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Disability costs and equivalence scales in the older population

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Non-technical summary

Disabled people face higher costs of living than do non-disabled people. These additional costs include the cost of adapting the home, overcoming the difficulties of getting about, and acquiring assistance with everyday tasks that non-disabled people can do unaided. Countries like the UK have welfare benefit systems that acknowledge these costs through disability-tested programmes like Attendance Allowance (AA) and Disability Living Allowance (DLA). But just how large are these disability-related costs? How far does the benefit system go in meeting them? And how should we take account of these costs when we measure poverty and inequality in populations that include both disaabled and non-disabled people?

In this research study, we construct dual indices of individuals' standard of living and degree of disability, using UK survey data covering over 8,000 people who are over state pension age. We use these indices to estimate the additional income that each disabled person would need in order to reach the same standard of living as he or she would enjoy without any disability. There are two major empirical findings.

(1) The additional costs of living associated with disability are large: among the group of people with some detectable degree of disability, we estimate the average cost to just under £100 per week, which is around 50% of their weekly income. As one would expect, the size of disability costs rises sharply with the severity of disability.

(2) Although the disability benefits AA and DLA are well-targeted on people with significant disability, many disabled people do not receive them and, for those who do, they generally fall short of meeting the whole costs of disability. The average amount of benefit received by people with some disability is estimated at around £19, or less than a fifth of average costs.

As a consequence of these findings, we can say that older disabled people primarily cope with disability costs by accepting a substantially reduced standard of living rather than by generating additional income through the benefit system. Our findings also underline the importance of taking account of disability-related living costs when drawing conclusions about poverty and inequality in the older population, where the prevalence of disability is particularly high.

DISABILITY COSTS AND EQUIVALENCE SCALES IN THE OLDER POPULATION

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ABSTRACT: We estimate the implicit disability costs faced by older people, using data on over 8,000 individuals from the UK Family Resources Survey. We extend previous research by using a more flexible statistical modelling approach and by allowing for measurement error in observed disability and standard of living indicators. We find that disability costs are strongly related to the severity of disability and to income and – at an average level of almost £100 per week among over-65s with significant disability – they typically far exceed the value of any state disability benefits received.

KEYWORDS: costs of disability, disability indexes, standard of living, equivalence scale, structural equation modelling.

JEL CODES: C81, D1, I1.

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INTRODUCTION

Disabled people experience significant additional costs as a consequence of their disability, and this is recognized in social security systems through the provision of benefits designed to compensate for disability-related consumption costs. When carrying out analysis of the distributional impact of tax-benefit reforms, it is crucially important to make some allowance for these additional living costs, since failure to do so would give a misleadingly favourable view of the position of disabled people (Hancock and Pudney, 2010).

At least five different methods have been used to estimate and adjust for the costs of disability. One is to exploit the existing benefit system and assume that the political process has resulted in an acceptable evaluation of disability costs. This implies use of an income measure for distributional analysis which excludes any receipt of disability benefit (see Hancock and Pudney, 2010, Morciano *et al.*, 2010), on the assumption that income from disability benefit is exactly offset by the extra costs of disability. However, in practice such payments follow simple rules not well tailored to each individual’s specific configuration of impairments and they are not necessarily intended to meet the full costs of disability. There may also be imperfections in the eligibility judgements made by programme administrators and non take-up by potential claimants. Consequently, this approach may give a poor approximation to disability costs, with underestimation in many cases, leading to bias in the distributional analysis.

A second, judgement-based, approach attempts to estimate the disability costs by asking a panel of ‘experts’, or disabled people themselves, to identify disability-related costs: see Martin and White, 1988, Thompson *et al.*, 1990, Smith *et al.*, 2004 for examples of this approach. The difficulty here is that the appropriate costs may depend not only on the nature of the impairments suffered by the individual, but also other characteristics that vary across households, and it is not feasible to use expert judgement at the level of individual respondents to large-scale surveys. Disabled people themselves may also find it difficult to envisage and evaluate the counterfactual situation in which their disability is removed but all else remains constant.

A third 'objective' revealed preference approach constructs an equivalence scale by using the consumption pattern (typically the household's food budget share) as an indicator of living standards in a comparison of a sample of disabled people with matched individuals who are unaffected by disability. This has been done extensively in the context of adjustment for household size and structure, but less often for disability (although see Jones and O'Donnell, 1995 for a UK example). The main difficulty with this revealed preference method is the need for strong assumptions to overcome inherent identification problems (Pollack and Wales 1979; Muellbauer 1979; Coulter *et al.*, 1992; Banks *et al.*, 1997; Deaton and Paxson, 1998).

A fourth alternative is to use a 'subjective' equivalence approach, based on individuals' reported satisfaction with their well-being. Two main types of subjective information have been used: evaluations of standard of living using an arbitrary numerical scale; or judgements on the level of income believed necessary to reach a specified standard of living (see Stewart, 2009). For the subjective approach, there are concerns about the quality of subjective assessments and the failure to address problems caused by measurement error.

In this paper, we pursue a fifth and less widely-used Standard of Living (SoL) approach which lies somewhere between these last two approaches. The method is closely related to work on material deprivation which seeks to expand the concept of poverty beyond conventional income- or consumption-based constructs (see Berthoud *et al.*, 1993; Zaidi and Burchardt, 2005; Cullinan *et al.*, 2011). We assume that disabled people, in diverting resources to goods and services which are required because of disability, experience a lower SoL than their non disabled counterparts. The absolute costs of disability can be identified as the additional income required by a disabled person to reach the same SoL as a non disabled person, holding constant other characteristics, and the relative cost is the ratio of this amount to income. As Zaidi and Burchardt (2005) point out, estimates depend on the choice of a suitable standard of living indicator and the form of its relationship to income and disability status.

Our aim is to develop and improve the method further in two important respects. First, we allow for a more flexible relationship between income and SoL, so that the structure of the estimated disability cost and equivalence scale is not dictated by an unduly restrictive functional form assumption. Second, we address the problem of measurement error in disability and SoL. Both SoL and disability status are typically measured using either a binary classification or a count index based on a range of different questionnaire items[1]. Although sensitivity analyses are often used to assess robustness, this is not effective if all the alternatives entail similar measurement error biases. To address this we use a latent factor model for disability and SoL, which explicitly allows for the existence of measurement errors in the observable indicators.

Using a two-latent factor structural equation model we estimate the extra cost of disability for a representative sample of people over state pension age living in private households in Great Britain, who were interviewed in the 2007/8 Family Resources Survey (FRS). Ten indicators of ability to afford particular items or activities are used to construct a latent continuous index of SoL. The latent SoL is modelled as a function of income, (latent) disability, and other characteristics, which reflect the many factors which determine an individual's achieved standard of living. In line with previous work (Morciano *et al.*, 2010), disability is assumed to be a latent concept which can be measured imperfectly by a vector of survey indicators reflecting difficulties in domains of life and is influenced by observed socio-economic and demographic characteristics of the individual.

This paper is organized as follow. Section 2 briefly describes the standard of living approach and its usage. Section 3 presents the latent-factor structural equation framework we employ. Section 4 describes the data used. Section 5 presents estimates of the structural equation model and derives the associated estimated extra costs of disability. Section 6 reports some sensitivity analysis on the initial results. The final section draws conclusions.

1. THE STANDARD OF LIVING METHOD

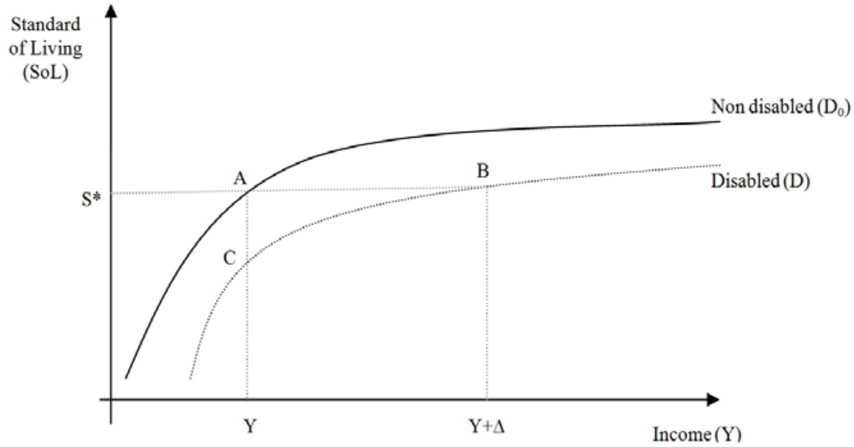
Berthoud (1991) reviews various early attempts at conceptualizing and quantifying how standard of living (SoL), income and disability are related. Berthoud *et al.* (1993) and Zaidi and Burchardt (2005) formalized this approach, which has been

[1] The Katz activities of daily living (Katz *et al.*, 1963) and Barthel indices (Mahoney and Barthel, 1965) are two widely used tools for assessing ability to perform activities of daily living. These indices assign scores to self-reported degrees of difficulty in performing a number of activities, such as feeding, dressing, moving, bathing etc. Scores for each item are then aggregated. These indices have been criticized for the way reported difficulties are aggregated and for not taking account of potential measurement errors in self-reported difficulties (Feinstein *et al.*, 1986; Hartigan, 2007).

used also by Saunders (2007) and Cullinan *et al.* (2011) for estimating the cost of disability in Australia and Ireland respectively. The SoL approach is illustrated in Figure 1, where we compare a positive level of disability D with the baseline of non-disability, D_0.

FIGURE 1

Standard of Living, Income and Disability



The two curves plot the relation between income and SoL conditional on disability, and are assumed to increase monotonically with income. For any given value of income, the SoL of the disabled person lies below that of the non-disabled person and the vertical distance AC measures the difference in their standards of living at the level of income Y. This measure is essentially Sen's concept of "conversion handicap" (Doessel and Whiteford, 2004). The horizontal distance AB provides a measure of the extra income (Δ) required to bring the SoL of the disabled person up to the same level as the non-disabled person.

To formalise this idea, consider the following additively separable SoL function:

$$S = f(Y) - g(D) + h(X, \varepsilon) \quad (1)$$

where S is the SoL, Y is a measure of financial resources, D is the degree of disability status and X and ε represent other observable and unobservable individual characteristics. Some individuals may be in receipt of disability benefit (B), others may not. To allow for this, we decompose income as:

$$Y = Y_0 + B \quad (2)$$

where Y_0 excludes disability benefits. Now define a reference level of disability D_0 and assume that the reference non-disabled person receives no disability benefit. We now pose the following question: what is the smallest amount of additional income, over and above Y_0, that would be needed for a person with disability level D to achieve the same SoL as he or she would have with income Y_0 and disability reduced to the reference level D_0? Given the additivity of (1), this additional income need, Δ, is independent of X and ε, and solves the following optimisation problem:

$$\min \Delta \quad \text{subject to:} \quad f(Y_0 + \Delta) - g(D) \geq f(Y_0) - g(D_0) \tag{3}$$

In general, the total disability-induced living cost Δ and the associated proportional equivalence scale $\sigma = (Y_0 + \Delta)/Y_0$ depend on the levels of both income Y_0 and disability.

For the cost Δ to depend only on severity of disability D (as implied by the design of some benefit systems), the income-SoL profile must have the linear form $f(Y_0) = \gamma_1 Y_0$, in which case the cost of disability and associated equivalence scale are:

$$\Delta = [g(D) - g(D_0)]/\gamma_1; \qquad \sigma = 1 + [g(D) - g(D_0)]/f(Y_0) \tag{4}$$

For the equivalence scale σ to depend only on disability would require $f(Y_0 + \Delta) = f(\sigma Y_0)$ to be expressible as $f(Y_0) + a(\sigma)$, for all positive σ and some function $a(.)$. The only function satisfying this property is $f(Y_0) = \gamma_1 \ln(Y_0)$, which implies the following cost of disability and equivalence scale[2]:

$$\Delta = Y_0 \left\{ e^{\frac{g(D) - g(D_0)}{\gamma_1}} - 1 \right\}; \qquad \sigma = e^{\frac{g(D) - g(D_0)}{\gamma_1}} \tag{5}$$

This is the form usually adopted for equivalence scales designed to adjust for demographic differences between households in conventional income inequality analysis. Both the linear and log-linear specifications have the advantage of simplicity and incorporate the property of base independence (or invariance of the equivalence scale to income level) in additive or multiplicative form (Lewbel, 1997).

In addition to these standard forms, we also use a more flexible log-quadratic function of the kind that has been found useful in Engel curve studies (Banks *et al.*, 1997) and embodies the constant- σ model as a special case. If $f(Y_0)$ is specified as:

[2] Strictly speaking, f can be any affine transform of $\ln(Y_0)$; but an additive translation has no effect.

$$f(Y_0) = \gamma_1 \ln(Y_0) + \gamma_2[\ln(Y_0)]^2 \quad (6)$$

then the solution to (3) gives the cost of disability and equivalence scale as:

$$\Delta = exp\left[\frac{-\gamma_1 - \sqrt{\gamma_1{}^2 - 4\gamma_2 C}}{2\gamma_2}\right] - Y_0 \quad (7)$$

$$\sigma = Y_0{}^{-1}\, exp\left[\frac{-\gamma_1 - \sqrt{\gamma_1{}^2 - 4\gamma_2 C}}{2\gamma_2}\right] \quad (8)$$

where $C = -[\gamma_1 \ln(Y_0) + \gamma_2[\ln(Y_0)]^2 + g(D) - g(D_0)]$. Note that this solution requires the condition $C \leq \gamma_1{}^2/4\gamma_2$ to be satisfied.

This emphasises the importance of the specification used to relate SoL to income and the need to allow for the possibility of departures from the simple assumptions of linear or log-linear forms.

2. A STATISTICAL MODEL

We use the following two-latent factor simultaneous equation model:

$$S_{iq} = \mathbf{1}(\lambda_q \varphi_i + \zeta_{iq}) \quad (9)$$

$$D_{ik} = \mathbf{1}(\mu_k \eta_i + \xi_{ik}) \quad (10)$$

$$\varphi_i = f(Y_i; \boldsymbol{\gamma}) + \alpha_1 \eta_i + \boldsymbol{\alpha}_2 \boldsymbol{x}_i + \varepsilon_{1i} \quad (11)$$

$$\eta_i = \boldsymbol{\beta} \boldsymbol{z}_i + \varepsilon_{2i} \quad (12)$$

where i denotes sampled individuals (i = 1 ... N), $f(.)$ represents the linear, log-linear or log-quadratic function and $\boldsymbol{\gamma}$ contains the corresponding coefficients. The latent measure of SoL is φ_i which underlies the observed SoL indicators $S_{i1}...S_{iQ}$, and the latent disability index η_i generates observed disability indicators $D_{i1}...D_{iK}$. The parameters λ_q and μ_k are factor loadings associated with the S_{iq} and D_{ik} indicators respectively. ζ_{iq} and ξ_{ik} are the measurement errors associated with the SoL and disability indicators. The indicator function **1**(.) maps the latent indexes on the right-hand side of the measurement equations (9) and (10) into the observed binary indicators of SoL and disability.

Observable covariates representing personal characteristics and household circumstances appear in vectors $\boldsymbol{x}_i$ and $\boldsymbol{z}_i$. They contain socio-economic and demographic influences on living standards and disability respectively. In this model socio-economic factors have both a direct and an indirect effect on SoL. Income, for example, has the direct effect of increasing resources available for consumption; this is captured by the function $f(Y_i;\boldsymbol{\gamma})$. Income also has an indirect influence on disability, through the term $\boldsymbol{\beta z}_i$, which then increases disability-related costs through the term $\alpha_1\eta_i$. The use of a latent disability model allows us to separate these direct and indirect effects. Note that the income concepts relevant to the direct and indirect paths are different. The direct effect involves current resources available for consumption, which includes receipt of disability benefit. In contrast, modeling of the indirect effect requires a long-term concept of economic resources reflecting the cumulative effect of past living standards on the current health state. Since disability precedes the receipt of disability benefit, it follows that the latter should be excluded from the income variable used to capture the indirect causal path.

Identification is achieved by imposing the assumption that the structural errors ε_1 and ε_2 are uncorrelated and their scale is normalised by setting var(ε_1)= var(ε_2)=1. We also make the conventional assumption that the measurement errors ζ_{iq} and ξ_{ik} are independent. Because the normalisation results in arbitrary scales for φ and η, we present coefficient estimates for equation (11) in an alternative standardized version. The variance of the latent SoL index in (11) is $var(f(Y_i;\boldsymbol{\gamma}) + \alpha_1\eta_i + \boldsymbol{\alpha}_2\boldsymbol{x}_i) + 1 = (1 - R_\varphi^2)$, where $R_\varphi{}^2$ is the squared multiple correlation of φ. Switching to a standardised version of φ would then multiply each coefficient by a factor $(1 -$ $R\varphi 2 - 1/2$ and this renormalized coefficient is interpretable as the change in φ in standard deviation units, produced by a 1-unit increase in the value of the covariate. Disability η is also a latent construct, with variance $var(\boldsymbol{\beta z}_i) + 1 = (1 - R_\eta^2)$, where R_η^2 is the squared multiple correlation of the disability equation. Therefore the standardized coefficient of φ on η is $\alpha_1^{STD} = \alpha_1\sqrt{((1 - R_\eta^2)/(1 - R_\varphi^2))}$, which can be interpreted as the change in φ (in standard deviation units) generated by a 1-standard deviation increase in η.

3. DATA

The data are taken from the 2007-08 Family Resources Survey (FRS). The FRS is a large UK household survey which collects very detailed incomes and assets information from respondents and asks them questions covering a range of difficulties due to health or disability problems. Additionally, the survey includes a series of questions aimed at measuring material deprivation (Department for Work and Pensions, 2009). For this paper we restrict the analysis to households in Great Britain where all members are aged over state pension age (65 for men; 60 for women) and the household contains only a single person or a couple. The age restriction is imposed in order to limit endogeneity bias which may arise for younger adults for whom disability may cause a reduced income by limiting labour market participation[3]. In estimating equations (11) and (12) we measure income at the household level assuming that all members of the households benefit to the same extent from total household income. This is less likely to be true for households which contain members other than a single or couple pensioner who are therefore excluded. After dropping a few cases where relevant information is missing the resulting sample contains 8,183 individuals (5,812 households). About 58% of the sample are partnered and the remainder live alone.

Deprivation indicators are derived from a set of questions about items or activities, seen as potential 'necessities', that households have or do; households who did not have the items or do the activities were asked whether this was because they did not want them or because they could not afford them. From these household-level indicators, we created individual-level indicators in which each household member is assigned the values of the deprivation indicators of their household. Each such indicator is set equal to 1 if the respondent answered "*We/I would like to have this but cannot afford this at the moment*" and 0 otherwise. It has been suggested (McKay, 2004, 2008; Berthoud *et al.*, 2009) that certain segments of the population with lowered expectations, such as disabled older people, may be less likely than others to admit to being unable to afford particular activities or goods. We therefore carry out a sensitivity analysis in which the deprivation indicator is set to 1 if the household does not do or have the activity/good in question, irrespective of whether

[3] For a discussion on this point we refer, amongst others, to Goldman (2001) and Adams *et al.* (2003).

they say that is because they cannot afford or they do not want them. Sample statistics corresponding to the two alternative definitions of deprivation are shown in Table 1.

Table 1

Sample means and standard deviations (in brackets) of the deprivation indicators

Do you (and your family/and your partner) have...	Cannot afford to…	Do not want/ have / or cannot afford to …
Enough money to keep your home in a decent state of decoration?	0.083 (0.276)	0.101 (0.302)
Hobby or leisure activity?	0.036 (0.187)	0.254 (0.435)
Holidays away from home one week a year?	0.162 (0.368)	0.436 (0.496)
Household contents insurance?	0.049 (0.217)	0.109 (0.312)
Friends/family round for drink or meal at least once a month?	0.068 (0.252)	0.413 (0.492)
Make savings of £10 a month or more?	0.214 (0.41)	0.404 (0.491)
Two pairs of all-weather shoes for each person in the household?	0.022 (0.146)	0.038 (0.19)
Replace any worn out furniture?	0.153 (0.36)	0.323 (0.468)
Replace or repair broken electrical goods?	0.104 (0.306)	0.179 (0.383)
Money to spend each week on yourself, not on your family?	0.079 (0.27)	0.118 (0.322)

Notes: Sample means and standard deviation computed over a sample of 8,183 FRS 2007-8 respondents.

In estimating equations (9)-(12), we invert these deprivation indicators to construct the SoL indicators, $S_{i1}...S_{iQ}$, which take the value 0 if the respondent cannot afford the activity/good and 1 otherwise. In subsequent sensitivity analysis, they take the value 0 if the respondent does not do/have the activity/good and 1 otherwise.

Respondents in the FRS are asked whether they have a health problem or disability. If they answer 'yes' they are then asked if that means they have significant difficulties in any of 9 areas of life. The list of disability indicators together with their prevalence is reported in Table 2. Fifty-three per cent of the sample reported having no disability; 20% reported having three or more difficulties. The most common difficulties are those concerning physical impairment (difficulties in mobility; with lifting, carrying or moving objects).

Table 2

Sample means and standard deviations of the disability indicators

Does this health problem(s) or disability(ies) mean that you have significant difficulties with any of these areas of your life? Please read out the numbers from the card next to the ones which apply to you.	Mean	Standard Deviation
difficulty in mobility (moving about)	0.327	0.469
difficulty with lifting, carrying or moving objects	0.301	0.459
difficulty with manual dexterity using hands for daily tasks	0.120	0.325
difficulty - continence (bladder/bowel control)	0.071	0.256
difficulty with communication (speech, hearing or eyesight)	0.089	0.285
difficulty with memory/concentration/learning/understanding	0.063	0.242
difficulty with recognising when in physical danger	0.013	0.114
difficulty with your physical co-ordination	0.109	0.312
difficulty in other area of life	0.123	0.328

Notes: Statistics computed over a sample of 8,183 FRS 2007-8 respondents.

The explanatory covariates used in the SoL and disability equations are summarised in Table 3. The income indicator Y used in the SoL equation represents the resources of the household currently available for meeting the consumption needs of the household members. We use a household-level income measure, net of direct taxes and housing costs, in line with the "After Housing Cost" measure used in the official *Households Below Average Income* analysis (DWP, 2009) and also by Zaidi and Burchardt (2005). This measure includes income from investments (interest, rent, dividends, private pensions, annuities) but, unlike Zaidi and Burchardt, our income variable includes disability benefits since, as argued earlier, it is available, like any other income component, to be used to maintain SoL (see also Stapleton, 2008 and Cullinan *et al.*, 2011). Disability benefits comprise the non-means-tested Attendance Allowance and Disability Living Allowance[4], an estimate of income attributable to the Severe Disability Premium component[5] of means-tested pensioner benefits and

[4] Attendance Allowance is the main disability-related cash benefit available to people aged 65 or over in th UK. In 2007 it was £64.50 or £43.15 depending on level of care need. Disability Living Allowance is a similar benefit that must be claimed before age 65 but can continue to be paid beyond age 65. It has three alternative rates for care needs and three for mobility needs such that in 2007 weekly payments ranged from £17.75 to £109.50.

[5] The Severe Disability Premium is worth up to £48.45 for an older disabled person receiving a means-tested benefit.

other minor disability-related benefits that are received by a small number of older people in our sample.

Table 3 Sample means and standard deviations of covariates

	Mean	Standard Deviation
Age of adult last birthday	73.54	7.431
Female	59.2%	0.491
No. of yrs in FT education beyond school living age	1.02	1.676
Whether Partnered	58.0%	0.494
Area of Residence:		
North East	4.6%	0.209
North West and Merseyside	10.9%	0.312
Yorks and Humberside	8.4%	0.277
East Midlands	7.5%	0.263
West Midlands	8.3%	0.276
Eastern	8.8%	0.283
London	6.9%	0.253
South East	12.2%	0.327
South West	8.7%	0.282
Wales	5.3%	0.225
Scotland	18.4%	0.387
Net household income including disability benefits but after deducting housing costs (£ pw)[a]	283.70	176.69
Net household income excluding disability benefits and after deducting housing costs (£ pw) ('Pre-disability benefit income')[b]	*268.20*	*177.67*
Home Ownership	75.1%	0.432
Financial wealth (in £)	20,886	63,376

Notes: Sample means computed over the 8,183 respondents. Monetary values are in 2007 prices and rounded to the nearest 10p.
a. Computed as the sum across all household members of: cash income from private and state pensions, investments and savings, other market income, disability and means-tested state benefits minus income tax and housing costs. Housing costs are the sum of gross rents, council tax payments, costs of insurance on structure of property and mortgage interest payments net of housing benefit and council tax benefits.
b. Pre-disability benefits income is computed by deducting disability benefits currently received by all household members from household income.

The measure of income used as a covariate (in $\boldsymbol{z}$) in the disability equation also includes current income from investments, since interest, rent, dividends, private pensions and annuities are returns on assets accumulated over the lifecycle and are, consequently, good indicators of the past access to resources that exerts a cumulative positive influence on health. For the same reason, we also include a measure of financial wealth[6] in the disability equation and a dummy variable to indicate home ownership. Note that the income measure used as a covariate in the disability equation excludes current receipt of disability benefits, since those are a consequence, rather than a determinant, of current disability.

Rather than use an arbitrary equivalence scale to adjust income for household composition, we include a dummy variable to indicate whether the household contains a single person or a couple in the disability and SoL equations. In line with previous work (Zaidi and Burchardt, 2005, Stewart, 2009), we also include a set of personal characteristics including age, gender, level of education, home ownership and marital status, together with regional dummies to reflect geographical differences in cost of living and in health.

4. PARAMETER ESTIMATES AND ANALYSIS

4.1. ESTIMATES OF THE STRUCTURAL EQUATION MODEL

Estimation results for the model comprising equations (9)-(12) are presented and discussed in Tables 4-6.[7] The log-quadratic form of the SoL equation fits the data best (see Table 7). The estimated measurement equations (9) and (10) using this form of the SoL equation, are summarised in Tables 4 and 5. They show respectively the factor loadings λ_q which capture the effect of the latent standard of living index φ on the indicators S_q, and the factor loadings μ_k associated with the disability score η. We also report the squared correlation of each indictor with the underlying latent construct. The factor loadings are all positive and highly significant.

Being unable to afford to replace/renew durable goods or to keep the home in a decent state of decoration are the most sensitive indicators of the latent SoL construct φ; the inability to afford house insurance, hobbies or leisure activities are the least sensitive.

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[6] Deposit and saving account balances, stocks, bonds, certificate deposits and other savings held by the household. The information recording the amount of liquid wealth in FRS was severely affected by non-response, which we deal with by imputation based on grossing up investment income. Financial wealth is not used as a covariate in the SoL equation.

[7] Estimates were computed using the robust maximum likelihood estimator of *Mplus 6.11* (Muthén and Muthén, 2010).

Table 4 Standard of Living measurement

Factor loadings λ_q and squared correlations of SoL indicators with φ

Indicator(s):	Factor Loading	R^2
enough money to keep your home in a decent state of decoration	1.229***	*0.710*
hobby or leisure activity	0.86***	*0.545*
holidays away from home one week a year	1.139***	*0.677*
household contents insurance	0.864***	*0.547*
friends/family round for drink or meal at least once a month	0.972***	*0.604*
make savings of £10 a month or more	1.001***	*0.618*
two pairs of all weather shoes for each person in the HH	0.895***	*0.564*
replace any worn out furniture	1.789***	*0.838*
replace or repair broken electrical goods such as fridge, washing machine	1.615***	*0.809*
money to spend each week on yourself, not on your family	1.08***	*0.654*

Significance: * = 10%; ** = 5%; *** = 1%; R^2 is the squared correlation between *Sq* (*Can afford to do/have things or goods indicators*) and φ. Estimates are obtained using the quadratic in ln(Y) model specification.

The highest correlation with the latent disability construct is found for indicators of difficulties with mobility, lifting and dexterity, while lower correlations are found for indicators of cognitive disability.

Table 5 Disability measurement

Factor loadings μ_k and squared correlations of disability indicators with η

Indicator(s):	Factor Loading	R^2
difficulty in mobility (moving about)	2.138***	*0.840*
difficulty with lifting, carrying or moving objects	2.435***	*0.872*
difficulty with manual dexterity using hands for daily tasks	1.327***	*0.669*
difficulty - continence (bladder/bowel control)	0.766***	*0.402*
difficulty with communication (speech, hearing or eyesight)	0.656***	*0.330*
difficulty with memory/concentration/learning/understanding	0.813***	*0.431*
difficulty with recognising when in physical danger	0.737***	*0.384*
difficulty with your physical co-ordination	1.382***	*0.686*
difficulty in other area of life	0.465***	*0.198*

Significance: * = 10%; ** = 5%; *** = 1%; R^2 is the squared correlation between D_k and η. Estimates in the table are obtained using the quadratic in ln(Y) model specification.

Results reported in Table 6 show that the conditional mean of η increases almost linearly with age, although we allowed for non-linearity using a spline function of age, with a single node at the median age 73 observed in the sample. The structural estimates provide no evidence of a significant relation with gender. Indicators measuring economic well-being are jointly significant at the 1% level: more educated individuals experienced a low level of disability as well as those with high current pre-disability benefit income. A negative relation between wealth and disability emerges and this relation involves both housing wealth (captured by owner-occupation) and financial wealth.

Table 6

Estimates of the structural parameters of the disability equation

Covariate(s):	Coeff.	S.E.
Spline age 73	0.033***	*0.002*
Spline age 73 and over	0.033***	*0.003*
Female	-0.005	*0.028*
Post-compulsory schooling	-0.036***	*0.009*
(ln) pre-disability benefit income	-0.114***	*0.028*
Home ownership	-0.299***	*0.034*
(ln) financial wealth	-0.029***	*0.004*

Note: Significance: * = 10%; ** = 5%, *** = 1%; ¹ Cut-off set to 73, the median age in the sample. Model also includes controls for region of residence and marital status. R^2=0.127. Estimates are obtained using the quadratic in ln(Y) model specification.

Estimates for the regression coefficients of the SoL equation are reported in Table 7, using three different functional forms of $f(Y)$: the linear-in-income (model 1); the linear-in-log income (model 2); and the quadratic-in-log income model (model 3). Age, level of education, home ownership, marital status and region of residence are found to be highly significant at the 1% level and their signs, for the most part, are as expected. A gender dummy is not significant. Here, we focus on the structural parameters of interest in deriving the equivalence scale. The structural estimates of the α_1 and γ provide strong evidence that latent disability and current income affect the SoL. Increased disability is associated with lower values of the SoL index, while income is positively associated with the SoL, no matter which functional form is used. Holding other variables constant, a 1-standard deviation increase in disability η

produces a reduction of 0.233 standard deviations in φ using model 1, 0.254 using model 2 and 0.236 using model 3. The estimated income coefficients imply that a £10 increase in weekly income increases SoL by 0.03 standard deviations in model 1 and in model 2 a 10% increase in net income produces an increase of about 0.0631 standard deviations in the SoL. In model 3, the coefficient associated with the added square of log household income is significant at the 1%, implying a significant non-linear relationship of income and the SoL index φ. Thus, controlling for disability level, disability costs appear to vary with income in both absolute terms and as a proportion of income.

At the bottom of Table 7 we report the number of free estimated regression parameters (k), the maximized log-likelihood (L) and its correction for non normality factor (CF), the Akaike information criterion AIC and the Bayesian Information criterion BIC for the model comprising equations (9)-(12). According to these measures the quadratic-in-log form (model 3) fits the data best but, as the plots in Figure 2 show, its implications are remarkably close to those of the linear specification.

Table 7

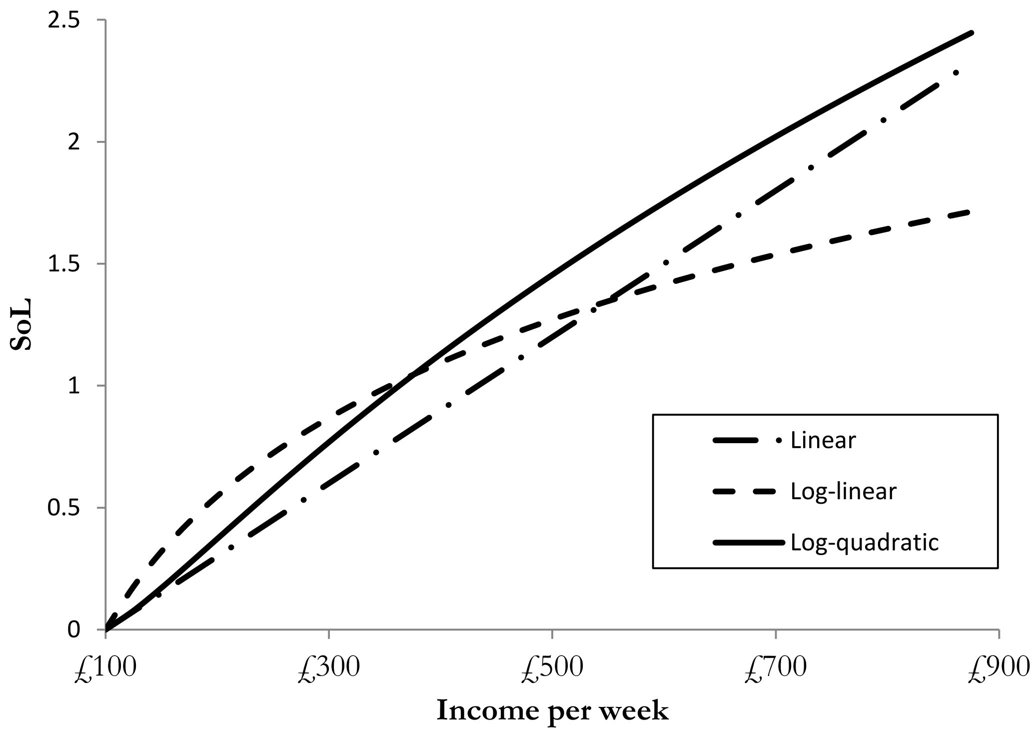
The standard of living equation: parameter estimates for latent disability and income

	Model (1) linear in Y		Model (2) linear in ln(Y)		Model (3) quadratic in ln(Y)	
Parameter(s):	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
α_1^{STD}	-0.233***	0.016	-0.254***	0.016	-0.236***	0.016
γ_1^{STD}	0.003***	0.001	0.631***	0.026	-2.61***	0.201
γ_2^{STD}					0.307***	0.019
K	74		74		75	
L	-38718.413		-38759.401		-38694.623	
CF	1.004		0.992		0.994	
AIC	77584.826		77666.803		77539.247	
BIC	78103.552		78185.529		78064.983	

Notes: Significance: * = 10%; ** = 5%, *** = 1%. Models also include regional dummy variables and controls for socio-economic characteristics which are reported in Appendix B. R^2 of model (1), (2) and (3) are 0.384; 0.334; and 0.382, respectively.

Figure 2

Estimated form of the Income-SoL profile



4.2. DISABILITY COSTS AND EQUIVALENCE SCALES

On the basis of the parameter estimates displayed in table 7 and after selecting the reference level of disability D_0, we can derive the relative/absolute costs of disability, under the three models, defined as the minimal compensating amount (3). The procedure is as follows. First, we calculate the model-based posterior prediction $\hat{\eta}$ as the estimate of the expectation of η conditional on all observed information for the individual. Second, we calculate the estimate of disability cost as (4), (5) or (7) evaluated at the point $\hat{\eta}$. Finally, we calculate means of these estimated costs by decile of $\hat{\eta}$.[8]

Since we use a continuous measure of disability, the definition of D_0 is less straightforward than when using a dichotomous indicator. We can think of D_0 as a reference level of disability above which some financial compensation is judged

[8] Note that this is a conservative estimate, for the log-linear and (to a lesser extent) the log-quadratic model. Because of the convexity of the *exp*(.) function in (5) and (7), the true average cost will be understated: to a degree that depends on the posterior variance of η.

appropriate, but how should this reference level be chosen? Table 8 reports the prevalence of reported difficulties by decile of $\hat{\eta}$. As noted in section 4, about 53% of the sample reported some disability. All individuals who fall in the highest four deciles of $\hat{\eta}$ reported at least one disability, most having a difficulty with mobility, lifting, carrying or moving objects. The mean number of reported disabilities increases non-linearly with position in the latent disability distribution. It is clear from Table 8 that there is a definite discontinuity at the median and, as a consequence, we adopt the median level of $\hat{\eta}$ (D_0 = 0.972) as our reference level. Figure 3 shows the empirical kernel distribution of the predicted disability index $\hat{\eta}$ from the log-quadratic model.

Table 8

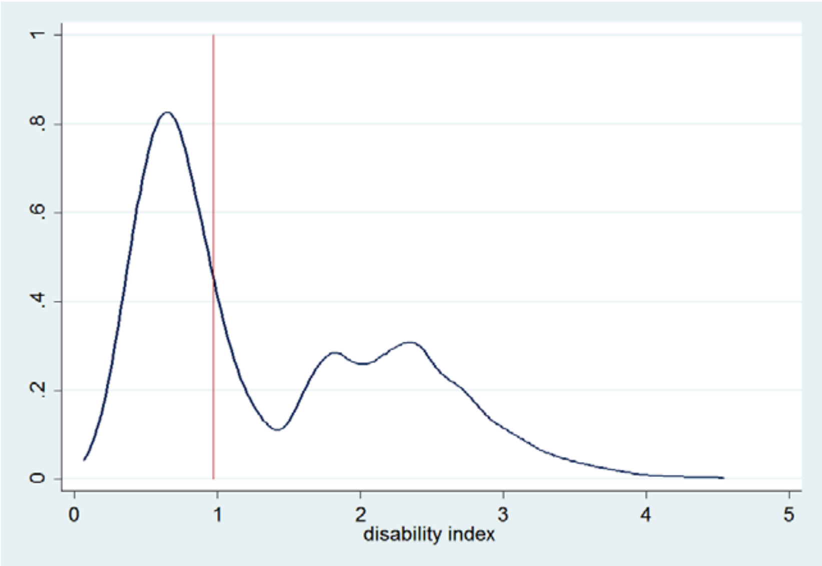
Self-reported difficulties by decile of $\hat{\eta}$

	% of those who reported		
Decile of $\hat{\eta}$	any difficulties	difficulties with mobility, lifting, carrying or moving objects	Number of difficulties reported
1	0.0%	0.0%	0.00
2	0.0%	0.0%	0.00
3	0.0%	0.0%	0.00
4	0.2%	0.0%	0.00
5	5.5%	0.0%	0.06
6	63.2%	2.3%	0.67
7	100.0%	91.8%	1.22
8	100.0%	98.4%	2.22
9	100.0%	100.0%	3.03
10	100.0%	100.0%	4.97
Mean	46.9%	39.2%	1.22

Notes: Statistics computed over a sample of 8,183 FRS 2007-8 respondents.

Figure 3

Kernel Density Estimator of η



Notes: vertical line represents the reference level of disability (D_0).

Income and receipt of disability benefits by decile of latent disability are displayed in Table 9. Average weekly post-disability benefit household income (Y) is reported per-capita and without adjustment for household composition. The association between disability and socio-economic status is widely recognized (see for instance Cutler *et al.*, 2011 and Goldman, 2001 for a review) although the extent to which this association reflects causality is still in debate (Conti *et al.*, 2010). Similarly we find that there is a strong association between disability and per-capita income which declines monotonically until the fifth decile of η and is almost flat afterwards. Thus poor health and low income are strongly associated even if the measure of income used, as here, includes the disability benefit that individuals receive. The last 3 columns of Table 9 show the percentage of individuals in the sample in receipt of any disability benefit by decile of latent disability, the proportions of those recipients who are in each disability decile and the average amount of disability benefits received by individuals in each disability decile. The proportion of individuals in the sample who receive these benefits ranges from under 2% in the lowest disability decile to 50% in the top decile. Overall, amongst those in the upper half of the disability distribution the percentage is 27%. Although current disability benefits appear well targeted on disabled people, a significant proportion of those who face severe disability do not receive disability benefits. Non take-up of disability benefits among disabled people has been noted elsewhere (Pudney, 2010, Currie and Madrian, 1999) and the receipt of disability benefit may often be delayed by several years after disability onset (Zantomio, 2010).

Table 9

Mean income and receipt of disability benefits by deciles of latent disability

Decile of $\hat{\eta}$	Mean Y[a] £s pw, 2007 prices		% of individuals receiving disability benefits	% of individual disability benefit recipients in each disability decile	Average amount of disability benefit[b] received £s pw, 2007 prices
	Per capita	Unadjusted for household composition			
1	263.90	442.90	1.8	1.2	1.20
2	206.00	353.10	3.2	2.0	1.90
3	187.40	309.10	3.6	2.3	2.30
4	162.80	257.70	5.0	3.2	2.70
5	141.30	203.80	6.9	4.4	4.00
6	148.70	221.50	10.3	6.6	6.30
7	172.20	264.10	15.5	10.0	10.00
8	175.50	263.80	24.1	15.4	15.70
9	174.10	255.50	35.6	22.8	23.50
10	181.70	264.10	50.1	32.1	37.80
Mean for deciles 6 to 10	*170.40*	*253.80*	*27.1*	*86.9*	*18.60*

Notes: Statistics computed over a sample of 8,183 FRS 2007-8 respondents. All monetary values are rounded to the nearest 10p.
a. Household income including disability benefit.
b. Measured at the individual level.

Estimated costs of disability are presented in Table 10. There are 260 cases (out of 8,183 in the estimation sample) where the condition $C \leq {\gamma_1}^2/4\gamma_2$ in equation (8) is violated. All have a combination of low income (mean £88 compared to £290 for the full sample) and low estimated latent disability (mean 0.65 compared to 1.40). In the calculations reported below, we set their disability costs to zero; the alternative procedure of dropping cases with very low income and disability leads to virtually identical estimates.

Average estimated disability costs (Δ) and the equivalence scale (σ) are displayed in Table 10 by deciles of $\hat{\eta}$ (above the median) for each of the three model variants[9]. On

[9] Appendix A reports equivalence scales and disability costs among disabled people by deciles of household income.

average, a person in the upper 50% of the disability distribution requires an additional £90 to reach the same standard of living as a comparable person at the median level of disability, according the linear model. Average disability costs are about £17 per week in the sixth decile of the disability distribution, rising to £164 in the top decile. For the log-linear specification the estimated disability costs are higher (about £154 per week for those in the upper 50% of disability) and they increase more sharply with disability. The log-quadratic model generates estimates which are much closer to those of the linear model, but with slightly higher values in the upper tail of the disability distribution. The estimated average cost of disability among the upper 50% of disabled people is about £99 per week; in the top decile of disability it is £180.

The most important observation on the estimates of the equivalence scale (σ) is that σ increases with disability[10]. If we define a disabled person as someone with a disability in the top half of the disability distribution, an older disabled person requires, on average, an increase of about 55% of net weekly pre-disability household income (Y_0) to reach the same standard of living as a comparable non-disabled person, according to the linear model. Average disability costs are about 11% of Y_0 in the sixth decile of the disability distribution, rising to 106% in the top decile. For the log-linear specification, estimated disability costs are about 65% higher on average in the disabled population and increase more sharply with disability. The log-quadratic model generates estimates which are much closer to those of the log-linear model, but with slightly lower values in the upper tail of the disability distribution. The average extra cost of disability is about 62% of the net weekly pre-disability household income.

[10] By construction, σ obtained using model 1 and 2 is lower than 1 for those individuals who fall below the median level of disability $[g(D) < g(D_0)]$ and increases afterwards. However, nothing prevents the equivalence scale derived from model 3 for some people with disability level below D_0 from being greater than 1. That is because the base dependent equivalence scale we derived from specification 3 while increases with level of disability, it is a decreasing function of income. In practice this occurs for only 1.07% of the sample.

Table 10

Estimated costs of disability and average equivalence scale by deciles of latent disability

Decile of $\hat{\eta}$	Model (1) linear in Y		Model (2) linear in ln(Y)		Model (3) quadratic in ln(Y)	
	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ
6	17.40	1.11	23.10	1.10	22.10	1.21
7	62.00	1.35	95.10	1.38	67.80	1.40
8	91.00	1.50	149.60	1.60	98.00	1.54
9	116.30	1.72	193.10	1.83	126.10	1.78
10	163.70	2.06	307.50	2.36	179.90	2.17
Mean for deciles 6 to 10	*90.0*	*1.55*	*153.60*	*1.65*	*98.70*	*1.62*

Notes: Estimates of Δ are unadjusted for household composition. All monetary values are rounded to the nearest 10p. Reference disability level for computing Δ and σ is the median.

5. SENSITIVITY ANALYSIS

In this section we discuss the sensitivity of our results to (*i*) the assumption that the costs of disability and the equivalence scale are independent of household composition, (*ii*) the income definition, and (*iii*) the construction of the SoL measure.

Demographic invariance The three models of the previous section imply invariance of the equivalence scale to household size and structure. This has the advantage that a benefit system with the same property does not create incentives for potential claimants to change their household type to increase their level of entitlement (Pendakur, 1999). We test whether estimates of the best-fitting quadratic model are sensitive to the assumption of demographic invariance by using a two-group analysis where we allow the parameters of the SoL equations (9) and (11) to differ for respondents from single-person and two-person households. In contrasting this with the unrestricted model, the Akaike information criterion suggests that the unrestricted model provides a slightly better balance of model fit and parsimony. In contrast, a Satorra-Bentler test (Muthén and Muthén, 2005) gives a $\chi^2(27)$-statistic of 70.85 (p=0.000) in favour of the restricted one. Panel (1) in table 11 shows the equivalence scale and the extra cost of disability computed for single people and couples, by disability index η. It should be noticed however, that about 58% of single people, compared with 44% of couples, belong to the top four deciles of $\hat{\eta}$. Thus single people (mainly widows) on average experience higher disability levels than people in couples (see also Zaidi and Burchardt, 2005). On the other hand, household income (not adjusted for household composition) of people in couples is generally higher than for single people. So that the reduction in the living standard caused by a given disability level is higher (lower) in relative (absolute) terms for single people than couples.

Housing wealth A further sensitivity analysis makes some allowance for housing wealth. We re-estimate equations (9)-(12) adding to the income variables in equations (11) and (12) an annual return from the (estimated) house wealth of 2% and 4%, respectively[11]. This increases the household income measure only for the 76% of people who are owner occupiers. Estimates of equivalence scales and the extra costs of disability using a 2% and 4% return on housing wealth are remarkably close to the base case and are reported in panel (2) of Table 11.

Interpretation of SoL indicators A final sensitivity test sets the indicators S equal to 0 even in cases where respondents replied *"We/I do not want/need this"* to the deprivation question (see section 2). This produces a lower coefficient for η (-0.272) a higher γ_1^{STD} (-1.793) and a lower γ_2^{STD} (0.217), yielding an estimate of the extra cost of disability among disabled people of about 89% of their household income. Results are shown in panel (4) of Table 11.

[11] Estimates of housing wealth are derived by estimating an interval regression using recorded Council Tax band information and a set of controlling characteristics available in the FRS. Council Tax is a local property tax for which all domestic properties have been valued and the value placed in a band. This regression gives us a vector of estimated coefficients with we use to derive homeowners' expected housing wealth conditional on being in the respondent council tax band, evaluated at the time when their properties were last valued (1991 for England and Scotland and 2005 in Wales). Finally, observed regional changes in house prices between then and 2007 are applied to yield estimated housing wealth in 2007 prices. Return on housings wealth is then computed at a weekly basis (dividing the assumed annual return by 52).

Table 11

Sensitivity Analysis: mean costs of disability and equivalence scale by deciles of η

Decile of $\hat{\eta}$	(1) Couples (N=4,752)		(1) Singles (N=3,438)		(2) Returns from Housing wealth 2%		(2) Returns from Housing wealth 4%		(3) SoL indicator = 0 if does not want/ have / or cannot afford to, 1 otherwise	
	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ
6	23.60	1.11	14.70	1.15	21.40	1.20	21.70	1.20	29.90	1.23
7	74.00	1.31	55.40	1.42	66.30	1.39	67.30	1.40	100.70	1.56
8	108.20	1.43	80.60	1.57	96.10	1.52	97.40	1.53	148.90	1.78
9	139.00	1.55	102.40	1.82	123.50	1.76	125.20	1.77	192.20	2.13
10	197.10	1.82	147.40	2.25	176.30	2.14	178.90	2.15	281.30	2.74
Mean for deciles 6 to 10	*107.60*	*1.44*	*80.60*	*1.65*	*96.70*	*1.60*	*98.10*	*1.61*	*150.50*	*1.89*

Notes: Estimates of Δ are unadjusted for household composition. All monetary values are rounded to the nearest 10p.

6. Discussion and Conclusions

In this paper, we have applied the standard of living approach to estimate the cost of disability among older people in Great Britain and extended previous research by developing a two-latent factor structural model to estimate equivalence scales for disability. Disability is treated as a latent construct which is measured imperfectly by a vector of survey indicators and is influenced by observed socio-economic characteristics. Ten indicators of deprivation are used as observable counterparts of the latent continuous index of SoL, which varies in relation to household income and disability. Our approach allows us to construct a base-independent equivalence scale which takes account of the severity of disability. The restrictions on preferences imposed by the assumption of a base-independent equivalence scale for disability are not supported by our data. This implies that the extra income that disabled people on higher incomes need to be as well off as their non-disabled counterparts is lower than the equivalent sum needed by disabled people on lower incomes. Our application is the first, in our knowledge, to derive an equivalence scale for disability using a log-quadratic function on income of the kind that has been used in Engel curve studies.

The results show that the extra costs of disability are substantial, and rise with severity. Using the 2007/8 wave of the FRS we estimate that an older disabled person, defined as someone above the median level of disability for all older people, requires a net household income around 62% higher than that of a comparable person with a median level of disability to reach the same standard of living. This corresponds to around £99 per week on average as an allowance for the additional costs that households with a disabled member face. Only about 27% of those whom we estimate to face disability-related costs, are in receipt of disability-related cash benefits. In line with previous findings (Berthoud *et al.*, 1993; Thompson *et al.*, 1990) we find evidence that, although disability benefits are received mainly by people who do indeed face disability costs, they do not meet the full costs of disability for recipients, and a high proportion of people with severe disability do not receive disability benefits at all.

We have also investigated the sensitivity of our estimates to various aspects of the econometric specification, the measurement of SoL and the treatment of housing wealth. Estimates obtained using the preferred quadratic model are remarkably close to those obtained when a simple linear-in-income form is used. The estimates are sensitive to whether the equivalence scale is constrained to be the same for single people and couples and the reduction in living standards for a given disability level appears to be higher (but not parallel) for single people than for couples. Thus separate disability equivalence scales are needed for the two groups. The estimates are only marginally sensitive to the inclusion of the return on housing wealth in income.

The estimated equivalence scale is very sensitive to the way answers to survey questions on deprivation are interpreted. If we were to interpret all cases of non-possession as equivalent to deprivation, we would estimate that an older disabled person requires a net household income around 89% higher than a comparable non-disabled person to reach the same standard of living, compared with 62% when the index is based only on explicit inability to afford.

Our clear – and robust – conclusion is that the disability costs faced by British older people are substantial and increase strongly with severity of disability. Comparisons of the incomes of disabled and non disabled older people must make adequate allowance for these costs if meaningful inferences about their relative living standards are to be drawn.

REFERENCES

Adams, P., Hurd, M. D., McFadden, D., Merrill, A., and Ribeiro, T. (2003). Healthy, wealthy, and wise? Tests for direct causal paths between health and socioeconomic status. *Journal of Econometrics*,112(1), 3-56.

Banks, J., Blundell, R., and Lewbel, A. (1997). Quadratic Engel curves and consumer demand. *The Review of Economics and Statistics*, 79(4), 527-539.

Berthoud, R, Lakey, J., and McKay, S. (1993). *The Economic Problems of Disabled People*. London: Policy Studies Institute.

Berthoud, Richard. (1991). Meeting the costs of disability. In G. Dalley (Ed.), *Disability and Social Policy*. London: Policy Studies Institute.

Berthoud, Richard, Blekesaune, M., and Hancock, R. (2009). Ageing, income and living standards: evidence from the British Household Panel Survey. *Ageing and Society*, 29(07), 1105.

Burchardt, Tania. (2004). Capabilities and disability: the capabilities framework and the social model of disability. *Disability and Society*, 19(7), 735-751.

Conti, G., Heckman, J., and Urzua, S. (2010). The education-health gradient *American Economic Review*, 100 (2), pp. 234-38.

Coulter, F. A. E., Cowell, F. A., and Jenkins, S. P. (1992). Differences in needs and assessment of income distributions. *Bulletin of Economic Research*, 44(2), 77-124.

Cullinan, J, Gannon, B, and Lyons, S. (2011). Estimating the extra cost of living for people with disabilities. *Health Economics*, 20 (5), 582-599.

Currie, J., and Madrian, B. C. (1999). Health, health insurance and the labor market. In O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics vol. 3C* (pp. 3309-3416). New York: Elsevier Science.

Cutler, D. M., Lleras-Muney, A., and Vogl, T. (2011). Socioeconomic status and health: dimensions and mechanisms. In S. Glied, P.C. Smith (Ed.), *Oxford Handbook of Health Economics*, Oxford: Oxford University Press

Deaton, A., and Paxson, C. (1998). Economies of scale, household size, and the demand for food. *Journal of Political Economy*, 106(5), 897-930.

Department for Work and Pensions. (2009). *Households Below Average Income 1994/95-2007/2008*. London, The Stationery Office.

Department for Work and Pensions. (2009). *Family Resources Survey, 2007–8*. London, The Stationery Office.

Doessel, D. P., and Whiteford, H. (2004). Applying concepts from Mill and Sen to the standard of living for disabled people. *Mimeo. Brisbane: Queensland Centre for Mental Health Research, University of Queensland, Australia*, 1-27. Retrieved from http://www.ecosoc.org.au/files/File/TAS/ACE07/presentations (pdf)/Doessel.pdf.

Feinstein, A. R., Josephy, B. R., and Wells, C. K. (1986). Scientific and clinical problems in indexes of functional disability. *Annals of Internal Medicine*, 105(3), 413-420.

Goldman, N. (2001). Inequalities in health: disentangling the underlying mechanisms. In A. Weinstein, M., Hermalin (Ed.), *Strengthening the Dialogue between Epidemiology and Demography*. Annals of the New York Academy of Sciences.

Gordon, D., Adelman, L., Ashworth, K., Bradshaw, J., Levitas, R., Middleton, S., Pantazis, C., Patsios, D., Payne, S., Townsend, P. and Williams, J. (2000). *Poverty and Social Exclusion in Britain*. York: Joseph Rowntree Foundation.

Hancock, R., and Pudney, S. (2010). The distributional impact of reforms to disability benefits for older people in the UK. University of Essex: ISER Working Paper no. WP2010-35.

Hartigan, I. (2007). A comparative review of the Katz ADL and the Barthel Index in assessing the activities of daily living of older people. *International Journal of Older People Nursing*, *2*(3), 204-212.

Jones, A., and O'Donnell, O. (1995). Equivalence scales and the costs of disability. *Journal of Public Economics*, *56*(2), 273-289.

Kasparova, D., Marsh, A., and Wilkinson, D. (2007). *The take-up rate of Disability Living Allowance and Attendance Allowance : Feasibility study*. London: Department for Work and Pensions, Research Report No 442.

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., and Jaffe, M. W. (1963). Studies of illness in the aged. *The Journal Of The American Medical Association*, 185(12), 914-919.

Lelli, S. (2005). Using functionings to estimate equivalence scales. *Review of Income and Wealth*, (2), 255-285.

Lewbel, A. (1997). Consumer demand systems and household equivalence scales. *Handbook of Applied Econometrics*, 2, 167-201. Oxford: Blackwell.

Mahoney, F. I., and Barthel, D. W. (1965). Functional evaluation: the Barthel Index. *Maryland State Medical Journal*, 14(2), 61-65. Martin, J., and White, A. (1988). *The financial circumstances of disabled adults living in private households*. London: HMSO.

Mckay, S. (2004). Poverty or preference: What do "Consensual Deprivation Indicators" really measure? *Fiscal Studies*, 25(2), 201-223.

Mckay, S. (2008). Measuring material deprivation among older people : Methodological study to revise the Family Resources Survey questions. London: Department for Work and Pensions, Working Paper No 54.

Morciano, M., Zantomio, F., Hancock, R., and Pudney, S. (2010). Disability status and older people's receipt of disability benefit in British population surveys : a multi-survey latent variable structural equation approach. Paper presented at the Winter Health Economists' Study Group (HESG) meeting, London.

Muellbauer, J. (1979). McClements on equivalence scales for children. *Journal of Public Economics*, 12, 221-231.

Muthén, L. K., and Muthén, B. O. (2005). Chi-square difference testing using the S-B scaled chi-square. *Note on Mplus website*, www.statmodel.com.

Muthén, L. K., and Muthén, B. O. (2010). *Mplus User's Guide. Sixth Edition*. Los Angeles: Muthén and Muthén. Retrieved from http://www.statmodel.com.

Nelson, J. A. (1993). Household equivalence scales: Theory versus policy? *Journal of Labor Economics*, 11(3), 471.

Pendakur, K. (1999). Semiparametric estimates and tests of base-independent equivalence scales. *Journal of Econometrics*, 88(1), 1-40.

Pollak, R. A., and Wales, T. J. (1979). Welfare comparisons and equivalence scales. *The American Economic Review*, 69(2), 216–221.

Pudney, S. (2010). Disability benefits for older people: How does the UK Attendance Allowance system really work ? University of Essex, ISER Working Paper no. 2010-02.

Saunders, P. (2007). The costs of disability and the incidence of poverty. *Australian Journal of Social Issues*, 42(4), 461-480.

Smith, N., Middleton, S., Ashton-Brooks, K., Cox, L. and Dobson, B. (2004) *Disabled people's costs of living: more than you would think* York: Joseph Rowntree Foundation

Stapleton, D., Protik, A., and Stone, C. (2008). *Review of international evidence on the cost of disability*. Department of Work and Pensions research report 542. Retrieved from http://statistics.dwp.gov.uk/asd/asd5/rports2007-2008/rrep542.pdf

Stewart, M. B. (2009). The estimation of pensioner equivalence scales using subjective data. *Review of Income and Wealth* 55(4), 907-929.

Thompson, P, Lavery, M, and Curtice, J (1990) *Short-changed by Disability* London: Disability Income Group

Zaidi, A., and Burchardt, T. (2005). Comparing incomes when needs differ: Equivalization for the extra costs of disability in the UK. *Review of Income and Wealth*, 51(1), 89-114.

Zantomio, F. (2010). Older people's participation in disability benefits: targeting, timing and financial wellbeing. University of Essex, ISER Working Paper no. WP 2010-23.

APPENDIX A:

EQUIVALENCE SCALE AND DISABILITY COSTS AMONG PEOPLE IN THE UPPER 50% OF THE DISABILITY DISTRIBUTION BY DECILES OF PER CAPITA Y

Decile of per capita pre-disability benefit income[a] *(% of disabled people[b] in each decile)*	mean Y[c] £s pw, 2007 prices		Model (1) linear in Y		Model (2) linear in ln(Y)		Model (3) quadratic in ln(Y)	
	Per-capita	Unadjusted for household composition	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ	Δ £s pw, 2007 prices	σ
1 *(60.1%)*	95.10	141.50	95.60	2.16	81.50	1.72	115.60	2.65
2 *(59.6%)*	109.40	180.20	88.10	1.63	106.10	1.64	89.70	1.65
3 *(56.7%)*	127.60	204.50	89.80	1.56	120.70	1.65	90.90	1.57
4 *(63.8%)*	136.20	186.60	87.30	1.58	111.30	1.63	87.90	1.57
5 *(55.0%)*	149.30	211.40	89.20	1.51	133.20	1.65	91.00	1.51
6 *(52.1%)*	167.90	249.50	92.70	1.47	155.00	1.68	96.20	1.47
7 *(46.2%)*	192.90	287.40	89.90	1.39	167.40	1.65	95.40	1.41
8 *(42.7%)*	226.40	344.70	88.80	1.31	205.80	1.63	100.80	1.34
9 *(33.2%)*	270.00	403.50	90.10	1.27	246.90	1.64	108.60	1.31
10 *(30.4%)*	412.10	594.90	88.10	1.17	377.80	1.63	130.20	1.23
Overall mean (50.0%)	*170.40*	*253.80*	*90.00*	*1.55*	*153.60*	*1.65*	*98.70*	*1.62*

Notes:
a. Deciles computed over the pre-disability benefits income distribution of the whole population which includes non-disabled people.
b. Disabled people defined as those in the upper 50% of the distribution of disability
c. Household income including disability benefit.
Δs are unadjusted for household composition. Monetary values are rounded to the nearest 10p.

APPENDIX B:

PARAMETER ESTIMATES FROM THE STANDARD OF LIVING EQUATION IN THE THREE VARIANTS

	Model (1) Linear in Y		Model (2) Linear in ln(Y)		Model (3) Quadratic in ln(Y)	
Covariate(s):	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
η	-0.277***	*0.020*	-0.29***	*0.020*	-0.281***	*0.020*
(in s.d. units)	*-0.233****	*0.016*	*-0.254****	*0.016*	*-0.236****	*0.016*
linear in Y	0.003***	*0.000*				
(in s.d. units)	*0.003****	*0.000*				
linear in ln(Y)			0.79***	*0.036*	-3.424***	*0.272*
(in s.d. units)			*0.645****	*0.026*	*-2.691****	*0.201*
quadratic in ln(Y)					0.4***	*0.027*
(in s.d. units)					*0.315****	*0.019*
Female	-0.005	*0.033*	0.002	*0.033*	-0.004	*0.033*
(in s.d. units)	*-0.004*	*0.026*	*0.002*	*0.027*	*-0.003*	*0.026*
Spline age 73[a]	0.034***	*0.004*	0.03***	*0.004*	0.034***	*0.005*
(in s.d. units)	*0.026****	*0.003*	*0.025****	*0.004*	*0.027****	*0.004*
Spline age 73plus[a]	0.037***	*0.004*	0.038***	*0.004*	0.037***	*0.004*
(in s.d. units)	*0.029****	*0.003*	*0.031****	*0.003*	*0.029****	*0.003*
Post-compulsory schooling	0.043***	*0.012*	0.062***	*0.011*	0.041***	*0.012*
(in s.d. units)	*0.034****	*0.009*	*0.051****	*0.009*	*0.032****	*0.009*
Home owner	0.497***	*0.037*	0.481***	*0.037*	0.486***	*0.037*
(in s.d. units)	*0.39****	*0.030*	*0.393****	*0.030*	*0.382****	*0.029*
Married/cohabiting	-0.195***	*0.041*	-0.222***	*0.039*	-0.238***	*0.040*
(in s.d. units)	*-0.153****	*0.031*	*-0.181****	*0.032*	*-0.187****	*0.031*

Notes: Significance: * = 10%; ** = 5%, *** = 1%.
a. Cut-off set to 73, the median age in the sample. All models also contain controls for region of residence.