Psychometric Equivalence Scales for Household Composition and Disability – Evidence from the UK

(preliminary – comments welcome)

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Abstract

In this paper we attempt to identify the effect of the presence of a disability of a family member on the monetary needs of the household. We estimate subjective equivalence scales based on UK stated preference data on income satisfaction and assess the impact of disability cost on the income distribution. Our results show that the consumption cost of disability is positive. The overall income distribution is only slightly affected by this adjustment, however, poverty rates based on adjusted income differ from those which are based on nonadjusted income.

JEL Classification: D1, I12

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1 Introduction

In policy, inequality and poverty analysis, household income is often used as an indicator for a family's welfare. However, households differ in composition and needs, and hence, a simple comparison of household incomes might bias the analysis. The established method to overcome this problem in welfare economics is to calculate an *equivalent income* which takes account both of the differing needs and potential economies of scale in the household. In addition, this method allows to calculate the monetary compensation required by a family to achieve the same level of welfare as a reference family. This is useful, for example, for the determination of tax rates or child benefit.

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In the literature, several methods exist to arrive at such an equivalised income, for example, estimation based on family expenditure data, in which needs are identified from changes of spending patterns across families with different composition.[1] A second, relatively new method is to identify needs from stated preference data on satisfaction with household income.[2]

It would be optimal to calculate equivalent incomes which take account of all relevant differences in needs of the households and individuals therein. According to Sen [25], an individual welfare measure should take into account all personal, societal and environmental constraints an individual faces. However, traditional equivalence scales are estimated for household size and composition only. The purpose of this paper is to explore in which way the equivalence scale methodology can be used to calculate welfare measures which meet with Sen's requirements.

Each individual is unique, has infinite needs dimensions, which presents us with two problems. The first is measurement: we do not observe all these dimensions in household data, or even tailor-made questionnaires. The second is akin to the lack of degrees of freedom problem: even if we could observe all individual constraints, econometric estimation which takes into account *all* constraints would be impossible, at least within the traditional framework of equivalent income estimation. This is the reason why it is generally assumed that needs are influenced by a *subset* of characteristics of the household or its members, such as the household size or the health of each individual.

A further practical problem consists in the difficulty to distinguish whether a difference in expenditure or satisfaction is derived from a difference in *needs* or rather a difference in *preferences*. This distinction is important, especially if special needs of families, for example owing to a disability, are considered to be policy-relevant, while special preferences, for example, a taste for expensive wine, are rather considered to be the individual's personal business without further relevance for policy. While in this example, the difference is obvious for illustrative purposes, it is more difficult in practice, as we will see presently. The distinction between factors that affect needs and those which affect preferences is necessarily arbitary and requires value judgments on the part of the researcher. One possibility is to simply state that household composition is the only relevant difference between households. Another is to distinguish between needs as those factors beyond an individual's control and preferences as those within his or her control.[3]

In this paper, we will discuss in depths the distinction between needs and preferences. We come to the conclusion that the equivalence scale methodology is as such not the most appropriate technology to calculate a welfare index which meets with Sen's expectations. However, in the belief that disability is both a factor beyond an individual's control and one which inflicts significant

[1] This method was established first by Engel [9], for a recent survey see Deaton [8].

[2] This method is based on works by van Praag [19], [20] and has recently been applied by Bellemare, Melenberg and van Soest [2].

[3] This approach has been developed by Roemer [23] and has recently been applied to the measurement of an opportunity set by Burchardt and Le Grand [4].

costs on a household, we concentrate on extending the usual type of equivalent income estimation by identifying the effect the presence of a disabled family member on the household's monetary needs from UK income satisfaction data.[4] In line with Jones and O'Donnell's and Burchardt's results, our analysis shows that the presence of a disabled family member raises the costs of a household. For households without disabled members, we arrive at similar estimates of equivalent income as McClements for the UK. We also assess the impact this additional cost has on the UK income distribution, and come to the conclusion that this impact is almost negligible. When analysing poverty, however, we conclude that the income adjustment for disability costs has a strong effect.

The paper is structured as follows. In the next section, we explain the principle and methods of estimating equivalent incomes and list the main points of critique to each of them; a discussion of the distinction between factors affecting tastes and needs follows. In section 3 we present the empirical model used in this paper and explain the estimation method and the data used. In section 4 we present the results and section 5 concludes.

2 Equivalent Income as a Consumption Opportunity Set

This section is subdivided into three parts. In section 2.1 we first present a brief review of different methods to calculate equivalent income. We specifically refer to methods which use econometric techniques to identify each household's needs. Subsequently, in section 2.2 we discuss a potential differentiation between factors that affect needs (i.e. constraints on the household) and factors that affect preferences of a household. In the final subsection we explain in detail why we focus on disability in this paper.

2.1 Equivalence Scales

In order to use household incomes as a welfare indicator, it is necessary to make them comparable by taking account of the households' different composition and needs: A household with two parents and two children will most probably need more income to achieve the same level of welfare as a single person living on her own. Similarly, a couple with a handicapped child will require more income than one with an equally aged but healthy child, because they incur in costs of, for example, a wheelchair, ramps, or care. Comparability of incomes of household which exhibit different needs is achieved by the application of *equivalence scales*. An equivalence scale can be defined as a vector $m(\mathbf{z})$ of H normalising constants (H = number of households in the sample) which turn monetary household income y^h into *real*, or *equivalent* household income y^{he} by

[4] To my knowledge, the only paper that makes a similar attempt is Jones and O'Donnell [12] who identify the consumption cost of the presence of disabled members in the household from family expenditure patterns. Burchardt and ? (2002) estimate the cost of disability from standard of living indicators.

taking account of a vector $\mathbf{z}$ of different needs of the household. The scales are calculated with respect to a reference household, r, at a reference level of utility, $\bar{u}$.

$$m^h(\mathbf{z}) \equiv \left.\frac{y^{he}(\mathbf{z})}{y^r}\right|_{\bar{u}} \qquad h = 1, ...H \tag{1}$$

In the literature, four ways of arriving at equivalence scales exist, two of which are econometric and will be described more in detail below. The other two are "expert scales" and "pragmatic scales".[5]

One way of arriving at econometrically estimated equivalence scales is based on expenditure patterns of families. These scales are derived from standard consumer theory. Each household has a utility function u^h which is defined over a vector of goods $\mathbf{q}$, and is conditional on needs, $\mathbf{z}$ and preferences, $\mathbf{x}$, so that

$$u^h = u\left(\mathbf{q}^h, \mathbf{z}^h, \mathbf{x}^h\right). \tag{2}$$

u^h is maximised by the household subject to the budget constraint, $y^h = \mathbf{p}.\mathbf{q}$. It is thus assumed that expenditure patterns vary systematically with household needs.[6] By Shepard's lemma, the estimation of demand systems $\mathbf{q}$ allows the recovery of cost functions $c\left(u^h, \mathbf{p}, \mathbf{z}^h, \mathbf{x}^h\right)$; the equivalence scale is then the ratio of a household's cost function with respect to the reference household's cost function

$$m^h(\mathbf{z}, \mathbf{p}) = \frac{c\left(u^h, \mathbf{p}, \mathbf{z}^h\right)}{c\left(u^r, \mathbf{p}, \mathbf{z}^r\right)}. \tag{3}$$

As price data is often not available, these type of equivalence scales are routinely calculated by estimating Engel curves

$$w_i = f\left(\log\left(y^h\right), \mathbf{z}^h\right) \tag{4}$$

where w_i is the expenditure of the ith good as a fraction of household income. The Engel curves of households with different needs will be shifted as shown in Figure 3. In this case, for simplicity of presentation, the needs are only indicated by household size.

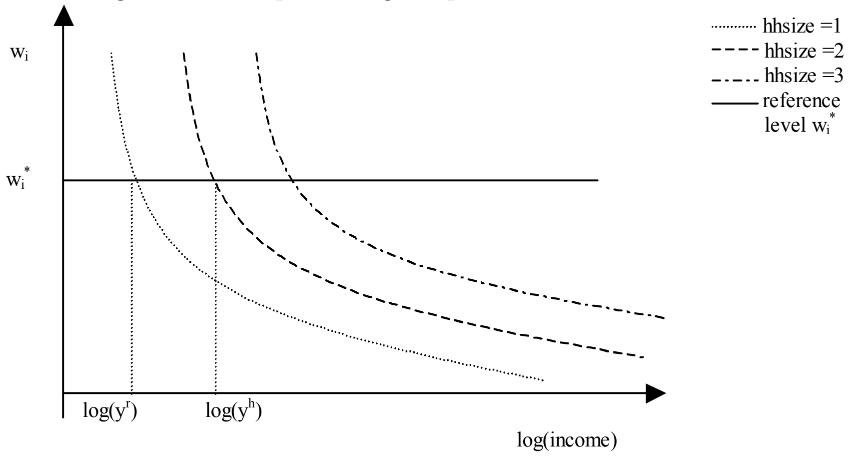
To identify the scales, a reference utility level must be defined; it is assumed that the expenditure share of the good i is a good indicator of the household's welfare. At the chosen reference level of the ith good's share, (in this case the food share, indicated by w_i^*) it is then possible to calculate the additional income that any household requires to be as well of as the reference household (this corresponds to the antilog of the distance between $\log(y^r)$and $\log(y^h)$ in Figure 3).[7]

[5] See Coulter, Cowell and Jenkins [6] for a detailed description and critique of all four. Expert scales are those which are calculated by experts in the Department of Social Security, in a fashion usually unknown to the analyst faced with the scales; pragmatic scales are "rules of thumb" such as the scales prescribed by the OECD.

[6] They also vary with preferences. For a discussion of the different treatment of needs and preferences in the analysis, see below, section 2.2 and 3.3.

[7] It has long been recognised that the food share is not necessarily a good indicator of welfare

Figure 1: Principle of Engle Equivalence Scales – Food Share



Apart from problems relating to the appropriateness of the reference welfare indicator in use, these type of equivalence scales are plagued by identification problems. For example, Pollak and Wales [18] have argued that the cost function and hence equivalence scale cannot be uniquely recovered from demand information, as the corresponding utility function itself can be a function of the characteristics of the household. This is, for example, the case of planned children: Parents presumably plan and subsequently have children because they increase their level of utility. In that case, the utility function is of the form

$$u^h = F\left(u^h\left(\mathbf{q}, \mathbf{z}^h\right), \mathbf{z}^h\right). \tag{5}$$

where F is some monotone transform. Both utility functions (2) and (5) imply the same cost function. The direct increase in utility through children cannot be identified by these methods based expenditure data because only demands *conditional* on a household's characteristics can be estimated. Blundell and Lewbel [3] have argued that, once a true (unconditional) equivalence scale is given for one price regime, conditional equivalence scales can be used to "recover the true values of all equivalence scales in all other price regimes". They suggest (p.59) that psychometric data may be used to help solve the identification problem. Coulter, Cowell and Jenkins ([6],p. 96) agree with Van Praag and Van der Sar [21] that the *psychometric approach* might be a useful complement to the traditional one.

The psychometric approach is the second way of arriving at econometrically estimated equivalence scales. It originated in Van Praag's [20] work on the

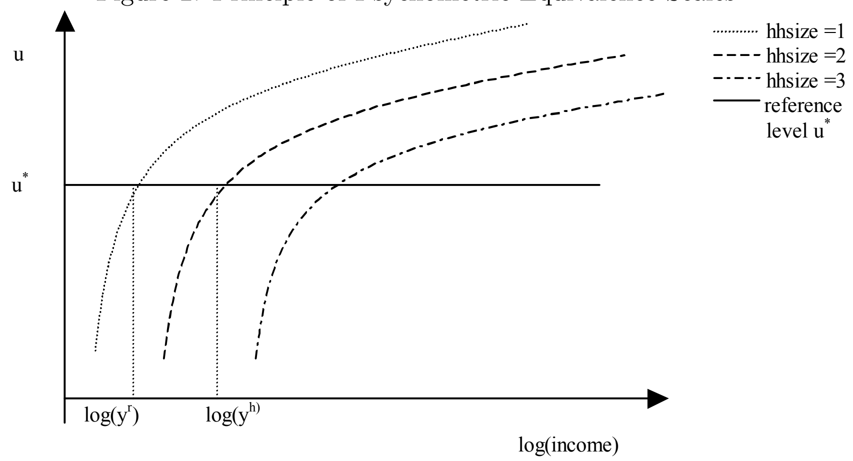
(see Deaton [8] for a detailed analysis, but also Perali [17] for a defense of the method). The related *isoprop method* uses a basket of goods. The Rothbart method uses the level of *adult goods* expenditure in the household. In that case, the Engle curves are upward sloping. There also exist commodity specific scales, such as Barten scales. Deaton provides an overview of all methods based on expenditure data and their respective advantages.

individual welfare function of income and has been applied for the estimation of equivalence scales by Van Praag, Hagenaars and Van Weeren [22], and recently by Bellemare, Melenberg and van Soest [2]. Subjective information on utility is used to estimate a household utility function u^h of income y^h, conditional on $\mathbf{z}$ and $\mathbf{x}$ *directly* so that

$$u^h = u\left(y^h, \mathbf{x}^h, \mathbf{z}^h\right). \tag{6}$$

At a given reference level of income utility, the additional income to make a household equally well off as the reference household can be calculated as shown in Figure 4.[8]

Figure 2: Principle of Psychometric Equivalence Scales



This method suffers from two problems. Firstly, it is viewed suspiciously by economists from the revealed preference school, because it is based on what individuals *say* rather than their *actions*. However, in other areas of economic research the value of stated preference data has been recognised and is used for policy analysis.[9] The second problem is related to the fact that some variables in the utility function are correlated with utility in a non-policy relevant manner. In other words, some factors might affect income satisfaction separately from the effect they have on household costs; for example, a person might be depressed, and therefore never be happy with any household income. This will be covered more in depth in the next section.

[8] Van Praag has devised a lognormal utility function, which implies increasing marginal utility of income where income is low. This functional form as been criticed by Hartog [11] and subsequently by Seidl [24]. In this graph, and in the model below, a log utility function is used instead.

[9] See, for example Louviere, Hensher and Swait [13] for examples in transport policy, marketing, and environmental evaluation. See also Manski [14] for an assessment of the usefulness of psychometric data in econometric applications.

2.2 Preferences versus Needs

Equivalent income that takes into account all special needs a family faces can be interpreted as a *consumption opportunity set*. (see Deaton and Muellbauer [7], p.226). If we subscribe to the individualist principle that each household is the best judge of its own utility, this is a legitimate way to proceed: given the household's preferences, it has the freedom to choose any consumption bundle from this adjusted budget set. This line of argument supposes that differences in needs are ethically relevant, while differences in preferences are not. The factors that affect needs can be interpreted as non-monetary constraints on the household, in addition to the usual monetary budget constraint. To adjust family income for needs requires therefore a distinction between the factors that affect needs and those that affect the preferences of a family. This distinction is difficult in theory, and in practice cannot be identified from the data. In what follows, we will outline the reasons for this, and discuss alternative strategies to differentiate between needs and preferences in applied models.

In theory, preferences and needs are often muddled: current needs are usually an outcome of earlier choices made by the household, the consequences of which should have been taken into account at that time. This is the cited example by Pollak and Wales, where parents have children because they have a preference for them; in overall welfare terms, the utility received from having children outweighs the cost these children inflict upon the household. Similarly, the place of living can impose extra cost (i.e. extra needs) on the household, but location is, at least in principle, subject to choice. In these cases, needs which are a result of a previous choice might not be ethically relevant, and no adjustment of income for these factors would be necessary. Although these arguments are strictly speaking only valid in a world without uncertainty, and with perfect family planning, they illustrate the difficulty to distinguish needs from preferences in theoretical terms.[10]

In practice, we cannot directly measure needs, only factors that affect them. But some of the factors which affect needs also affect preferences. For example, the age of an individual might affect his needs, in that he requires less caloric intake as a pensioner than if working as a carpenter, but on the other hand, the fact that he is a pensioner might influence his preferences in a very different way, maybe in that he has developed a taste for high-quality and thus high-cost holidays. As we will see, health variables can affect both needs and preferences, especially if they concern the mental health of an individual. The presence of children in a household can similarly work as a catalyst on preferences. Although they affect the needs of the household, the fact that children are present might shift parents' preferences to a more homely and thus low-cost life-style than they had before they had children. Alternatively, the ethnic background of an individual might affect her preferences, but might also imply higher costs for her if she is discriminated against because of her skin colour.

In the empirical literature on equivalence scales, often without any further

[10] They also pinpoints to the necessity of a discussion about the responsibility of a household or an individual for his or her previous decisions. This is beyond the scope of this paper.

justification, the difference is made between *preference shifters* and *needs indicators*. Needs indicators are those variables that affect the needs of the household in a (policy) relevant way, most prominently the family size and composition. Taste shifters are those variables which affect the utility function, but presumably not in a (policy) relevant fashion; they might be demographic attributes such as sex or race, or variables more or less subject to choice such as the level of education, location and marital status. They are usually included to achieve unbiased estimation of the remaining parameters. In the actual calculation of equivalence scales, the preference shifters are left out. This differentiation is of course subject to the problems mentioned in the previous paragraph.

In a recent paper on employment opportunities, Burchardt and Le Grand [4] have recognised the difficulty to distinguish constraints from preferences and devised a method to incorporate different levels of constraints successively into the analysis. Drawing on Roemer [23], they distinguish the level of needs by the level of control an individual exercises over it. According to this, characteristics which are outside an individual's control (e.g. sex, race, health) constitute the first layer of constraints of their opportunities, characteristics under long-term control (e.g. education) the second, and the last layer consisted in stated preference indicators. They are careful in pointing out that they conduct a descriptive analysis of opportunity sets, not a normative one, and thus do not derive policy conclusions from their model. Nevertheless, the problem of a differentiation of tastes and needs is not solved. In a sense, the problem above is reversed: while standard equivalence estimation assumes these factors to be taste shifters only, Burchardt and Le Grand assume them to be constraints only, albeit of different importance. Furthermore, unbiased estimation is not guaranteed if the variables at different layers of constraints are correlated with each other. In other words, there might be an omitted variable problem in the estimations which do not involve all constraint layers together.

In summary, theory guides us only in limited ways when we attempt to differentiate factors that affect needs from those that affect preferences, and in practice, the partition between them will be necessarily fuzzy. It is possible to assess the consumption cost of a particular factor that affects needs (e.g. the cost that an additional child implies for the family), although it is not clear that the entire effect is owing to its effect on needs, or that the effect on needs is not softened by a simultaneous impact on preferences. This type of analysis is necessarily subject to value judgments which should be made explicit.

2.3 Disability as a Needs Indicator

Sen's requirements for an appropriate welfare indicator include that it takes account of all personal, social, and environmental restrictions an individual faces while making decisions. Equivalence scale estimation seems to be promising in providing us with an "objective" method for arriving at welfare indicators which meet with these requirements. There are three reasons however, why the equivalence scale method is not suitable for this – at least not more suitable than other methods. Firstly, as we have just seen, the distinction between restrictions owing to taste and those owing to needs remains necessarily arbitrary. Secondly, existing surveys do not have sufficient information on all personal, social and environmental restrictions, especially of individuals. Finally, the equivalence scale methodology assesses consumption opportunity sets indirectly, from stated preference or consumption data. The estimation is based on the idea that households with similar characteristics have similar financial needs. For sufficiently precise estimation, it is required to observe a sufficiently large number of individuals with the same characteristics. By definition, it is therefore impossible to estimate a different equivalence scale for each household in the sample.

Nevertheless, the equivalence scale methodology can be used to estimate welfare measures which take account of a particular additional need. In this paper, we extend the usual analysis, which determines the cost of children, to an assessment of the cost of disability of one or more of the household members. To my knowledge, all but one paper (Jones and O'Donnell [12]) in the demand-based equivalence scale literature and all psychometric equivalence scales only refer to household size and sometimes its demographic composition as needs indicators.[11]

The reason for focussing on disability as an additional factor are threefold. Firstly, it is most probable that the presence of a disabled family member implies considerable additional costs for a household. Necessary expenditures on wheelchairs, adaptation of the house (e.g. ramps), or special computer equipment can all reduce the remaining household budget and hence consumption opportunities significantly. Secondly, disability is a factor beyond an individual's control.[12] Its inclusion is therefore less controversial than, for example, the place of living of a household. Finally, the disability variable we use (whether or not an individual is a registered disabled) is measured relatively objectively, as opposed to, for example, a self-assessed health status or other self-reported needs. It might therefore reflect more precisely the actual needs of a family.

The disadvantages of this variable are its crudeness, and the caveat that we do not know in which way disability affects an individual's preferences. In reality, disability is of course not a black-and-white condition as represented by the dummy-variable with which we measure it. Considerable costs might be incurred by a family due to the health status of one of its members before he or she can officially register as disabled. Similarly, once a person is registered as disabled, the severity of the condition might imply a very different level of additional costs. However, as a first approximation of the cost of disability, we believe this to be a relevant exercise. In the future, we will work on a refinement of this variable.[13] The fact that we do not know how disability affects preferences

[11] Burchardt and ? have recently tried to assess the cost of disability for a household by using a standard of living methodology developed by ?. As they use a rather subjective indicator of standard of living, their method has much in common with the stated preference method.

[12] Aside from pathological cases of self-harm and the decision to have a long-term unhealthy life-style which might lead to a disability.

[13] The difficulty with this is that the number of disabled in the sample is already very small. A finer distinction of levels of disability with additional dummy variables reduces the number

as opposed to needs, remains a limitation of these kind of studies; nevertheless, it might be more reasonable to consider disability a factor that predominantly affects needs than, for example, sex or age by itself.[14]

For consistency in the estimation, we use a range of preference shifters as controls; in the data section below we provide details. We are aware however, and our results are in line with this, that some of the variables affecting preferences also have an effect on needs. As we cannot separate these two effects, we make the conservative assumption that the effect on needs in these cases is negligible.

3 Psychometric Equivalence Scales

This section is divided into three subsections. In 3.1 we present the empirical model of income satisfaction. We then describe the data in section 3.2 and explain the estimation method in section 3.3.

3.1 The model

We assume that overall household utility u^h is additively separable in utility u_c^h derived from consumption and utility derived from other sources, u_o^h such as from being healthy, or having children.

$$u^h = u_c^h\left(consumption\right) + u_o^h\left(health, children, ...\right) \tag{7}$$

In this paper, we are only interested in the first term of the right hand side of 7, i.e. the utility that a household derives from its consumption capacity. For simplicity, in the remainder of this paper, we will speak of u_c^h of the household's *utility*. We further assume that we cannot represent consumption as a composite consumption good across households, as households differ in needs. We therefore separate household consumption, c^h, into basic household consumption, c_b, household consumption due to bigger household size, c_s and household consumption due to other needs, c_z, so that

$$u_c^h = u_c^h\left(c_b, c_s, c_z\right) \tag{8}$$

of observations on which the estimates are based further, so that the results will be even more imprecise. It would be desirable to achieve a continuous variable which indicates the severity of a disability, e.g. the degree of disablement in %, as available in Germany.

[14]The literature on age and gender discrimination is of course, based on the opposite assumption.

where $\frac{\partial u_c^h}{\partial c_i} > 0,\ i = b, s, z$.[15] We assume that each houshold's consumption depends on their income y^h in the following way:

$$\begin{aligned} c_b^h &= f\left(y^h, \mathbf{x}^h\right) \\ c_s^h &= f\left(y^h, \mathbf{s}^h\right) \\ c_z^h &= f\left(y^h, \mathbf{z}^h\right) \end{aligned} \tag{9}$$

where $\mathbf{s}$ is an indicator of size of family, and $\mathbf{z}$ indicates the other needs of the household, for example, the number of disabled individuals. As the different components of c^h are not observable in practice, we work with the reduced form

$$u_c^h = u_c^h\left(y^h, \mathbf{s}, \mathbf{z}, \mathbf{x}\right). \tag{10}$$

This corresponds to a utility function defined over income conditional on a vector of sociodemographic household characteristics which represent factors affecting needs and preferences respectively, as discussed in the previous section.[16].

Here, we follow Melenberg and van Soest [15] and Bellemare, Melenberg and van Soest [2] in using a log utility function of net household income. The empirical model to be estimated consists of a log linear model

$$u^h = \beta_0 + \beta_1 \ln y^h + \boldsymbol{\beta}_2 \mathbf{z}^h + \boldsymbol{\beta}_3 \mathbf{x}^h + \boldsymbol{\varepsilon}^h \tag{11}$$

where ε^h is a normally distributed error term, and utility is interpreted as the level of satisfaction with income. Equation (11) can then be estimated from household survey data.

Real household income $y^{h,e}$ is defined as the income that would allow household h to achieve the same level of income satisfaction as the reference household r. The equivalence scale is hence defined as the ratio of each household's h real income and the reference household's income. We use a single person household without disability as the reference household.

Let household h's and the reference household r's utility function be given respectively, by

$$\begin{aligned} u^h &= \beta_0 + \beta_1 \ln y^h + \boldsymbol{\beta}_2 \mathbf{z}^h + \boldsymbol{\beta}_3 \mathbf{x}^h + \boldsymbol{\varepsilon}^h \\ u^r &= \beta_0 + \beta_1 \ln y^r + \boldsymbol{\beta}_2 \mathbf{z}^r + \boldsymbol{\beta}_3 \mathbf{x}^r + \boldsymbol{\varepsilon}^r. \end{aligned} \tag{12}$$

Estimating the parameters and setting $u^h = u^r$ as in the definition for equivalence scales, and dropping the element related exclusively to preferences $(\boldsymbol{\beta}_3 \mathbf{x})$, we arrive at

$$\hat{\beta}_1\left(\ln y^h - \ln y^r\right) = \hat{\boldsymbol{\beta}}_2\left(\mathbf{z}^r - \mathbf{z}^h\right)$$

[15] Intrahousehold allocation is not taken into account. This is standard practice in most equivalence scales estimation. While it is hardly possible to derive indicators of intrahousehold allocation from aggregate household expenditure, it would be possible to a certain extent to infer about intrahousehold allocation in the case of psychometric scales. This is the topic of a different paper.

[16] Some models of income satisfaction include other variables such as the average income in society (see, for example, Oswald [16]). This is not captured in our model. We believe this not to be a problem as our aim is not to explain income satisfaction *per se*.

As discussed in the previous section, the $\mathbf{x}$ are preference shifters and should not affect the calculation of the scales themselves, which are exclusively based on needs. The equivalence scale is then

$$m^h(\mathbf{z}) = \frac{y^h}{y^r} = \exp\left\{\frac{1}{\hat{\beta}_1} * \hat{\boldsymbol{\beta}}_2\left(\mathbf{z}^r - \mathbf{z}^h\right)\right\} \tag{13}$$

3.2 The Data

The data used in this study are taken from the British Household Panel Survey (BHPS), in scope and purpose very similar to the German Socio-Economic Panel (GSOEP). Since 1992, the BHPS has been conducted as an annual panel survey of a representative sample of approximately 10,000 individuals over the age of 16 in more than 5,000 households. A household questionnaire is answered by the head of household and individual questionnaires answered by all individuals over 16 which are members of this household. The individuals also answer a 'self-completion questionnaire', which provides information on potentially sensitive topics which might be vulnerable to the influence of family members' presence during the completion. In case of individuals which cannot be contacted directly or are too ill to fill in their own questionnaires a much shorter *proxy interview* is conducted with a family member. In case a person cannot be contacted otherwise, a telephone interview is used.

As the telephone and proxy interviews do not provide information on income satisfaction, they are excluded from the analysis. For the estimation in this paper, we used the information provided for the years 1996-1999.[17] 9.3% of the records contain missing data. So far, we have used listwise deletion, under the assumption that the data is missing randomly. This, together with the fact that some household heads did not respond in all panel waves, leads to the estimation of an unbalanced panel. We retained only those households where the household head did not change from 1996 to 1999. The analysis is thus based on 3378 households observed over four years.

Below, we describe the variables used in the analysis. 'Satisfaction with household income' and 'household income' are described in detail. As described, the identification of needs is based on an *a priori* partition of the set of variables. The variables indicating needs are household size, the number of children and their age group and number of adults, and the number of registered disabled living in the household. Variables indicating preferences are listed in the last paragraph. Table 1 summarises the main features of these variables.

- *Satisfaction with household income* u^h. This variable contains the answer to the question "How satisfied are you with your household income". This variable has seven categories from 0 (not satisfied at all) to 6 (completely satisfied).[18]

[17] Although wave J (2000-2001) is in principle available, no comparable income figure is so far available.

[18] The original coding was from 1 (not satisfied at all) to 7 (completely satisfied). We recoded this variable for computational purposes.

- *Household Income* y^h. The income variable used in this analysis is the annual net household income as provided by Jenkins [1], deflated with the corresponding retail price index.[19] The net household income includes disability and child benefits so that the scales calculated below have to be interpreted correspondingly.
- *Household size*: The number of persons living in the household.
- *Number and age group of children:* Number of children in each age group living in the household.
- *Number of adults:* Number of adults living in the household.
- *Number of disabled individuals:* Number of those individuals which are registered disabled living in the household. The inclusion of the number of disabled people is 'additional': a disabled person enters the vector $\mathbf{z}$ twice, once as a family member in his or her age group, and once as a disabled member. This reflects that the cost is born by the household as a whole.
- *Preference shifters*: age, dummies for sex (1 if male, 2 if female), marital status (1 if separated, divorced or living as couple, 0 otherwise)[20], education level (1 if highest education level is lower than GCE A-levels, 0 otherwise) and job status of household head (1 if unemployed or inactive, 0 otherwise), housing tenure (1 if owned without mortgage, 0 otherwise), regional dummies, and time effects.

3.3 Estimation

Given the categorical nature of the dependent variable in our model and the ordinal nature of utility, which is measured by this dependent variable, the appropriate technique for estimating equation (11) is a discrete choice model with a panel structure. Although a seven-category dependent variable is a borderline case in that it could possibly be approximated by a linear regression, preliminary estimates for such models have exhibited considerably higher standard errors than those tailor-made for discrete variable models. As we assume the error term to be normally distributed, the correct model is the ordered probit model.[21] We use the ordered as opposed to the multinomial probit model as the dependent variable has a scale with an intrinsic ordering: the higher the satisfaction with income, the higher the individual is on the scale.

[19] Some household incomes are unnaturally low, even when including the received benefits and tax credits. Further investigation with the data depositor is required to solve doubts about the reliability of these data.

[20] In the original estimation, there was a dummy for each marital status. I restricted this later to this form.

[21] A logit model could also be estimated. There is no clear *a priori* theory which to prefer, however, a logit model requires the error term to be extreme-value distributed. In practice, the models often differ not significantly.

Table 1: Summary of Variables

Variable	Mean	Std. Dev.	Min.	Max.
u^h	3.51	1.67	0	6
$\log\left(y^h\right)$	9.74	9.42	0	12.55
size	2.40	1.30	1	8
noch02	0.06	0.24	0	2
noch34	0.07	0.26	0	2
noch511	0.25	0.60	0	4
noch1215	0.12	0.40	0	3
noch1618	0.03	0.19	0	3
noadult	1.87	0.78	1	8
nodis	0.09	0.31	0	3

Obs.=12877

It is most probable that the preference indicators do not control for all relevant heterogeneity in the sample. With panel data, it will be possible to estimate the parameters of the model consistently in the presence of this unobserved heterogeneity. This heterogeneity might be related to a further heterogeneity in preferences – or needs–, but also to a heterogeneity in the perception of the satisfaction scale.[22] We estimate both a random and a fixed effects ordered probit model. As our observations consists in a sample of households randomly drawn from a large population, it is reasonable to assume that this heterogeneity is also random. On the other hand, a fixed effects model guarantees consistent estimators. In the following two subsections, we describe briefly the ordered probit model and its panel version. We then give a summary of the final model specification and some expectations for the results.

3.3.1 The Ordered Probit Model

The response to the question "How satisfied are you with your income" can be viewed as the outcome of an underlying metric regression. Utility is usually assumed to be a continuous variable, but is observed only in the categories provided in the questionnaire. We assume that the individuals choose the category which most closely represents their own feelings. For simplicity of exposition, let $\mathbf{x}$ denote those factors which influence satisfaction with household income, the level of income, needs and preferences, i.e. the matrix of all exogenous variables. Then the utility function can be written

$$u^* = \mathbf{x}'\boldsymbol{\beta}+\varepsilon \tag{14}$$

where ε is a normally distributed error term with mean 0 and variance 1, and u^* is the underlying, continuous utility of monetary income, which is unobserved.

[22] This is related to the ordinality of the underlying utility.

What we do observe is

$$\begin{aligned}
u &= 0 \text{ if } u \leq 0 \\
u &= 1 \text{ if } 0 < u^* \leq \mu_1 \\
u &= 2 \text{ if } \mu_1 < u^* \leq \mu_2 \\
&\ldots \\
u &= 6 \text{ if } \mu_5 < u^*
\end{aligned} \tag{15}$$

The μs are unknown parameters (threshold parameters) to be estimated with the $\boldsymbol{\beta}$. Given the assumptions for the error term, we arrive at the following probabilities

$$\begin{aligned}
\Pr(u = 0|\mathbf{x}) &= \Phi(-\mathbf{x}'\boldsymbol{\beta}) \\
\Pr(u = 1|\mathbf{x}) &= \Phi(\mu_1 - \mathbf{x}'\boldsymbol{\beta}) - \Phi(-\mathbf{x}'\boldsymbol{\beta}) \\
\Pr(u = 2|\mathbf{x}) &= \Phi(\mu_2 - \mathbf{x}'\boldsymbol{\beta}) - \Phi(\mu_1 - \mathbf{x}'\boldsymbol{\beta}) \\
&\ldots \\
\Pr(u = 6|\mathbf{x}) &= 1 - \Phi(\mu_5 - \mathbf{x}'\boldsymbol{\beta})
\end{aligned} \tag{16}$$

For all probabilities to be positive, it is required that $0 < \mu_1 < \mu_2 < \ldots < \mu_7$.[23]

3.3.2 Random Effects in the Ordered Probit Model

The formulation of equation (14) the ordered probit panel model is as follows:

$$u_{it}^* = \mathbf{x}_{it}'\boldsymbol{\beta} + \varepsilon_{it} \tag{17}$$

where i indicates the household and t the time dimension of the variables, and

$$\varepsilon_{it} = v_{it} + \eta_i$$

η_i is the unobserved, individual-specific heterogeneity. In the ordered probit random effects model we make the following assumptions:

$$\begin{aligned}
E[v_{it}|\mathbf{X}] &= 0; \operatorname{Cov}[v_{it}, v_{is}|\mathbf{X}] = \operatorname{Var}[v_{it}|\mathbf{X}] = 1 \text{ if } i = j \text{ and } t = s, \text{ 0 otherwise} \\
E[\eta_i|\mathbf{X}] &= 0; \operatorname{Cov}\left[\eta_i, \eta_j|\mathbf{X}\right] = \operatorname{Var}[\eta_i|\mathbf{X}] = \sigma_\eta^2 \text{ if } i = j, \text{ 0 otherwise} \\
\operatorname{Cov}\left[v_{it}, \eta_j|\mathbf{X}\right] &= 0 \text{ for all } i, j, t
\end{aligned} \tag{18}$$

where $\mathbf{X}$ is the matrix of all x_{it} in the data. The assumption that the unobserved heterogeneity is uncorrelated with the included exogenous variables is strong. To safeguard ourselves as much as possible against this potential problem, we include a wide range of taste shifters as described above in the hope that this mops up most of the heterogeneity.

[23] These thresholds are assumed to be fixed. It would be interesting to analyse whether a more flexible specification improves the estimation. (A random parameter probit model, in which the thresholds are assumed to be drawn randomly from a distribution).

From equation (18) it follows that

$$
\begin{aligned}
E\left[\varepsilon_{it}|\mathbf{X}\right] &= 0 \\
\mathrm{Var}\left[\varepsilon_{it}|\mathbf{X}\right] &= \sigma_v^2 + \sigma_\eta^2 = 1 + \sigma_\eta^2 \\
\mathrm{Corr}\left[\varepsilon_{it}, \varepsilon_{is}|\mathbf{X}\right] &= \rho = \frac{\sigma_\eta^2}{1+\sigma_\eta^2}
\end{aligned}
$$

The likelihood function can be derived as in the binomial probit panel model.[24]

3.3.3 Fixed Effects in the Ordered Probit Model

The fixed effects model does not make the strong assumption of no correlation between the unobserved and the observed heterogeneity. However, the ordered probit model is subject to the incidental parameters problem, i.e. that in non-linear models, the η_i cannot be consistently estimated, which in turn translates into an inconsistency of the remaining parameters in the model. However, new software is now available which estimates these models consistently.[25] Another problem of the fixed effects model in our context is the fact that the fixed effects absorb effects of those variables with little variance. Particularly the variables household size and disability are subject to little change over the four years under analysis, so that these variables loose significance, compared to the random effects model.

3.3.4 Other Model Specification and Estimation Issues

In summary, we will estimate a random effects ordered probit model (RE Oprobit) and a fixed effects ordered probit model (FE Oprobit). The estimation of these models is not trivial, and to achieve convergence is often difficult.[26] For this reason, we have also included a pooled or population averaged ordered probit model (PA Oprobit).[27]

As the precision of the scales will depend on the number of observations for each case, (which in turn depends on the amount of needs indicators in the model), two model specifications are tested: (1) a simple specification, which includes as a needs indicators the log of the household size and the number of disabled household members, and (2) a more complex specification which includes the number of adults, number of children in each age group, and the number of disabled in the household. Note that the two models are not nested.

While equivalence scale estimation based on demand systems faces the problem that some of the factors affecting needs are compensated by a substitution

[24] see Greene [10] and Baltagi.

[25] LIMDEP 8.0 has a routine to estimate fixed effects ordered models with an unconditional estimator.

[26] See Greene[10] for a discussion of the difficulties involved in the estimation.

[27] Obviously, unobserved heterogeneity is not taken account of in this model.

effect[28], psychometric equivalence scales have to deal with the fact that some factors might affect satisfaction on income without affecting household cost. For example, someone suffering from depression might not be satisfied with any household income. We assume in this paper that the presence of a disability has a negligible effect on income satisfaction apart from the cost channel.

Finally, we calculate the standard errors of the equivalence scale using the delta-method

$$\operatorname{var}(\mathbf{m}(\mathbf{z})) = \left(\frac{\partial m(\mathbf{z})}{\partial \boldsymbol{\beta}}\right) \operatorname{cov}(\boldsymbol{\beta}) \left(\frac{\partial m(\mathbf{z})}{\partial \boldsymbol{\beta}}\right)' \tag{19}$$

This method is based on a first order Taylor expansion, and hence we have to assume that the estimators ($\boldsymbol{\beta}$) are sufficiently close to their true counterparts.

It is to be expected that the estimated equivalence scales reflect a) the economies of scale present in the household, and b) higher costs for those households with disabled members. The economies of scale are due to the presence of fixed costs or indivisibilities: rental costs are usually not doubled when the household size doubles, similarly, certain consumer durables do not need to be bought separately for each household member (for example, a fridge or a laundry machine). Not all costs are fixed, however, as we expect food and possibly clothing to vary with household size. We therefore expect that a model with the log of the household size as a needs indicator would result in a scale which exhibits decreasing increments in costs for each additional household member. A more complex model taking account of the number and age group of each household member would result in a scale that exhibits additional costs which increase with age.

Furthermore, we expect that the scales reflect the additional costs the disability inflicts on the household. For the UK, to our knowledge, only Jones and O'Donnell have estimated the costs of disability, and we will use their results for comparative purposes. We will compare our scales for households without disabled members with the demand-based scales estimated for the UK by McClements [5]. The comparison with other psychometric scales is difficult, as the only comparable estimates are for Germany, and household costs might differ significantly in different countries, especially when different benefit levels are involved.[29]

[28] For example, in the case of adult good scales, the level of alcohol or cigarette consumption might fall when children are present, because parents are breastfeeding or taking their role as a rolemodel for their children into account. Also, expenditure on going out might be less once small children are present, because more time is spent at home together. This is the effect described above, where factors that affect needs also impinge on preferences.

[29] The scales calculated by Van Praag and Van der Sar [21] are not directly comparable as they use a different reference family.

4 Results

This section is divided into three parts. In section 4.1 we describe the estimation results for the simple and the complex specification. We then discuss some examples of resulting equivalence scales and compare them to results in the literature on equivalence scales in section 4.2. Finally, in section 4.3 use our results to illustrate the effect of the cost of disability on inequality and poverty analysis in the UK.

4.1 Estimation Results

4.1.1 Simple Specification

A summary of the simple specification models is presented in table 2. Except for the random effect ordered probit model, all models converged quickly.[30] The results for all models exhibit the expected signs.[31] Satisfaction of income depends positively on household income and negatively on household size. In the pooled ordered probit and the random effect probit, the number of disabled individuals in the household also has a significant negative effect on income satisfaction.[32]

Whether or not the household head is male or female does not seem to have a significant effect on satisfaction with income; the age of the household head has a significant positive effect in the first two models, this is in line with the literature, where a positive cohort effect is observed. This is reversed in the fixed effects models.

A significant positive effect of housing tenure can be observed in the first two models: tenants and household heads living in mortgaged houses are generally less satisfied with their income than those who own a house outright. This is natural, as those who own their house outright, do have lower housing costs in the present than those who do not. Although of policy interest, post-housing cost equivalence scales as those reported by McClement [5] are difficult to calculate with the psychometric method. This variable is not significant in the fixed effects models, as the variation is too little over the observed period.

Marital status is also important. Household heads which live with their partners without being married, are significantly less satisfied with their income. This might be due to non-optimally pooled resources while the relationship is not formally binding. The divorced and separated are also less satisfied with their income than both married individuals and those who have never been married. This could be explained by the fact that these individuals might be liable to pay

[30] The reason for this seems to be a flat likelihood function. The random effect ordered probit model results have to be interpreted with care.

[31] The interpretation of signs in the ordered probit model is tricky, see Greene [10], p. 738. Strictly speaking, only the interpretation of the signs for the probability to fall in the first or last category of income satisfaction are unambiguous.

[32] The fact that this variable is not significant in the fixed effects models is owing to the little variation in this variable over the four years of analysis. It is "mopped up" by the fixed effect. Once more years of data become available, a more precise estimation of this parameter in the fixed effects models will be possible.

Table 2: Summary: Simple Specification

Model Variable	Oprobit, PA	Oprobit, RE	Oprobit, FE
$\log\left(y^h\right)$	0.50***	0.55***	0.37***
Needs			
$\log\left(size\right)$	-0.44***	-0.51***	-0.23***
nodis	-0.27***	-0.25***	-0.04
Tastes			
sex	-0.007	-0.07	–
$\log\left(age\right)$	0.21***	0.40***	-3.38***
married	-0.30***	-0.40***	-0.27***
owned	0.24***	0.27***	-0.07
No. Obs.	12877	12877	12877
R^2	0.04		
LogLik	-22848	-20781	-15883

*** denotes significance at 1% level, ** at 5%, * at 10%
Detailed results available from the author

for alimony, or simply that the situation they find themselves in has a depressing effect on (income) satisfaction without really affecting their costs. The widowed are significantly more satisfied with their income than married couples. These findings are robust across the different models. The interpretation of our results show how difficult it is to separate the variables that affect needs from those which affect tastes. Although we can explain the significance of some of these variables by the effect they have on household needs, we reiterate here that we do not use these variables for the calculation of the scales. The adjusted income hence does not reflect the needs for higher housing costs or alimony.

4.1.2 Complex Specification

A summary of the results for the complex specification is presented in table 3. This specification includes the number of children in each age group and the number of adult members of the household, instead of the simple log of the household size. Again, all models exhibit mostly the expected signs; the fixed effects model suffers from the fact that the number of children in each age group changes littel in the observed period, and hence not all effects are significant. In the pooled ordered probit and the random effects probit model children have a significant effect on household costs. The effect of small babies and toddlers (from 0 to 4 year old) seems to be negligible, however: their parameter is not significant. Older children generally cost more, with additional adults having the biggest impact on household cost. This is natural, if we assume that the older the children the more cost they imply in terms of food, schooling, holidays etc.. Curiously, the effect of 16 to 18 year old children is less than that for 12 to 15 year old in the random effects model. However, statistically the difference is almost negligible as the parameter is estimated with a relatively large standard variation. The cost of children is highest in the random effect ordered probit model, but again, these results have to be taken with care due to the flatness of the likelihood function at the optimum. In the fixed effects models, children from 12 to 15 years imply a significant cost on the household, as do additional adults.

Disabled members of the household have a significant effect on household cost in the pooled probit and random effect ordered probit model. As we have described, a disabled member in this model counts twice: first as an additional child or adult, and again, as a disabled member of the household. Consequently, if a disabled adult joins the household, the incremental cost is calculated based on the sum of the parameter for her age group and for a disabled person.

Table 3: Summary: Complex Specification

Model **Variable**	**Oprobit, PA**	**Oprobit, RE**	**Oprobit, FE**
$\log\left(y^h\right)$	0.53***	0.54***	0.36***
Needs			
no. ch 0-2	0.00042	-0.07	-0.10*
no. ch 3-4	-0.0085	-0.10*	-0.09
no. ch 5-11	-0.065***	-0.12***	-0.06
no. ch 12-15	-0.15***	-0.21***	-0.11*
no. ch 16-18	-0.16***	-0.15**	0.006
no. adults	-0.27***	-0.24***	-0.87*
nodis	-0.26***	-0.25***	-0.05
Tastes			
sex	-0.01	-0.04	–
$\log(age)$	0.35***	0.50***	-3.44***
married	-0.30***	-0.39***	-0.27***
owned	0.23***	0.27***	-0.07
No. Obs.	12877	12877	12877
R^2	0.05	n.r.	n.r.
LogLik	-22845	-20789	-15883.25

*** denotes significance at 5% level, ** at 5%, * at 1%

Detailed results available from the author

Gender of the household head does not seem to matter, and again, we observe a positive cohort effect in that older people are likely to be more satisfied with their income in the pooled and random effect models. The effects of the remaining control variables are very similar to those reported in the simple specification.

4.2 Results for Psychometric Equivalence Scales

In table 4 the equivalence scales derived from all models are reported. Let us first analyse the scales for household size only. Although all scales meet with our expectations in that they exhibit economies of scale in the household, and positive costs of disabled members, the point estimates of the scales differ greatly across models. For example, a two-person household needs 1.83 times the income to be as happy as the reference household, when using the pooled ordered probit scale, but only 1.55 times the income of a reference household when using the fixed effects probit scale. A four person household would need 3.38 times the reference household's income in the PA scale, and only 2.41 times the reference household's income on the fixed effects probit scale. When taking into account the statistical nature of the scales, however, the fixed effects estimators exhibit large standard errors, which make it difficult to statistically distinguish the results in the different models.[33]

A similar effect can be observed when taking into account the scales for disability. The scales are very high for the pooled and random effect model, a disabled person needing between 1.70 and 2.4 times the amount of a non-disabled person, depending on the household size[34]. However, in the fixed effects model, a disabled person would need between 1.1 and 1.3 times the amount of a non-disabled person. Obviously, this difference is due to the low disability parameter in the fixed-effects estimations. As the age effect is not taken into account in the scale calculations, this most probably does not reflect the real cost of disability to the household.

For the simple scales, hardly any comparative scales exist in the literature. Bellemare et. al. [2] have estimated similar scales for Germany.[35] Bellemare et al. estimate cross-section probit models without taking account of individual effects, so that we have to compare their scales, depicted in table 5, with our estimate for the population averaged probit above.[36] Of course, we can only compare the scales for households without disabled members. Their scales are small compared to our estimates and exhibit lower standard errors. Their scales are not significantly different from our fixed effects scales, but this is due to the high standard error.

[33] In fact, the standard errors in the fixed effects models are so large that the scales are hardly significant at all. This is not surprise, given the low significance of the parameters in the model. We hope that this effect will vanish once more waves of the panel become available for analysis.

[34] The effect that a disabled individual has a bigger impact on houshold cost in a small family than in a large one is due to the logarithmic scale. An intuitive explanation is that larger households usually live in larger houses, and more adaptations are required. (()) the additional cost is fixed in terms of percentage!! that is the clue to present this coherently.

[35] Although not really comparable, as calculated for different countries, where costs may differ, it might still be illustrative to present these numbers.

[36] They estimate other models, based on semiparametric models. However, the estimates

Table 4: Examples for Equivalence Scales – simple specification

	Oprobit, PA		**Oprobit, RE**		**Oprobit, FE**	
Household Type	scale	s.e.	scale	s.e.	scale	s.e.
1 person	1.00	–	1.00	–	1.00	–
1 person, disabled	1.70	0.09	1.56	0.13	1.12	0.22
2 persons	1.83	0.05	1.91	0.09	1.55	0.21
2 persons, 1 disabled	3.13	0.19	3.02	0.30	1.74	0.41
3 persons	2.62	0.11	2.79	0.22	2.01	0.43
3 persons, 1 disabled	4.48	0.31	4.42	0.52	2.26	0.65
4 persons	3.38	0.18	3.66	0.36	2.41	0.66
4 persons, 1 disabled	5.77	0.45	5.79	0.77	2.71	0.90

Source: Own calculation based on estimations in appendix 1. Standard errors calculated with delta method

Table 5: Comparison: Psychometric Scales for Germany

	Bellemare		**Oprobit, PA**		**Oprobit, FE**	
Household Type	scale	s.e.	scale	s.e.	scale	s.e.
1 person	1.00	–	1.00	–	1.00	–
2 persons	1.34	0.02	1.83	0.05	1.55	0.21
3 persons	1.59	0.04	2.62	0.11	2.01	0.43
4 persons	1.80	0.05	3.38	0.18	2.71	0.90

Estimations for Germany, based on GSOEP [2]
Standard errors calculated with the delta method

Another comparison can be effected with the estimates by Van Praag and Van der Sar [21] for the UK. In this case, we can only compare the results for the increment in the equivalence scale for an additional adult, as presented in table 6. In case of Van Praag's scales, the increments are much smaller than in our (simple) models. Again, the increments in the fixed effects scales are smaller than in the pooled and random effects models. From these less than perfect comparisons, it is not possible to come to a conclusion regarding the correctness of our scales.

Table 6: Comparison of results with Van Praag: Incremental Cost of additional adults

	Increment from 2-person household			
additional person	Van Praag	Oprobit, PA	Oprobit, RE	Oprobit, FE
1	+0.12	+0.43	+0.46	+0.29
2	+0.08	+0.41	+0.45	+0.26
3	+0.07	+0.40	+0.45	+0.24
4	+0.07	+0.23	+0.25	+0.13

Let us now turn to an analysis of the scales derived from the complex specification, presented in table 7. Both scales are reasonable in that they exhibit economies of scale in the household, and disability costs seem not unreasonable. Based on the population averaged probit model, with a single adult as the reference household, a second adult "costs" the household, on average, 0.66 times that of the first. In the fixed effects ordered probit, this reduces to 0.28 times the amount of the first. If an adult is acompanied with a 12 to 15 year old child, the additional cost is about 1/3, across all models. A family of four with two children needs about 2 to 2.5 times the income of a single adult to be as satisfied with their income.

The scales for disability differ greatly among the models. Comparing lines 2 and 6 of table 7, we observe that in the ordered probit model, the disability of one adult costs a couple 65% of their income, or in other words, they need 65% more income than a couple without disabilities to achieve the same income satisfaction. In the fixed effects probit, this amounts to only 14% more.[37] When comparing lines 7 and 8 in table 7, we observe that in a household with parents and one child, the disability of one person requires between 14% and 64% as well.

We can compare these results with those estimated by McClement [5] (for the UK, before housing cost, We can compare these results with those estimated by McClement (for the UK, before housing costs, available in the BHPS data) and those by Bellemare et al.[38]. Table 8 presents the comparison. Again, as no adjustment for disability has been made in these scales, we can only compare the results for household without disabled members.

are in a similar range as their ordered probit estimates.

[37] Again, this low number is due to the low parameter value in the fixed effects probit model.

[38] For the latter, the caveat applies again that the estimates are for Germany.

Table 7: Examples for Equivalence Scales – complex specification

	Oprobit, PA		**Oprobit, RE**		**Oprobit, FE**	
Household Type	scale	s.e.	scale	s.e.	scale	s.e.
1 Adult	1.00	–	1.00	–	1.00	–
2 Adults	1.66	0.04	1.56	0.06	1.26	0.12
2 Adults, 1 ch 0-2	1.66	0.14	1.77	0.19	1.70	0.35
2 Adults, 1 ch 5-11, 1 ch 12-15	2.49	0.14	2.89	0.34	2.07	0.66
1 adult, 1 ch 12-15	1.32	0.06	1.48	0.12	1.35	0.22
2 adults, 1 disabled	2.74	0.15	2.49	0.24	1.44	0.32
2 adults 1 ch 12-15, 1 disabled	3.64	0.27	3.70	0.47	1.96	0.58
2 adults, 1 ch 12-15	2.21	0.11	2.31	0.21	1.71	0.37

Source: Own calculation based on estimations in appendix 1. Standard errors calculated with delta method

As in the simple specification, our scales are higher than Bellemare's; as their scales are for Germany with a more extensive benefit system both for children and the elderly, this is not surprising. What is surprising is the difference in standard errors of both scales. This might be due to better quality of the data in the GSOEP. In this model, we finally have the opportunity to compare out scales with the official scales used in the UK, the McClement scales. Although the two scales are based on different methods, (consumption-based versus psychometric analysis), their point estimates coincide for the pooled probit, and are statistically very similar to the fixed effects ordered probit model scales.

Table 8: Examples for Equivalence Scales – complex specification – comparison with McClement Scales

	Bellemare		**McClement**	**Oprobit, PA**		**Oprobit, FE**	
Household Type	scale	s.e.	scale	scale	s.e.	scale	s.e.
1 Adult	1.00	–	1.00	1.00	–	1.00	–
2 Adults	1.30	0.02	1.63	1.66	0.04	1.26	0.12
2 Adults, 1 ch 0-2	1.34	0.03	1.78	1.66	0.14	1.70	0.35
2 Adults, 1 ch 5-11, 1 ch 12-15	–	–	2.41	2.49	0.14	2.07	0.66
1 adult, 1 ch 12-15	1.17	0.03	1.44	1.32	0.06	1.35	0.22
2 adults, 1 ch 12-15	1.52	0.04	2.07	2.21	0.11	1.71	0.37

Source: Own calculation based on estimations in appendix 1, Bellemare () McClement ()

Finally, we compare our results with those of Jones and O'Donnell. These authors have estimated log scales for disabilities, which are presented, together with our corresponding estimates, in table 9.[39] Their estimates are based on the estimation of foodshare and alcohol equations with non-linear income effects. Our point estimates in the ordered probit and the random effects probit are slightly higher than theirs. However, for both food and alcohol, the disability variable is hardly significant in their estimations,and hence the log scales are badly determined. The point estimates of the log scales they report for fuel and transport services are of a similar size, but also not very precise, none of their scales are significantly different from zero.

We conclude for now, that we can identify economies of scale in the household, and positive consumption cost of disability. In the remainder of this paper, we will analyse the effect of these scales on inequality and poverty analysis.

[39] The log scales for disability correspond in our models to the negative of the ratio between the parameter that accompanies the number of disabled people in the household and the parameter for log household income (complex model). For the calculation of logscales in Jones and O'Donnell, see their paper [12], p. 279.

Table 9: Comparison with Jones and O'Donnell scales for disability

	Jones and O'Donnell			This Paper	
	Food	Alcohol	Oprobit, PA	Oprobit, RE	Oprobit, FE
Log Scale	0.14	0.34	0.54^{***}	0.45^{***}	0.10

*** implies significance at the 1% level

4.3 Impact on Inequality and Poverty Analysis

In this section, we will use the point estimates of the equivalence scales in the previous section to illustrate the impact of adjustment for disability on inequality and poverty measures in the UK. For these purposes, we calculate the Theil general entropy measure and the Atkinson inequality measure for both the pooled and fixed effects ordere probit scale, for the years 1996 and 1999. We compare these measures among each other and to the official McClements scales. We also compare our scales when adjusting for disability, and when not taking into account disability. That gives us a direct measure of the "additional" inequality caused by additional consumption cost through disability. Because of the relatively high consumption cost of disability in the pooled ordered probit model, we expect a higher impact of adjustment for disability in the distribution based on this model. To assess the effect of adjustment on the lower straits of society, we will calculate the poverty rates for each scale for the entire population, and finally, focus on the poverty rates among those families with disabled members. The additional consumption cost of disability should be mirrored in higher poverty rates.

Figure 3 shows kernel density estimates of the log of the 1999 net household income distribution in the UK. The solid line represents the official McClements scales while the dotted lines represent the pooled and fixed effects ordered probit scales.

In table 10, we compare the Theil and Atkinson measures of the income distributions based on the pooled and fixed effects ordered probit as well as the McClements scale. For the Theil measure, a higher index signifies lower inequality, while for the Atkinson index, a higher index indicates a less equal society. The distribution of officially equivalised net household income (third column of table 10) has decreased slightly between 1996 and 1999, this tendency is observed more strongly in the Atkinson index. Both scales calculated in this paper – in the first and second column of table 10 show very similar results. Inequality decreases slightly from 1996 to 1997, however, less so for the distribution based on the pooled ordered probit scale. This implies that in 1999, society is less equal when the ordered probit scale is used than when the other two scales are used. This is related to the high consumption costs of disability implied by the pooled ordered probit model.

In figure 4 we compare each scale with adjustment with the scale without adjustment for disability. The scales without adjustment use the same formulae as

Figure 3: Distribution of Equivalised Household Income 1999

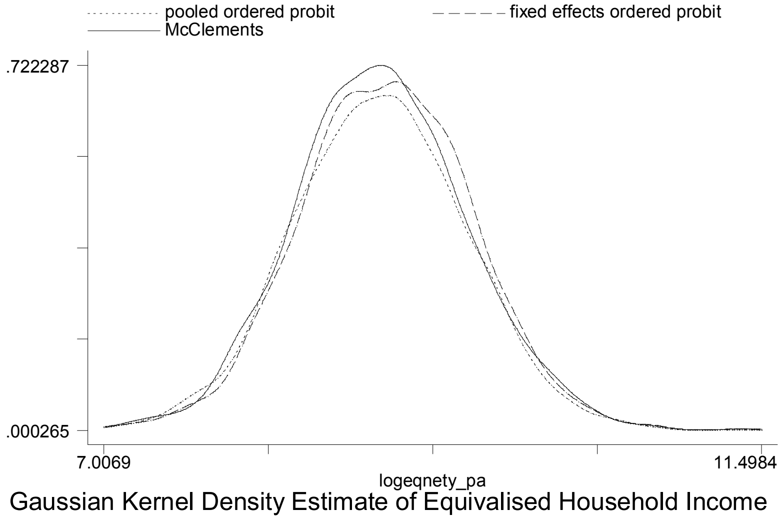


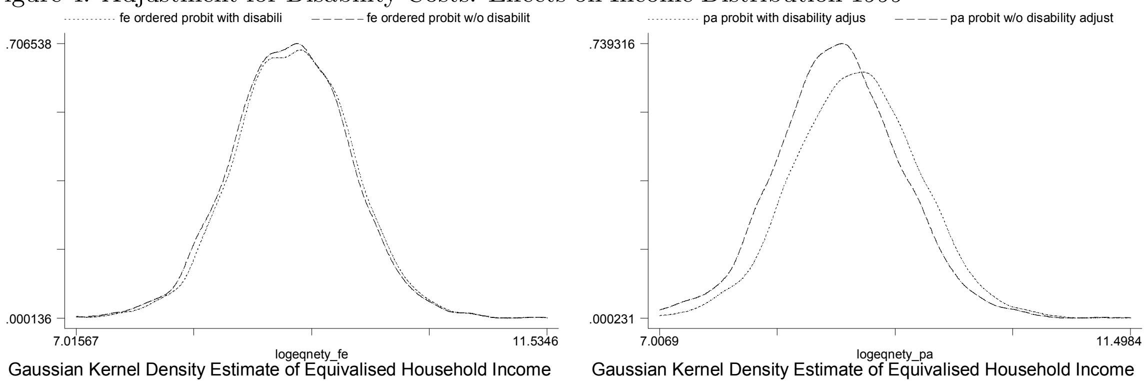
Table 10: Comparison of Scales: Inequality Indices

			Scale	
Year	Index	Oprobit, PA	Oprobit, FE	McClement
1996	Theil GE	0.19	0.17	0.18
	Atkinson[\a]	0.41	0.40	0.40
1999	Theil GE	0.20	0.18	0.19
	Atkinson	0.36	0.33	0.33

[\a]Aktinson: $\varepsilon = 2$

the scales with adjustment, however, leave out the term referring to disability.[40]

Figure 4: Adjustment for Disability Costs: Effects on Income Distribution 1999



Pooled Ordered Probit — Fixed Effects Ordered Probit

Given the small size of the parameter acompanying the variable indicating disability in the fixed effects model, it is not surprising to see that adjustment does not have a big impact on the distribution. In effect, the distribution based on the fixed effects model can hardly be distinguished from the distribution based on the McClements scale. In the second panel of figure 4 we observe a contrast between the distribution based on the scale with adjustment and the one without adjustment.

In tables 11 and 12, we compare the scales with and without adjustment in terms of inequality. The distribution based on the PA model without adjustment is very similar to the one based on the official scales, in both years of analysis. The distribution which is adjusted for disability costs exhibits less equality, and also a lower decrease in inequality across time.

Table 11: Comparison of PA Scales with and without disability: Inequality Indices

		Scale	
Year	Index	Oprobit, PA w/o adjustment	Oprobit, PA w/ adjustment
1996	Theil GE	0.17	0.19
	Atkinson	0.39	0.41
1999	Theil GE	0.19	0.20
	Atkinson	0.33	0.36

In contrast, the scale bsaed on the fixed effects model, there is hardly any distinction visible between the distribution based on the scale without adjustment

[40]This corresponds to treating disability as a preference indicator, not a needs indicator, as would usually be the case in equivalence scale estimation.

versus the scale with adjustment.

Table 12: Comparison of FE Scales with and without disability: Inequality Indices

		Scale	
Year	Index	Oprobit, FE w/o adjustment	Oprobit, FE w/ adjustment
1996	Theil GE	0.16	0.17
	Atkinson	0.39	0.40
1999	Theil GE	0.18	0.18
	Atkinson	0.33	0.33

Let us now turn to the analysis of poverty rates. For illustrative purposes, we examine two poverty lines, 40 and 60% of median income respectively. Table 13 compares the poverty rates for the PA and FE scale with the official McClements scales. The poverty rates are very similar in all three distributions. However, the rate for the PA based distribution is slightly higher for the 40% line compared with the FE and the McClements based distributions. For all three distributions, poverty has decreased from 1996 to 1999.

Table 13: Comparison of Scales: Effect on Poverty Rates

		Poverty Rate in %		
Year	Poverty Line	Oprobit, PA	Oprobit, FE	McClement
1996	40% of median inc.	7.78	5.83	5.03
	60% of median inc.	19.77	20.81	19.77
1999	40% of median inc.	6.17	4.75	4.47
	60% of median inc.	19.76	17.18	16.46

In table 14 we compare poverty rates when adjusting for disability with those where disability is not taken into account. For the PA model-based distribution, the poverty rate lies slightly higher when adjusting for disability. For the fixed effects model, again, not much difference can be established.

In table 15 we present the same poverty rates, however, we focus on the disabled population. The poverty rate among families with disabled members is generally lower than in those without. This might be a results owing to successful redistribution through the benefit system. However, if we adjust for the higher consumption cost of disability based on the models in this paper, the benefit system is not sufficient to compensate for all of it. In both 1996 and 1999, in the distribution based on the FE model, the poverty rate below 60% of median income is 50% higher than in the distribution based on the official scale. In the PA model, this rises to more than double. The distributions which do not adjust for disability have poverty rates very similar to the distribution

Table 14: Poverty Rates, scales with and without adjustment

		Poverty Rate in %			
		without adjustment		with adjustment	
Year	Poverty Line	Oprobit, PA	Oprobit, FE	Oprobit, PA	Oprobit, FE
1996	40% of median inc.	6.39	5.90	7.78	5.83
	60% of median inc.	18.59	19.95	19.77	20.81
1999	40% of median inc.	4.85	4.88	6.17	4.75
	60% of median inc.	16.64	17.05	19.76	17.18

based on the McClements scale. Particularly striking is the high poverty rate of the distribution based on the PA model: almost a third of the families with disabled members lives below the 40% line.

Table 15: Poverty among families with disability, with and without adjustment

		Poverty Rate in %				
		without adjustment		with adjustment		
Year	Poverty Line	PA	FE	PA	FE	McClements
1996	40% of median inc.	4.92	3.41	28.03	4.92	3.41
	60% of median inc.	18.94	20.08	58.71	34.09	21.97
1999	40% of median inc.	3.54	4.51	20.00	5.80	4.19
	60% of median inc.	13.87	15.48	59.68	22.25	14.52

It is also interesting to see how much poverty is reduced from 1996 to 1999. While for the lower line, only the PA model exhibits a strong decrease in poverty, for the upper line, all but the PA model exhibit at least a 5% point decrease in poverty.

5 Conclusion

In this paper, we have explored the potential of equivalence scale estimation for the calculation of welfare measures that meet with Sen's requirements of reflecting an individual's personal, social and environmental restrictions in decisionmaking. We came to the conclusion that, due to statistical restrictions, equivalence scale estimation can at best be used to account for a handful of factors, rather than for all those which affect decisionmaking. Outcome-based measures might be a more useful alternative for this.

We extended the usual type of equivalence scale estimation by taking account of the presence of individuals with disabilities in the household. We have used subjective information on income satisfaction to identify so-called psychometric equivalence scales to arrive at welfare indicators which reflect the household's needs in a more precise way.

For families without disabled members, the equivalence scale results for probit estimation are plausible in size and in line with those scales estimated by McClements based on UK demand data. The increments for each additional adult are significantly bigger than Van Praag's estimates, which are based on subjective data. This might be due to the different form of the utility function or the fact that their estimation did not take account of the panel structure.

The consumption cost of disability is positive and significant in some models, and higher than the estimations by Jones and O'Donnell. Despite these positive results, the standard errors of our estimations are high, and these scales should be used for policy analysis only with great care.

The impact of disability costs on the overall income distribution seems negligible, which might be caused by the small proportion of disabled individuals in the sample. However, when analysing the effect on poverty, we conclude that an adjustment for disability costs moves a considerable number of households below the poverty line. The main caveat here is that we use the point estimates of the scales to illustrate the impact of adjustment for disability costs, and don't take into account the standard errors. Without higher precision in the estimates, this remains an illustrative rather than a conclusive analysis.

In future research, we will concentrate on a refinement of the disability indicator and aim at a higher precision of the scales.

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