ferrer-i-Carbonell and van Praag, 2002; Groot and van den Brink, 2008; Mentzakis, 2011; Powdthavee and van den Berg, 2011; O Neill, 2016).

Relative to this previous work, I am able to address a number of critical empirical challenges when it comes to using the compensating income variation approach for monetising health conditions. First, I control for endogeneity bias when estimating the effect of household income on life satisfaction by using an instrumental variables approach. There are a number of reasons to expect, a priori, that when using conventional regression analysis, endogeneity with respect to income may lead to biased

[1] Here, equivalent household income is calculated by dividing household income by the square root of the household size. This implies that, for instance, a household of four persons has needs twice as large as one composed of a single person. This scale is often used by the OECD and other organisations for comparing income inequality and povery across areas

estimates of the relationship between income and life satisfaction. One source of potential endogeneity bias is due to bi-directional causality, as some studies have shown that higher well-being can lead to higher future income (Schyns, 2001; Diener, Lucas, Oishi, & Suh, 2002). In addition, neglecting unobserved heterogeneity which may be correlated with both income and life satisfaction can also result in biased estimates. For instance, incomes are likely to be highly positively correlated with factors such as working hours, time spent away from family and loved ones, time sent commuting and stress, all of which are potentially strongly negatively correlated with life satisfaction, thus leading to downward biased estimates. Lastly, income is also often recorded with measurement error which can bias the estimated effect of income towards zero. Failure to correctly identify the effect of income on life satisfaction could mean that the amount of extra income calculated using the compensating income variation approach that individuals would need in order to leave utility unchanged, after a change in health, may be significantly biased.

The solution to these endogeneity problems is to find an instrument for household income, i.e. something that is correlated with income but does not have an independent effect on life satisfaction, after conditioning on the other included variables. In this study, I used the education level of the respondent's parents to identify the effect of household income on life satisfaction. While likely to be related with individuals' household income, parental education level is unlikely to influence individual's life satisfaction directly. An additional advantage of this work is that I am able to test for any potentially confounding role of personality traits. Personality differences may lead to biased estimates of the effect of health conditions on life satisfaction, as personality traits are correlated with both life satisfaction as well as the likelihood of acquiring a wide range of mental and physical disorders. Findings from a meta-analysis by Steel et al. (2008), for example, suggest that four of the Big Five personality traits,[2] namely neuroticism, extraversion, agreeableness and

[2] The Big Five personality trait taxonomy classifies individuals according to five factors: openness to experience; conscientiousness; extraversion; agreeableness and neuroticism. This taxonomy has been widely used to classify personality traits in the psychology literature.

conscientiousness are significantly related to life satisfaction. The fifth 'openness' while significantly related to happiness is generally not related with life satisfaction. Similarly, considerable research within psychology suggests that personality traits, in particular neuroticism and conscientiousness, are significantly correlated with a variety of health conditions (Goodwin and Friedman 2006). Neglecting this unobserved heterogeneity may result in what psychologists call a 'personality bias' on the obtained estimates. I include a measure of individual's personality traits (namely the Big Five personality traits) as additional controls in the regression analysis of life satisfaction to account for any potential personality induced bias in the coefficient estimates.

3. Data

The dataset used in this analysis is the Understanding Society survey. This is a comprehensive annual longitudinal household panel survey that started in 2009 with a nationally-representative stratified, clustered sample of around 50,000 individuals living in the United Kingdom. It uses an overlapping panel design with data collection for a single wave conducted across 24 months. Interviews are typically carried out face-to-face in respondents' homes by trained interviewers. Our measure of life satisfaction is based on respondents answer to the following question: Please choose the number which you feel best describes how dissatisfied or satisfied you are with your life overall. Respondents are given a 7 point scale ranging from 1 completely dissatisfied to 7 completely satisfied. The key explanatory variables of interest are derived from participants' response to a question about whether they have been diagnosed with certain health conditions asked in wave 1 of the survey. Participants were presented with a card with 17 health conditions and asked 'Has a doctor or other health professional ever told you that you have any of the conditions listed on this card'. Participants who reported that they had been diagnosed with one of these conditions were then asked if they still had that health condition. Using this information, I derive dummy variables indicating if a survey participant is *currently* suffering from a specified health condition. A further advantage of this survey dataset is that it allows for a relatively detailed classification, in comparison to many prior studies of health conditions. For example, respondents are asked to report whether they suffer from a number of specific cardiovasicular diseases (e.g. angina, high blood pressure, congestive heart failure, coronary heart disease, stroke) as opposed to just a broad classification of heart or cardiovasicular issues. Similarly, respondents are asked to indicate if they have a curent diagnosis of a number of respiratory conditions (e.g. asthma, chronic bronchitis, emphysema). Other conditions examined are cancer or malignancy, liver conditions, epilepsy, diabetes, arthritis, hyperthryoidism and hypothryoidism. The dummy variables reflecting whether a respondent has a current diagnosis of one of these 15 health conditions along with equivalent household income are then entered as the main explanatory variables of interest in a regression analysis of life satisfaction (see table 1)[3].

Based on prior research, I include a rich set of commonly observed predictors of life satisfaction (see Dolan 2008 for a review of this literature). These include socio-economic variables such as age, gender, relationship status, number of children, education and labour force status. I add variables reflecting the extent to which individuals talk with their neighbors and participate in religious activities as overall proxy variables for social capital. I also added a variable reflecting whether respondents care for someone that is sick, disabled or elderly as this has recently been found to be negatively related with life satisfaction (van den Berg et al., 2014). Regional dummies variables were included to capture regional differences in access to medical care. I include household income in its natural logarithm which reflects the diminishing marginal utility of income. I also controlled for the square root of household size to make a real equivalent household income variable, i.e. make household income comparable across different household compositions (see footnote 1).

[3] Two of the 17 health conditions were excluded from the analysis for various reasons. Depression was left out from the analysis given the close correspondence between psychological health and general life satisfaction. While a number of individuals reported that they had a heart attack, as one would expect in a survey such as this none of the respondents reported that they were actually suffering from a heart attack. Therefore if we included this measure we would be estimating the effect of being diagnosed at some point with a heart attack on life satisfaction as opposed to the effect of suffering from a heart attack on life satisfaction

Other factors which may affect health and life satisfaction, which are typically difficult to isolate and until recently, largely absent from large scale surveys are personality traits. Interviews for wave 3 of the Understanding Society survey (conducted between 2011 and 2013) contain information on the Big Five personality traits. To obtain a measure of the Big Five personality traits, participants in this wave were asked to what extent they agree/disagree with 25 statements beginning with the quote "I see myself as someone who". Each statement is classed in one of five categories: extraversion, agreeableness, conscientiousness, neuroticism and openness. A composite score for each personality trait is then derived by summing the scores for each of the individual categories. Initially consisting of 44 statements, recent scale-development studies have indicated that the Big Five traits can be reliably assessed with a smaller number of items (e.g., Gosling et al., 2003). The Understanding Society survey relies on five statements in each domain to derive a measure of each personality trait.

One potentially problematic issue in using these personality traits as control variables in our analysis is that individuals' personality traits are recorded in wave 3 of the survey, whereas the health conditions are recorded in wave 1. Given that a longitudinal study design is employed (mostly the same respondents are re-interviewed in each wave) I can, however, match individuals with diagnosed health conditions in wave 1 (2009-2011) to their personality traits collected in wave 3 (2011-2013). Although the personality traits are recorded in a different wave and hence time period to our data relating to health conditions, personality traits vary little once individuals reach adulthood (Borghans et al. 2008). That being said, while personality traits are relatively stable over time (at least among adults), this matching could still potentially be problematic given that individuals with relatively more serious health conditions are perhaps more likely to drop out of the survey between wave 1 and 3 than an average survey participant. This could give rise to a selection bias if we are relying on this data to test the effect of personality traits on health conditions. Still, in the absence of better data, testing the sensitivity of our health coefficients to the inlcusion of the Big

Five personality traits does at least give us a useful indication of the likeihood of 'personality induced bias' affecting the regression estimates.

4. Analysis

The analysis begins by assuming that the life satisfaction measure (LS) is a function of the log of equivalent household income (Y), the particular health condition of interest (h), a vector of other heath conditions (H) and the individual's other characteristics (X):

$$LS = LS(Y, h, H, X)$$

Assuming a linear functional form and a constant marginal utility of income yields:

$$LS = \beta_0 + \beta_1 Y + \beta_2 h + H'\beta_3 + X'\beta_4 + \varepsilon$$

For our purposes, the compensating income variation (CIV) for condition *h* can be determined as the level of equivalent household income required to equate life satisfaction in the presence of the condition (e.g. having congestive heart failure) (*h=1*) to the level that would exist in the absence of the condition (*h=0*):

We can solve to find the required CIV:

$$CIV = Y_i * \left(\exp\left(\frac{-b_2}{b_1}\right) - 1\right)$$

where Y_i = average equivalent household income [1]

Life satisfaction scores are reported on an ordinal scale. However, assuming cardinality of life satisfaction scores has been shown to have little influence on findings (Ferrer-i-Carbonell and Frijters 2004, Mentzakis 2011) and for ease of reading, I assumed cardinality in life satisfaction.

5. Results

5.1 Basic specification

Table 2 reports the basic life satisfaction regression including the full set of control variables. The results relating to the control variables are all along expected lines and correspond with the results widely documented in previous literature (see Dolan et al., 2008). For example, we observe a positive relationship between age and life satisfaction, but a negative relationship between age squared and life satisfaction. This would be in keeping with previous work which suggests a U-shaped relationship with higher levels of life satisfaction for the relatively younger and older groups, with the lowest levels in middle age. As expected, unemployment was negatively related, whereas education and being in a relationship was found to be positively related with life satisfaction. Our proxy variables relating to social capital (talk to neighbours and participate in religious activities) were both positively related with life satisfaction. Finally, in keeping with recent research by van den Berg et al. (2014), individuals who care for someone who is sick, disabled or the elderly is likely to have a significantly lower level of life satisfaction.

The key variables of interest are the log of equivalent household income and our dummy variables indicating whether a respondent has a current diagnosis of one of the 15 specified health conditions. The findings in relation to health conditions are all along expected lines. All the health conditions are statistically significant and negatively related with life satisfaction with the exception of hypothyroidism, which although of the expected sign is not statistically significantly different from zero. It is a relatively common disorder of the endocrine system in adults and causes a number of symptoms such as poor ability to tolerate cold, a feeling of tiredness, and weight gain. It would, however, typically be a relatively benign condition (at least in the majority of cases) and this perhaps explains its lack of statistical significance in our baseline specification. Turning to the other health conditions, in addition to being statistically significant, the relative magnitude of their effects are also along expected lines in that health conditions such as asthma and high blood pressure are associated with a smaller change in life satisfaction than what are generally regarded as more serious health conditions such as congestive heart failure and epilepsy. For example, having congestive heart failure is associated with a half point decrease in our seven point life satisfaction scale. On the other hand, having high blood pressure is associated with a 0.13 point decrease in the life satisfaction scale.

The log of equivalent household income also has the expected positive sign and is statistically significant suggesting that higher household incomes is associated with higher life satisfaction scores. One potential problem with directly interpreting the estimated coefficient of the log of equivalent household income is that this estimate is likely to be affected by endogeneity bias. A small number of previous studies have used instrumental variable methods to account for endogeneity bias when estimating the effect of income on either happiness or life satisfaction and this research suggests that conventional regression estimates (e.g. ordinary least squares (OLS)) significantly understates the true causal effect of income. Luttmer (2005), for example, used predicted household earnings to instrument for income when examining the role of relative earnings on happiness. He found that instrumenting income resulted in an estimated effect that was three times larger than what was estimated in his baseline OLS specification. Luechinger (2009) used similar instruments to that used by Luttmer (2005) as instruments for income when estimating the CIV for exposure to air pollutants. His estimated effect of log household income on life satisfaction more than tripled once he instrumented income as compared to the conventional OLS estimate. Powdthavee (2010) used variables relating to the proportion of household members who showed the interviewer their payslip to instrument for log of real household income and found that after instrumenting, the estimated effect of income on happiness doubled as compared to that estimated using OLS[4]. Knight et al. (2009), used mother's and father's years of education to instrument for

[4] Interestingly the study also found that while neglecting heterogeneity biases upward the income coefficient, the direction of the overall bias is negative once you correct for the omitted time-varying factors that correlate positively with income but are negatively correlated with life satisfaction

respondents' income in a study of the determinants of happiness in rural China. They found that the instrumented income coefficient was over four times larger than that estimated using OLS.

Conveniently in wave 1 of the Understanding Society survey, information relating to the education level of the survey participants parents is recorded. Using this data I am able to instrument log of equivalent household income with similar instruments to that employed by Knight et al. (2009). Specifically, I used four dummy variables, reflecting the education level of the survey respondents' parents as my instruments. These dummy variables reflect whether a survey participant reports that either their mother or father has a degree or some post school qualifications. These variables are likely to affect the household income of a survey respondent, but unlikely to influence their life satisfaction directly. Even the education level of the respondents themselves was found to be only weakly related to life satisfaction (see table 2). The estimated effect of the log of equivalent household income more than quadruples (i.e. from 0.13 to 0.60) when equivalent household income is instrumented compared to the conventional OLS estimate. This is a similar result to that reported by Knight et al. (2009) and also in line with the results reported by Luttmer (2005) Luechinger (2009) and Powdthavee (2010) who, using different instrumental variables, also found that the estimated effect of income on life satisfaction or happiness is significantly downward biased when using conventional OLS estimates.

The signs and significance of the instruments used in the first stage regression can be seen in column 5 of table 2. All the instruments have the expected effect on the log of equivalent household income, albeit fathers degree is not significant at conventional significance levels (p = 0.14). In all cases, the statistical tests suggest that the instruments are relevant. The Anderson canonical correlations likelihood ratio test rejects the null of underidentification. The obtained F statistic at 10.3 exceeds the conventional minimum standard of power of F = 10 (Stock et al., 2002). I can test the validity of the instruments, conditioning on the assumption that a subset of instrument is valid, by implementing the standard overidentification test. The resulting Sargan's test statistic was statistically insignificant with a p value of 0.77 and therefore we can be reasonably satisfied that our instruments are consistent in producing robust estimates of the effect of the log of equivalent household income on life satisfaction. Another important way to assess the validity of the instrumental variables is to test how robust the coefficients are to the selection of different combinations of instruments. I examined the effect of either just using mother's education level or father's education level as instruments and the results were robust to these different combinations. For instance, our estimated coefficient for the log of equivalent household income when I just used the two dummy variables reflecting the education level of the participants mother as instruments was 0.56, whereas when father's education levels was used, the estimated coefficient was 0.58.

5.2 Compensating differentials

Using the coefficients representing the effect of health conditions on life satisfaction, as well as our instrumented log of equivalent household income coefficient, I next derive an estimate of the extra equivalent household income (compensation) an individual with a health condition would require in order to experience the same level of life satisfaction, as an otherwise identical individual without that health condition. I do this for all 15 health conditions examined in the life satisfaction equation. To calculate the CIVs, I need to estimate equation 1 described earlier. Taking congestive heart failure as an illustrative example, the extra equivalent household income required to leave someone with congestive heart failure as well off in life satisfaction terms as someone without the condition amounts to £31,283 per annum. At the other end of the scale, the extra equivalent household income needed when it comes to asthma amounts to £4,235 per annum. For cancer or malignancy the compensating income variation amounts to £12,666 and a similar amount is calculated for liver conditions (£12,665). The results relating to the remaining health conditions are presented in table 3.

One important point to note is that these monetary values would have been grossly overstated if I had not instrumented our income measure. Specifically, failure to control for endogeneity in income will understate the effect of income on life satisfaction which means that the amount of extra income needed to 'compensate' individuals for losses in health (or indeed other arguments in their utility function) will be significantly overstated using conventional OLS estimates. Comparing the monetary estimates obtained in this study with derived estimates from other studies which have not taken account of endogeneity bias is challenging, given the variability in health conditions examined (most often just one) and the different income measures and time spans of the survey's used. Notwithstanding these difficulties, we can see a general pattern that the compensating income variations obtained in this study are generally much lower (and I would argue more realistic) than that reported in previous work which have used the CIV approach.

5.3 Sensitivity to personality controls

One potential threat to the validity of these results is due to 'personality induced bias' as personality traits are significantly correlated with both life satisfaction and certain health conditions. One way to test the likely importance of personality caused bias in the coefficient estimates is to test how robust they are to the inclusion of variables reflecting personality traits. I am able to test the sensitivity of the results relating to the effect of health conditions on life satisfaction (outlined in column 2 of table 2) to the inclusion of the Big Five personality traits. In keeping with the findings outlined in Steel et al. (2008), neuroticism, extraversion, agreeableness and conscientiousness were all significantly related to life satisfaction, whereas openness had no statistically significant relationship (see column 6 in table 2). The coefficients relating to both health conditions as well as the log of equivalent household income were largely unaffected by the inclusion of these personality variables (see column 6 of table 2). The exception is whether a respondent has a current diagnosis of a liver condition or a stroke, as while of the expected sign, these variables were no longer statistically significant. One potential explanation is due to attrition bias. Including personality traits in the regression analysis results in a significantly smaller size, as many of the respondents with a current diagnosis of these health conditions recorded in wave 1 were not re-interviewed in wave 3, which is when information relating to personality traits was collected. Given the serious nature of many liver and stroke conditions, it is possible that individuals who were not re-interviewed are systematically different than those who were. Notwithstanding these differences when it comes to liver and stroke conditions, we can see that, for the most part, our coefficients reflecting health conditions were robust to the inclusion of personality controls. This is in keeping with research by Helliwell (2008), who found that his estimated coefficient reflecting the relationship between individual's own subjective evaluation of their health status and life satisfaction, was also largely unaffected by the inclusion of personality related variables[5].

6. Conclusion

A rapid increase in expenditures has fostered the need to quantify the value of health benefits obtained by health care interventions. One commonly used method for monetising the benefits of health care interventions is to ascertain how much individuals are willing to pay for one health state relative to another. The two most commonly used approaches for eliciting willingness to pay are revealed preferences and contingent valuation. Revealed preferences involve deducing willingness to pay from observed behaviour (e.g. hedonic wages), whereas the contingent valuation method asks individuals to directly state their willingness to pay for a hypothetical change in health. An alternative approach that has been increasingly suggested by economists as a useful mechanism for eliciting monetary valuations for health care interventions is the compensating income variation (CIV) approach. This involves estimating a micro-econometric life satisfaction equation, with various

[5] Of course personality is not just related to health but also to many of the other explanatory variables. Personality, for example, may affect the likelihood of getting married, employment and social interaction with others and these have all been found in this study (and indeed many others) to be significantly related with life satisfaction. It is, therefore, interesting to report that the coefficients relating to these variables also appear to be largely unaffected by the addition of these personality variables.

health conditions and income included as explanatory variables. By calculating the marginal rate of substitution between income and health, we can calculate how much extra income an individual would require to compensate them for each of the health conditions examined. This income-health trade-off – or compensating income variation – represents the monetary value of a health improvement and can be interpreted for our purposes as the willingness to pay for the elimination/prevention of a health condition. While not without its own set of limitations (see Levinson (2012) for a more detailed overview), this approach does have a number of advantages over revealed and stated preference methods. Relative to stated preference methods (e.g. Contingent Valuation), for example, the scope for framing effects, strategic behaviour and hypothetical bias is reduced. It is also less cognitively demanding for individual's as they are not asked to value health conditions directly, rather to evaluate their own life satisfaction. Furthermore, it uses information on the entire population, thereby avoiding problems of self-selection and generalization associated with revealed preferences (e.g. the hedonic wage approach).

Using the compensating income variation (CIV) approach, I calculated the amount of income needed to make someone with a current diagnosis of one of 15 specified health conditions as well off as someone without these health conditions. The compensating equivalent household income variations ranged from £4,235 (asthma) to £31,283 (congestive heart failure) per annum depending on the health conditions examined. The average annual equivalent household income of the survey sample was £23,352. By putting what amounts to a price tag on various health conditions, health policy makers can make direct comparisons between the relative benefits and costs of different treatment options or ideally measures aimed at reducing the numbers of people acquiring these health conditions. This, in turn, can make decision making about which health care interventions to prioritise more straightforward than would otherwise be the case. It can also allow us to compare the benefits of good health with other factors found to affect individual's life satisfaction.

One advantage of the dataset used in this analysis is that it allowed a comparison of a wide range of health conditions. Furthermore, to the best of my knowledge, this study provides the first estimates of the amount of income that is needed to 'compensate' for different health conditions which correct for endogeneity in income. Results suggest that estimates of the effect of income on life satisfaction in previous studies using the 'compensating income variation' approach are likely to be downward biased due to endogeneity. This means that they will typically overestimate the amount of extra income needed to leave the life satisfaction of someone with a specified health condition the same, as someone without that condition. Of course it is not just in health where the life satisfaction approach has been used to value public goods and the same point applies. Without correcting for endogeneity bias, the amounts needed to compensate individuals for losses in health or other arguments in their utility function, is likely to be significantly overestimated. An additional advantage of this work is that I was able to examine the sensitivity of the results to the inclusion of variables designed to measure personality traits. The results were robust to the inclusion of the Big Five personality traits which suggest that 'personality induced bias' is not affecting the reliability of the CIV estimates and also should be of some comfort to other researchers who do not have measures of personality available as control variables.

To conclude, although assigning monetary amounts to health conditions is not a trivial matter and is controversial among some policymakers and clinicians, governments and health care insurers are increasingly required to make more efficient decisions regarding where best to allocate health care resources. In order to properly evaluate the health effects of policies and programmes, it is necessary to say something about their effects on individual's quality of life. While one can rely on an assessment by the medical doctor or clinician to value a health gain or loss, many consider that it is most appropriate to elicit valuations from those people who are currently experiencing the health states for which values are sought. Using individuals own assessment of their life satisfaction, our clear and robust conclusions is that health conditions significantly affect individuals' quality of life and that the monetary effect of those health conditions are substantive, albeit less than is commonly reported in the literature using the CIV approach to date.

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List of tables

Table 1: Key summary statistics

Health conditions	Number with each health condition
Angina	1,104
Arthritis	6,782
Asthma	5,074
Cancer or a malignancy	477
Chronic bronchitis	545
Coronary heart disease	737
Congestive heart failure	213
Diabetes	2,861
Emphysema	347
Epilepsy	374
High blood pressure	7,013
Hyperthyroidism (over-active thyroid)	277
Hypothyroidism (under-active thyroid)	1,310
Liver condition	396
Stroke condition	867
Mean equivalent annual household income	£23,352

Table 2: Determinants of life satisfaction

	Coef.	Std. Err.	t	Instrumental variable analysis	Personality controls
Log of equivalent household income	0.13 ***	0.01	11.73	0.60	
Age	-0.04 ***	0.00	-12.98		
Age squared	0.00 ***	0.00	13.26		
Female	0.05 ***	0.02	3.18		
In a relationship	0.34 ***	0.02	16.42		
Number of children	-0.04 ***	0.01	-5.29		
Third level degree	0.05***	0.02	2.94		
Self employed (employed is the reference category)	0.02	0.03	0.60		
Unemployed	-0.39 ***	0.03	-12.61		
Retired	0.25 ***	0.03	7.29		
Familycare	-0.05 *	0.03	-1.85		
Training	0.28 ***	0.03	8.99		
Disabled	-1.14 ***	0.05	-24.07		
Other	-0.56 ***	0.25	-2.27		
Regularly attend religious services or meetings	0.09 ***	0.02	4.42		
Regularly talk with neighbors	0.08 ***	0.01	5.69		
Cares for sick, disabled or elderly in the household	-0.23 ***	0.03	-8.57		
Angina	-0.16 ***	0.06	-2.62		-0.10
Arthritis	-0.15 ***	0.03	-5.93		-0.14***
Asthma	-0.10 ***	0.02	-4.14		-0.07**
Cancer or malignancy	-0.26 ***	0.08	-3.21		-0.29***
Chronic bronchitis	-0.38 ***	0.08	-4.48		-0.36***
Coronory heart disease	-0.18 ***	0.07	-2.58		-0.16 **
Congestive heart failure	-0.51 ***	0.14	-3.60		-0.66***
Diabetes	-0.25 ***	0.04	-6.92		-0.29 ***
Emphysema	-0.27 ***	0.11	-2.47		-0.32 **
Epilepsy	-0.36 ***	0.09	-4.01		-0.39***
High blood pressure	-0.13 ***	0.02	-5.08		-0.07 **
Hyperthyroidism	-0.32 ***	0.10	-3.10		-0.38***
Hypothyroidism	-0.06	0.05	-1.24		-0.01
Liver condition	-0.26 ***	0.09	-2.85		-0.10
Stroke	-0.22 ***	0.06	-3.39		-0.07
Regional controls left unreported for parsimony					
IV first stage regression results					
Father has a degree				0.04	
Father has a post school qualification				0.04	
Mother has a degree				0.10	
Mother has a post school qualification				0.10	

Personality controls					
Openness					-0.01
Agreeableness***					0.06 ***
Extraversion ***					0.04 ***
Neuroticism***					-0.17 ***
Conscientiousness***					0.09 ***
N	37,203			7,334	22,343

Table 3: Compensating income variations

Health condition	£ (per annum)
Angina	7,136
Arthritis	6,632
Asthma	4,235
Cancer or a malignancy	12,666
Chronic bronchitis	20,640
Coronary heart disease	8,169
Congestive heart failure	31,283
Diabetes	12,070
Emphysema	13,271
Epilepsy	19,198
High blood pressure	5,649
Hyperthyroidism (over-active thyroid)	16,453
Hypothyroidism (under-active thyroid)	2,455
Liver condition	12,665
Stroke condition	10,343