



Basic Needs (in)Security and Subjective Equivalence Scales

Steven F. Koch¹ 

Accepted: 16 July 2023 / Published online: 11 August 2023
© The Author(s) 2023

Abstract

Equivalence scales are policy parameters for inequality measurement, tax deductions and subsidies. Thus, their accuracy is relevant both for budgets and social cohesion; however, their measurement is subject to debate regarding the underlying measure of welfare. Self-assessed insecurities in terms of clothing, housing and food—or basic needs—imply that at least some households are at lower levels of welfare than those that are meeting their needs. We use this to determine the increase in total expenditure required to meet their needs, on average, and thus we are able to calculate the implied equivalence scales. We compare these subjective scales to ones that arise from objective measures, such as expenditure shares on the same items. Our subjective scales are more consistent and plausible across all goods, and are similar to those arising from food expenditure shares. While scales arising from either housing or clothing expenditure shares are neither similar to those arising from food shares or basic needs adequacy nor are they plausible, given the plausibility rules we apply. Furthermore, the subjective equivalence scales are smaller than those proposed in the OECD-modified scale.

Keywords Subjective · Objective · Basic needs · South Africa · Equivalence

1 Introduction

In this paper, we revisit the estimation of equivalence scales taking into account the fact that expenditure shares on food, clothing (adult/child) or even housing may not represent household welfare, and, therefore, the scales calculated from those shares following, for example, Deaton (1997), Pendakur (1999), Yatchew et al. (2003) or Dudel et al. (2021b) could be biased. Nicholson (1976), in particular, argues that child cost estimates from such data can be overstated, implying biased equivalence scales, because children primarily consume food and clothing.

An early draft of this manuscript was presented to the Western Economic Association International Meeting in Portland, OR, USA. The author would like to thank attendees at the conference for their comments and suggestions. Any remaining issues rest with the author.

✉ Steven F. Koch
steve.koch@up.ac.za

¹ Present Address: Department of Economics, University of Pretoria, Private Bag X20, Hatfield, Pretoria, South Africa

Instead, we rely on self-assessed household food, clothing and housing “adequacy”, arguing that households not able to meet their basic needs are necessarily achieving lower levels of welfare than those who do meet those needs. Pradhan and Ravallion (2000) suggest a similar approach to the estimation of subjective poverty lines, which they estimate for Jamaica and Nepal. Lokshin et al. (2006) apply that thinking to compare subjective and objective poverty lines in Madagascar, where they specifically refer to consumption adequacy questions (CAQ), which are similar to those used in this analysis. We were only able to find one other paper, de Ree et al. (2013), that uses CAQ to consider equivalence scales, although their primary focus is on price and utility dependence in the estimation of such scales, rather than the difference between objective and subjective scales, as is our focus here. For the most part, the literature has not used CAQ for the estimation of equivalence scales; instead, it has used other subjective queries, such as those related to life or income satisfaction or even minimum income needs, as we discuss in more detail, below.

Taking the concepts developed by Pradhan and Ravallion (2000), we estimate the compensation required for households of different types to have an adequate supply of basic needs, which we translate into equivalence scales for different household types. For comparison purposes, we also estimate equivalence scales from expenditure shares on the same goods. The analysis is predicated on the South African 2014/15 Living Conditions Survey (Stats SA, 2017), because it is the most recent survey that captures the relevant information.

In summary, we find that basic needs security leads to subjective scales that are consistent across types of need, which is in sharp contrast to scales calculated from basic needs expenditure shares, at least in this analysis; this could be due to the removal of potentially discretionary expenditure (Daley et al., 2020). Our subjective scales result in economies of scale and positive weights for both children and adults. We also find that scales for children tend to be larger in multiple-adult households than in single-adult households, and that is especially true for the first child. Our estimates are relatively consistent with a household scale economy of 0.5, and are generally lower than they would be if we had instead, applied the modified OECD scales. Finally, we find that scales, at least those we find to be more plausible, do not change all that much after including the control function.

2 Literature Review

It is common to estimate equivalence scales from microdata on consumption, especially food consumption, which is widely available in expenditure surveys around the world. Such estimates still tend to focus on developed countries as a recent series of papers focusing on Germany (Dudel et al., 2021a, b; Garbuszus et al., 2021) and Canada (Pendakur, 2018) demonstrates. There is a related literature underpinned by time use data. Bradbury (2008) uses both time and expenditure costs, finding relatively larger child costs than are underscored by consumption share analysis, alone. Borah (2020) also incorporates time use data and subjective income satisfaction data, finding greater monetary equivalence weights for adults than for children, while household production increases are associated more with children than with adults. Combining these two leads to rather similar child and adult weights in the equivalence scales. On the other hand, Couprie and Ferrant (2015), who focus on additional time needed, rather than full time costs, find that two singles living apart need about 2h15m additional free time to match their utility as a couple living together; however, the analysis did not consider children.

Not all consumption based estimation focuses on developed countries. Recent work, such as Daley et al. (2020), includes a number of years and countries, including South Africa, which is our focus. South African focused studies also exist; see, for example, Yatchew et al.

(2003), Posel et al. (2020) and Koch (2022). Although Daley et al. (2020) do not believe the square-root scale is appropriate, Koch (2022) finds robust empirical support for it, when considering South African food shares. Therefore, we provide further clarity on the appropriateness of that scale in this analysis. Daley et al. (2020) also find differences across countries and time, as well as across consumption bundles. In particular, they find larger economies of scale when considering necessities other than food, except for South Africa, where they suggest that consumption bundles for smaller families might include discretionary spending. We offer additional insight into commodity-based scale differences in the country, and, through the use of subjective measures of basic needs adequacy, we remove the potential for discretionary spending among all households, which we find yields more similarity in the underlying scales across goods types.

The literature has also developed equivalence scales from other subjective measures of well-being, including income satisfaction, minimum income needs and life satisfaction. van Praag and van der Sar (1988) show that income evaluation questions like those in van Praag (1971) may be used without assuming cardinal utility. Income evaluation questions request survey respondents to declare net income amounts that they would regard as very good, or sufficient or even very bad. A similar approach makes use of minimum income questions, which attempt to extract “the smallest amount of income that would be needed by the household to make ends meet each month” (Goedhart et al., 1977). In much of this analysis, the reported minima increase with actual income, which Goedhart et al. (1977) suggest is related to the need to make additional fixed payments, such as mortgages, although other interpretations are also offered. Since these survey questions require respondents to generally address hypothetical scenarios, the answers may not accurately reflect what is being requested (Bradbury, 1989; Melenberg and van Soest, 1996). Steiger et al. (1997) suggest that the cognitive tasks in answering these seemingly simple survey queries are, in fact, quite complex.

The hypothetical nature of the queries has been addressed in at least two different ways. One approach focuses on finding individuals whose minimum income matches their actual income. At the intersection of needs and actual (Goedhart et al., 1977), one can explicitly focus on households in poverty and avoid preference restrictions. Hartog (1988) specifically argues that welfare cardinality is not necessary; rather, we only need assume that there is a “common, interpersonally comparable feeling of welfare” of enough to get along. This argument is formalized as ordinal local comparability by Grodner et al. (2022), and leads to local equivalence scales. Essentially, ordinal local comparability is the ability to make comparisons only at a specific point, minimum needs income, and offers further support to the intersection method that is generally applied in that literature; see Goedhart et al. (1977), Kapteyn et al. (1987), Bishop et al. (2014) and Mysiková et al. (2022), for example. Kapteyn et al. (1987) find that the subjective evaluations lead to implausibly low family cost parameters, which imply very flat equivalence scales across household structure measures. Bishop et al. (2014) and Mysiková et al. (2022), present comparisons of subjective equivalence scales (from minimum income questions) across Europe. The former finds that there are greater economies of scale in developed welfare states, while the latter suggests that there is an East–West divide in the economies of scale. Both argue that subjective scales are different from modified OECD scales, lead to poverty rate differences, and that child costs are not as low as those in Kapteyn et al. (1987).

The second approach uses income or life satisfaction for scale estimation. Doing so has yielded lower economies of scale than those arising from the preceding minimum income questions, with life satisfaction leading to some of the lowest scales (Melenberg and van Soest, 1996; Charlier, 2002; Schwarze, 2003; Biewen and Juhasz, 2017). Charlier (2002)

finds that satisfaction with income scales increase with household size, and, therefore, are somewhat reasonable. Despite potentially addressing the hypothetical nature of minimum income questions, subjective well-being depends heavily on perceptions; Bradbury (1989) offers a relatively early review arguing that reference group effects are important in these analyses and may be systematically related to family type. In the literature, reference effects are underscored by a benchmark relative to oneself or even to others (Clark et al., 2008), income aspirations (Stutzer, 2004) and other features. Stutzer (2004) finds that subjective well-being depends on the gap between income aspirations and actual income, not on the income level as such; the higher the gap, the less satisfied. In other words, respondents are likely to conflate both their own views and societal references (Stutzer, 2004; Clark et al., 2008). Ferrer-i-Carbonell (2005), for example, consider three separate measures—own income, reference income and the gap between own and reference.

Given the possible confounding factors, extracting equivalence scales from subjective measures requires researchers to estimate appropriate reference groups; otherwise, the subjective view may not reflect what is required for equivalence scales (Borah et al., 2019). The literature suggests that a variety of comparisons, such as reference income from similar individuals (Ferrer-i-Carbonell, 2005) or from Mincerian earnings equations (Senik, 2008; Borah et al., 2019) are relevant. However, (Boyce et al., 2010) find that income rank is more important for life satisfaction than absolute income. Income gaps (D'Ambrosio and Frick, 2012) are also relevant, because households feel better off when they are relatively richer and worse off when they are relatively poorer. Furthermore, there may be a dynamic component with respect to relatively newer rich and poor households in the comparison group. This dynamic aspect might have two effects, one that is negative—due to relative deprivation - and another that is positive, as it suggests anticipatory possibilities (Senik, 2008). A simpler descriptor is “jealousy” and “ambition”, the former of which underscores old European sentiments, while the latter is uncovered in America and the former eastern bloc of Europe (Senik, 2008). Even though these subjective approaches do not require utility cardinality, and, therefore, ought to be relatively straightforward, the applied literature suggests that, empirically, it is anything but straightforward.

As highlighted at the outset, we focus on (self-assessed) food, clothing and housing adequacy—in other words, a respondent in the household replies that the household has “less than adequate”, “adequate” or “more than adequate” food, clothing or housing available. Similar to self-assessed life satisfaction or income adequacy, the responses are ordinal, and, therefore, do not require cardinality assumptions. Although it is beyond the scope of this research to compare equivalence scales derived from basic needs consumption adequacy to those derived from minimum income or life satisfaction questions (and we are not aware of any research attempting to do so), Pradhan and Ravallion (2000) argue that one advantage of CAQ is that individuals, especially the poor, may struggle to understand what income is, and, therefore, will not be in a position to define their income needs. It also seems that answering a CAQ question for the entire household is likely to be an easier task than answering a life satisfaction question for that household; it is likely that hungry members of the household will voice their hunger, for example, which might require less interpretation with respect to adequate food consumption than with an exact location on a scale of life satisfaction or income satisfaction. However, because CAQs are self-assessed, we remain concerned that respondents will conflate their views with reference effects. As noted so far, the literature suggests a range of potential reference options. In practice, since the exact choice of reference is not known, the application of any reference effect will necessarily be measured with error. Therefore, rather than applying a specific reference effect, we apply a

control function method accounting for the expectation that the suggested reference offers a noisy measure of the true reference effect.

We contribute to the literature in numerous ways. We offer one of the few studies of subjective equivalence scales that is available for developing countries, and the first of which we are aware for Africa. The only developing country studies applying subjective approaches that we could uncover are for Mexico (Rojas, 2007), which finds that an increase of 40% in household income is required to keep a person's economic satisfaction constant when a second member is added, and Indonesia (de Ree et al., 2013), which are found to be larger than those derived from a modified OECD scale (Hagenaars et al., 1994). We diversify the literature away from subjective well-being, defined either by minimum income evaluations, life or income satisfaction, focusing on more fundamental basic needs, such as the adequacy of food, clothing and shelter. This diversification in subjective measures affects the choice of reference measures. We do not use income gaps or Mincerian earnings to underscore reference group proxies, which is rather common in the literature, because we need to proxy for needs adequacy rather than income adequacy; thus our focus will be on needs expenditure, which we assume is a noisy measure of reference effects. We also offer further insight into the apparent disagreement in the literature on the square-root scale in South Africa (Daley et al., 2020; Koch, 2022). Through the use of basic needs (in) security, we remove the potential concern that smaller households have relatively larger discretionary expenditures. Finally, we present a formal comparison of the plausibility of the shares arising from both the subjective analysis and the more traditional share-based analysis, which has not received previous attention in the estimation of scales in developing countries.

3 Methods

We consider two methods, one based on expenditure shares of basic needs items (food, clothing and housing) and the other based on self-assessed adequacy of the same items. In the case of the former, linear regression will be applied, while for the latter, we will apply an ordered categorical model, since self-assessment is rankable and limited to 'less than adequate', 'adequate' and 'more than adequate'. Regardless of model, the resulting equivalence scales will be indirectly estimated. In our models, the shares and adequacy levels will be assumed to depend on total household expenditure (x_i), household structure characteristics (\mathbf{D}_i), such as the number of children and adults, other characteristics (\mathbf{Z}_i) and other unobserved factors. We describe each model and the approach to estimating the scales in the following subsections.

3.1 Budget Share Scale Methods

Under the assumption that the budget share of a basic needs item – food, clothing and/or housing – is a reasonable indication of household welfare, equivalence scales are indirectly estimated from budget share regressions. The welfare assumption arises from a near two-century old observation that richer households tend to purchase less food, as a proportion of their budget (Engel, 1857). We examine whether our shares meet that assumption, below. Thus, models are based on the ratio of an item's (represented by k) expenditure in household i (x_i^k) to that household's total expenditure (x_i). Thus, the share is $w_i^k = x_i^k/x_i$. Assuming additive unobserved factors (u_i^k) yields the function in Eq. (1), where f is not known.

$$w_i^k = f^k(\ln x_i, \mathbf{D}_i, \mathbf{Z}_i) + u_i^k \quad (1)$$

Although it is common to estimate (1) via semiparametric methods, such as those applied by Blundell et al. (2003), Yatchew et al. (2003), Dudel et al. (2021b) or Koch (2022), we will focus on a simple linear application. We do so, because we are mainly interested in a comparison for the adequacy-determined scales. As underscored in Koch (2022), although the scale estimates differed for the linear and semi-parametric approaches, confidence intervals overlapped significantly implying that there is not a significant loss in generality in applying linear methods in this setting.

Our linear budget share model incorporates a series of binary variables capturing household structure, rather than assuming household size has a constant effect, as is common (Deaton, 1997; Posel et al., 2020).¹ We also incorporate additional controls to account for differences in household preferences and expenditure behaviour leading to our linear share regression in (2), where ε_i^k is the error, and is consumption category specific. We discuss endogeneity concerns, below.

$$w_i^k = \alpha_0^k + \alpha_1^k \ln x_i + \sum_j \gamma_j^k Z_{ij} + \sum_j \rho_j^k D_{ij} + \varepsilon_i^k, \quad (2)$$

Assuming food, clothing and housing shares are a reasonable welfare proxy supports an analytic approach to the indirect estimation of scales from Eq. (2). To do so, set a typical household i 's share equal to that of a reference household share, denoted by r , as in (3).

$$\alpha_1^k + \beta_1^k \ln x_i + \sum_j \gamma_j^k Z_{ij} + \sum_j \rho_j^k D_{ij} = \alpha_1^k + \beta_1^k \ln x^r + \sum_j \gamma_j^k Z_j^r + \sum_j \rho_j^k D_j^r. \quad (3)$$

We rearrange Eq. (3) to capture the equivalence scale, which we denote by $\Lambda_{E_i}^k$. Intuitively, it is a function of the differences in the observed data across household types and the estimated parameters. In application, the reference household has one adult and zero children. Thus, (\mathbf{D}_{ij}) are binary non-reference values of adults and children, while D_j^r is "on" for one adult, but "off" for all other adult and child values. Although we estimate the model to account for differences in household characteristics, such as location and population group, as well as the education and marital status of the household head, we do not use those estimates within the equivalence scale calculation. We do this for ease of computation and presentation, limiting our results to household composition (adult and child) differences, as is common in the literature.² We undertake 399 parametric bootstrap replications to determine the variability of the scales, and the analysis is separately undertaken for each consumption good k , which allows for scales to differ across consumption good.

$$\Lambda_{E_i}^k = \frac{x_i}{x^r} = \exp \left[\frac{1}{\beta_1^k} \left\{ - \sum_j \rho_j^k (D_{ij} - D_j^r) \right\} \right] \quad (4)$$

¹ For a household with two adults and three children, the separate binary indicators "two adults" and "three children" will be turned on, while all the other indicators, such as "three adults", "four adults", ..., and "one child", "two children", "four children, ... are switched off. Please, see the empirical results in Tables 7 for all of the binary indicators included in the model.

² It is certainly possible to extend the results to capture differences in equivalence scales across location, or other features included in the model. Doing so would require the inclusion of $\sum_j \gamma_j^k (Z_{ij} - Z_j^r)$ in Eq. (4).

In the analysis, we control for a wide range of Z related to the head of the household, such as their age, gender, race, education and marital status, as well as a range of location controls, including province, and urbanity. Thus, it is possible to estimate equivalence scales for each of these different household types; the combinations are many. However, for the scales reported below, we remove all Z factors from the scale calculations, although they are included in the regressions to control for potential unobserved heterogeneities that are correlated with household structure and income/expenditure.

3.2 Basic Needs (in)Security Scales

One problem associated with the use of food, clothing and/or other goods expenditure shares is that such shares may not truly capture welfare (Nicholson, 1976) or requires strong assumptions for identification (Blackorby and Donaldson, 1993) that do not always hold in application (Pendakur, 1999; Dudel et al., 2021a). For that reason, other measures might be of interest. In the living conditions survey we use, there are a series of questions assessing whether the household has less than adequate (as well as adequate and more than adequate) food, housing and clothing. Whether or not all members of a household are adequately fed, sheltered or clothed is plausibly more appropriate on welfare grounds than budget shares on expenditure items. Despite being more plausible, the use of self-assessed values does raise questions related to ‘reference effects’. Expenditure shares are objective, while views of adequacy are subjective, and may very well depend on one’s own perceptions of conditions. We discuss how we control for this concern, below.

We define b_i^k as the assessment of the adequacy of the consumption of good k for household-type i . We are interested in the conditional probability that their consumption is (in-)adequately met. Thus, it is reasonable to focus on the adequate/inadequate frontier, i.e., the border between b_0^k and b_1^k . However, from an analytic point of view, doing so ignores potentially relevant information in the data, and, therefore, we include all three levels of the categorical variable. We do consider the sensitivity of the results to this assumption.

$$b_i^k = \begin{cases} 0 & \text{if adequate needs for household } i \text{ are not met for good } k \\ 1 & \text{if adequate needs for household } i \text{ are met for good } k \\ 2 & \text{if needs for household } i \text{ are more than adequately met for good } k \end{cases} \quad (5)$$

We estimate the probability that a household assesses itself within a particular adequacy level $j \in \{0, 1, 2\}$. For notation, we define p_{ij}^k as the probability that household i ’s basic need k has adequacy level j , i.e., $p_{ij}^k = P(b_i^k = j | \ln x_i, D_i, Z_i)$. Since the probabilities sum to one, one category will be the base category for identifying the model. We will use inadequacy as the base.

3.2.1 Ordered Logit Model

To estimate the predicted probabilities used for the scales calculations, we assume that the outcomes in Eq. (5) can be clearly ranked, and, therefore, fit a proportional odds or ordered logit framework. Recalling $p_{ij}^k = P(b_i^k = j | \ln x_i, D_i, Z_i)$ and noting that the cumulative probability measures the probability of being in any category up to K : $\gamma_{iK} = P(b_i \leq K)$. Therefore $\gamma_{iK} = \sum_{k=1}^K p_{ik}$.

Ordered models can be estimated using a cumulative link function, and we will assume the logit version; estimation is conducted in R using `polr` from the MASS package (Venables and Ripley, 2002). Essentially, we consider a single equation model, such as

$$g(\gamma_{ik}) = \theta_k + \beta_2^k \ln x_i + \sum_j \psi_j^k Z_{ij} + \sum_j \phi_j^k D_{ij} + v_i. \tag{6}$$

In this formulation, θ_k is a category-specific ‘‘intercept’’. Instead of applying the logit transformation to the response probabilities, they can be applied to the cumulative response probabilities, so:

$$\text{logit}(\gamma_{ik}) = \ln \frac{\gamma_{ik}}{1 - \gamma_{ik}} = \theta_k + \beta_2^k \ln x_i + \sum_j \psi_j^k Z_{ij} + \sum_j \phi_j^k D_{ij} + v_i \tag{7}$$

Exponentiating leads to

$$\begin{aligned} \frac{\gamma_{ik}}{1 - \gamma_{ik}} &= \exp\{\theta_k\} \exp\left\{\beta_2^k \ln x_i + \sum_j \psi_j^k Z_{ij} + \sum_j \phi_j^k D_{ij}\right\} \\ &= \lambda_k \exp\left\{\beta_2^k \ln x_i + \sum_j \psi_j^k Z_{ij} + \sum_j \phi_j^k D_{ij}\right\} \end{aligned} \tag{8}$$

On the left hand side, we have the *odds* that $b_i \leq k$, or that the response is in category k or below. In the model, λ_k is the baseline odds. The model is referred to as the *proportional odds* model, because the cumulative odds are proportional to $\exp\{w_i^k \zeta\}$. The model is also referred to as the *ordered logit* model, because we make use of a cumulative logit.

To determine equivalence scales, we note that (8) offers an equation similar in form to (2). Thus, it is possible to set the underlying probabilities across goods and household types equal and solve for the own to reference expenditure ratio similar to that suggested for Eqs. (3) and (4). We follow that process to determine the subjective equivalence scales for each good household- and good-type, denoted by Λ_S^k . As before, it is a function of the differences in the observed data across household types and the estimated parameters, while we continue with the same reference household of one adult and zero children. Again, we eliminate all Z factors from the scale calculations, even though they are included in the regression to address unobserved heterogeneities that are potentially correlated with household structure and expenditure. We also undertake 399 parametric bootstrap replications to determine the variability of the scales, and the analysis is separately undertaken for each consumption good k .

$$\Lambda_{S_i}^k = \frac{x_i}{x^r} = \exp \left[\frac{1}{\beta_2^k} \left\{ - \sum_j \phi_j^k (D_{ij} - D_j^r) \right\} \right] \tag{9}$$

3.2.2 Sensitivity Analysis

The preceding categorical analysis makes two assumptions that deserve further scrutiny. The first is that the outcomes are necessarily rankable, such that an ordered model is appropriate. In analyses not reported, we considered a multinomial logit model that relaxes the rank assumption. The results were not particularly different, and are available from the author upon request. The second is that the adequate v more-than-adequate cut line contains

relevant information for the underlying analysis of scales. Specifically, it assumes that all three adequacy levels are needed in order to correctly estimate the parameters of the model. Given that scales are calculated only across the boundary between inadequate and just adequate consumption (and not more than adequate), a binary logit analysis containing only inadequate and just adequate outcomes might better capture the relevant empirical information. In a further sensitivity analysis, we apply a binary logit model, rather than an ordered model; the results are also not different enough to present separately. Therefore, in an effort to save space we note that those results are available from the author.

3.3 Endogeneity

Endogeneity issues are likely extensive in this analysis. For example, total expenditure could be measured with error or could be simultaneous to expenditure choices (Summers, 1959). Household size might also be endogenous (Edmonds et al., 2005; Klasen and Woolard, 2008). In either case, endogeneity could lead to biased estimates and incorrect scales. Also, due to the subjective nature of views of adequacy, which are likely to depend on lived experiences and peers – which are not observed, but are expected to be correlated with observed data – an additional endogeneity concern arises within the categorical response models.

The normal solution is to find an instrument for, say, household size or expenditure. However, an instrument may not be available. We address expenditure endogeneity by applying Dong (2010). It is a control function method that does not require an instrument. Instead, it requires a continuous control that has a large support. We use income, which has a large support, larger than total expenditure. The control function in the second stage is the residual from a nonparametric regression of expenditure against income, \mathbf{D} and \mathbf{Z} from the model.

In the case of unobserved reference effects, a typical solution is to find a proxy variable, although, by definition, such a variable will be measured with error. The proxy we use is the household's share of the budget devoted to food, clothing and housing.³ Thus, for food adequacy, our proxy is the food share – similarly, we use the clothing and housing shares to proxy for clothing and housing adequacy unobserved reference effects, respectively. As noted, we recognize that these proxies are measured with error, and, therefore, rather than estimating with only the proxies, we estimate with the proxies and associated control functions that are also based on Dong (2010). The control function is the residual from a nonparametric regression of the relevant share (food, clothing and housing) against income, \mathbf{D} and \mathbf{Z} from the model. Again, income is used, because it has large support, even though it may not be exogenous.

For the nonparametric estimates, we follow Li and Racine (2004). We implement the models using the `np` package (Hayfield and Racine, 2008) in R (R Core Team, 2021). For continuous data an `epanechnikov` kernel is used, while the Li and Racine (2007) kernel underpins the categorical/discrete variables. The results from the nonparametric analyses are available. upon request. They are not reported here, in an effort to conserve space.

³ In an analysis not presented, but available from the authors, we used the average share of food, clothing and housing for all other households in the primary sampling unit (in other words, household i 's recorded average consumption share does not include household i 's consumption). Our findings are in line with what is reported. The estimated scales from the endogenous component of that analysis are slightly lower than even here, which, in turn, leads to slightly lower child costs and economies of scale parameters compared to those reported in Table ~4. They are available from the author, upon request.

3.4 Plausibility

Our approach suggests a wide range of estimates. We have food, clothing and housing shares assuming (or not) exogeneity, as well as ordered models focusing on food, clothing and housing security, again with and without exogeneity. From each of these, the equivalence scales are also estimated. For each type of model (linear share or ordered) and each assumption about the error term (endogeneous or endogenous), we have coefficient estimates and share estimates. Although the scales are comparable to each other, there are no obvious statistical tests associated with the estimated shares to determine if they are correct. Instead, we borrow from the plausibility rules outlined in Dudel et al. (2021b) to examine rules violations across the different models to see where they arise, and determine which model performs better, on average. For our purposes, the average is a simple mean based on counts – it is the sum of the violations divided by the total possible violations.

We follow Dudel et al. (2021b) in defining the scales (Λ) to be a function of the household's utility (u), the vector of prices that the household faces (\mathbf{p}) and the number of adults (a) and children (c) in the household, such that $\Lambda = \Lambda(u, \mathbf{p}, a, c)$. For plausibility, we assume that each marginal equivalence cost of an child or adult is nondecreasing, while that marginal cost is nonincreasing; together, these imply that there are consumption/security economies of scale and that larger households require more consumption and have more needs. Implicit in this assumption is that no additional child or adult costs more than an adult on their own. We also assume that an additional adult is relatively more costly than an additional child, at the margin. We formalize these in the following equations:

$$\begin{aligned}
 \text{Nondecreasing adult or child costs :} & \quad \Lambda(u, \mathbf{p}, a + 1, c) \geq \Lambda(u, \mathbf{p}, a, c) \\
 & \quad \Lambda(u, \mathbf{p}, a, c + 1) \geq \Lambda(u, \mathbf{p}, a, c) \\
 \text{MC of adult or child} < 1 : & \quad \Lambda(u, \mathbf{p}, a + 1, c) \leq \Lambda(u, \mathbf{p}, a, c) + 1 \\
 & \quad \Lambda(u, \mathbf{p}, a, c + 1) \leq \Lambda(u, \mathbf{p}, a, c) + 1 \\
 \text{Nonincreasing MC of adult or child :} & \quad \Lambda(u, \mathbf{p}, a + 1, c) - \Lambda(u, \mathbf{p}, a, c) \leq \\
 & \quad \Lambda(u, \mathbf{p}, a, c) - \Lambda(u, \mathbf{p}, a - 1, c) \tag{10}
 \end{aligned}$$

and

$$\begin{aligned}
 & \quad \Lambda(u, \mathbf{p}, a, c + 1) - \Lambda(u, \mathbf{p}, a, c) \leq \\
 & \quad \Lambda(u, \mathbf{p}, a, c) - \Lambda(u, \mathbf{p}, a, c - 1) \\
 \text{MC adult} > \text{MC child :} & \quad \Lambda(u, \mathbf{p}, a + 1, c) > \Lambda(u, \mathbf{p}, a, c + 1)
 \end{aligned}$$

As we describe further, below, we limit our analysis to households with no more than six adults and no more than four children. Applying these rules across that data yields 152 different comparisons in each set of estimates. We report the performance from these different models in Tables 1 and 2.

4 Data

The preceding methods are applied to data taken from the South African Living Conditions Survey (LCS) 2014/2015 (Stats SA, 2017), which is collected to help understand living conditions and poverty in South Africa. Although a similar survey was conducted in 2008–09, the LCS is cross-sectional. It is useful for our analysis, because it captures all of the

Table 1 Count of plausibility violations when scales are indirectly estimated from linear regression models over expenditure shares

	Total Comparisons	Exogenous violations			Endogenous violations		
		Food	Clothing	Housing	Food	Clothing	Housing
Increasing child cost	24	0	0	24	0	0	0
Child increase less than one	24	0	22	0	0	22	24
Decreasing marginal child cost	18	18	12	14	7	12	18
Increasing adult cost	25	5	0	24	5	0	0
Adult increase less than one	25	0	25	0	0	25	25
Decreasing marginal adult cost	20	5	15	10	5	15	10
MC adult exceeds MC child	16	12	8	10	12	9	11
Total possible violations	152	40	82	82	29	83	88
Proportion of possible violations	1.00	0.26	0.54	0.54	0.19	0.55	0.58

Plausibility results are underscored by the series of rules comparisons outlined in Eq. (10) and described there. If any comparison fails, that leads to a rules violation, and all failures are counted and presented for each rule, each good and each error assumption. In the second to last row, we present the count of all violations in each column. The last row presents the proportion of violations uncovered out of the total possible. Thus, lower proportion represent better performance

Table 2 Count of plausibility violations when scales are indirectly estimated from ordered probability models over basic needs (in)security

	Total Comparisons	Exogenous violations			Endogenous violations		
		Food	Clothing	Housing	Food	Clothing	Housing
Increasing child cost	24	0	0	0	0	0	0
Child increase less than one	24	0	0	0	0	0	0
Decreasing marginal child cost	18	12	6	12	12	6	12
Increasing adult cost	25	0	5	5	0	5	0
Adult increase less than one	25	0	2	4	0	0	2
Decreasing marginal adult cost	20	5	10	5	5	10	5
MC adult exceeds MC child	16	7	8	11	5	7	11
Total possible violations	152	24	31	37	22	28	30
Proportion of possible violations	1.00	0.16	0.20	0.24	0.14	0.18	0.20

Plausibility results are underscored by the series of rules comparisons outlined in Eq. (10) and described there. If any comparison fails, that leads to a rules violation, and all failures are counted and presented for each rule, each good and each error assumption. In the second to last row, we present the count of all violations in each column. The last row presents the proportion of violations uncovered out of the total possible. Thus, lower proportions represent better performance

relevant data, including the adequacy of consumption on food, clothing and housing, as well household expenditure, expenditure on particular types of goods, household size and structure and some information on gender, ethnicity and household location. We defined children to be 15 years and under, which is also the age at which individuals are allowed to

leave school, according to Republic of South Africa (1996). The survey covered 23,380 households containing 88 906 individuals (which is limited to individuals residing in the household at least four nights per week); the reported response rate for the survey was 84.9%.

The adequacy questions were asked at the household level, thus answers come from only one individual. The question was asked in the following format, “During the month prior to the survey period, what was your household’s standard of food consumption/housing/clothing?”⁴ Expenditure and income information follows classification of individual consumption by purpose (COICOP) categories. Food expenditures lie in Category 01, clothing expenditures lie in Category 03, while housing expenditures are in Category 04. These expenditure categories match the basic needs categories, and, thus are appropriate for the analysis. Every subcategory of expenditure is summed within a household; however, we do not include food purchased away from home in the food expenditure. Although our focus is on consumption adequacy and expenditure shares for the calculation of scales, the data includes an income satisfaction question, a minimum income question and a living standards question, which could also be used for the estimation of equivalence scales.

In this data, there are few differences between total consumption and total consumption in-kind. For the analysis, we use household consumption expenditure capturing both monetary and in-kind payment for all goods and services, as well as the money metric value of the consumption of home services. The primary service captured is rent, which is set at 7.5% of the reported value of the building. The LCS data is collected for 12 months, with different samples in different provinces; in other words, we do not have repeated observations for any household. We inflate/deflate expenditure values to April 2015, the midpoint of the survey year, using the consumer price index.⁵

5 Descriptive Results

5.1 Sample Data

We begin by describing the data used in the analysis, which we present in Appendix Table 5. The data is separated by self-assessed food adequacy. The initial data included 23,380 households. However, after removing data for which there are missing values, we end up with 18,354 observations.⁶

The descriptive statistics imply not unexpected correlations across the data. For instance, 69% of households with less than adequate food also have less than adequate clothing, 63% also have less than adequate housing. We similarly see that nearly 20% of adults in such

⁴ The question also asked about healthcare and children’s schooling, which are both publicly (at subsidised rates) and privately provided; therefore, we did not include them in the analysis.

⁵ The data from the survey is collated in a number of files, including a person file, a household file and an expenditure and income file. For the analysis, we use `haven` (Wickham and Miller, 2021), the `tidyverse` (Wickham et al., 2019), `stargazer` (Hlavac, 2018), `qwraps2` (DeWitt, 2021), `knitr` (Xie, 2014), `kableExtra` (Zhu, 2021) and `rmarkdown` (Xie et al., 2020), which are packages for R, to organize the data for the analysis, prepare the data in tables and write the paper in a completely repeatable manner (Racine, 2019). Code for the preparation of the data, figures, tables and all empirical modelling will be made available on <https://doi.org/10.25403/UPresearchdata.21550716>.

⁶ We lose 96 observations for missing information on marital status and education, 254 for missing food expenditures, 2547 for missing clothing expenditures, 83 for missing housing expenditures and 1467 for missing data on adequacy, income, expenditure, and various data related to adult and child hunger. When merging, since these are not all the same households, the result is 5026 fewer observations in total.

households go hungry often or always; however, the same figure is only about 1% for households who assess that they have above adequate food. We report on a number of additional survey questions related to how households deal with their perceived food access; questions include how common it was for them not to have money to buy food or whether they had to make smaller meals, skip meals or prepare less food when they did not have enough money. Across the board, we find that worse food security correlated with inadequate food, and, by implication, clothing and housing.

South Africa's apartheid past, as might be expected, offers a subtext for basic needs in/security. Non-whites, Africans in particular, were more likely to be in the below adequate food category, rather than adequate or above. We find that being married correlates with food security, probably due to dual income sources, and that better education—which also correlates with household income/expenditure and wealth—is associated with more favourable food security. Location does not offer as clean a relationship as might have been expected; however, households located in formal urban settings are more likely to be food secure, while those in traditional rural areas are less so.

In terms of expenditure share *welfare*, there is some concern that housing is not an appropriate measure. Although more examination is presented below, we see that the housing budget share is highest for households that are more food secure. The opposite is true for food and clothing, which suggest they are more in line with Engel's original welfare argument that smaller shares represent higher welfare.

The final variable of interest is the number of children and adults in the household. Our analysis sample does not differ appreciably, especially in terms of adults, when we consider food security. It does appear, however, that food security is associated with a reduction in the number of children. Below, after controlling for other household feature differences, we find that households with fewer adults and children have, for the most part, a higher probability of accessing adequate food (and other goods).

5.2 Budget Shares

As we see in Table 5, there are differences in budget shares by food security category. In order to examine more carefully the plausibility of using food, clothing and housing shares as a measure of welfare, we illustrate fitted shares from a nonparametric regression against the natural log of household expenditure for different subsets of household structures. See Figs. 1, 2 and 3. The figures suggest that both food and clothing are reasonable shares for welfare purposes, while housing expenditures are not. Despite this fact, we continue to include housing shares in our analysis for comparison purposes.

6 Model Results

As described in the methods section, we estimated linear share regressions for food, clothing and housing with and without control functions to examine the potential for endogeneity. For adequacy, we estimated ordered logit models with and without control functions.

6.1 Budget Share Estimates

The share estimates are reported in Appendix Table 6. The table contains three sets of columns, one set for each share: food, clothing and housing. Each set contains results without (Exogenous) and with (Endogenous) the control function for log expenditure.

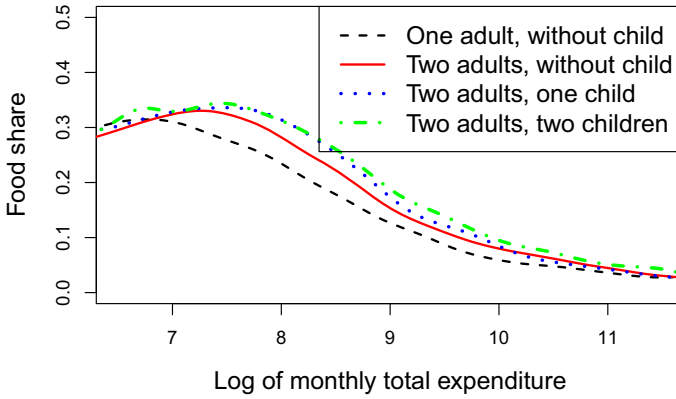


Fig. 1 Fitted nonparametric regressions of household food shares against total household log expenditure: selected households sizes

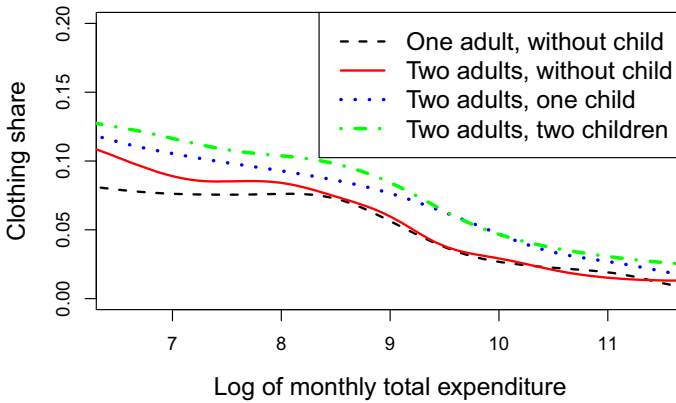


Fig. 2 Fitted nonparametric regressions of household clothing shares against total household log expenditure: selected households sizes

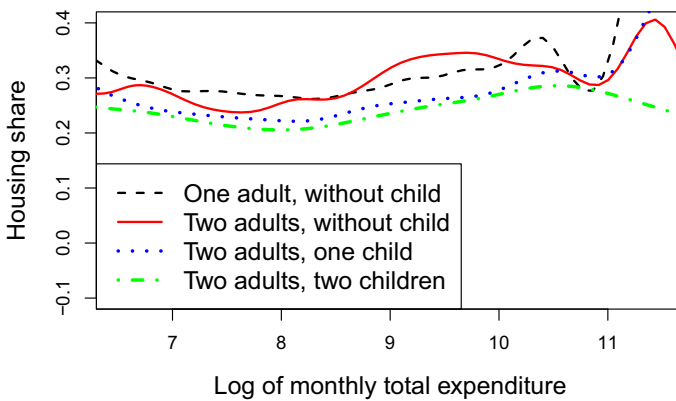


Fig. 3 Fitted nonparametric regressions of household housing shares against total household log expenditure: selected households sizes

Although there are too many results to discuss, we would like to point out the sign differences for adults and children that can be seen for the housing share relative to the others. The sign differences suggest that food/clothing shares increase with the number of household members, while housing shares decrease along the same dimensions. We also find the expenditure estimate is rather different between food and clothing relative to housing. These differences are not unexpected, given Figs. 1, 2 and 3, which showed differences in the relationship between log expenditure and the food/clothing share relative to the housing share.

We also see that the endogeneity effects are somewhat different across the shares. Firstly, the control function for log expenditure is statistically significant in all share models; it is positive for the food share, but negative for both the clothing and housing shares. Focusing on children and adults in the household, controlling for endogeneity leads to increased household size effects, along with an increased magnitude expenditure gradient for food shares. For clothing shares, endogeneity correction leads to small reductions in household size effects, as well as a reduced magnitude expenditure gradient. For housing shares, the expenditure gradient switches sign and increases, while household size effects increase slightly in magnitude. As we will see, these differences also impact the underlying scale estimates – yielding implausible equivalence scales in many cases.

6.2 Adequacy Estimates

The main adequacy estimates are available in Appendix Table 7. In the table, we present results that do not (Exogenous) and do (Endogenous) account for potential endogeneities.⁷ Although there are still too many estimates to discuss, there is more uniformity across adequacy outcomes than there was across budget share outcomes, which is supportive of the welfare measure that we use to underpin equivalence scale estimates in this research. Across all three household adequacy measures, we see that the parameter estimates for the number of children and the number of adults in the household is negative, i.e., larger households are less likely have adequate food/clothing/housing. We also see that controlling for endogeneity increases the magnitude of these estimates in most cases, as well as the magnitude of the log expenditure gradient. Although the food share control function is not statistically significant in the food adequacy model, the log expenditure control function is negative and statistically significant in all models, while the clothing share and housing share control functions are positive and statistically significant in the clothing and housing adequacy models, respectively.

7 Equivalence Scales

The standard Engel approach assumes that an expenditure share is an appropriate measure of welfare. It may not be. As we have seen so far, budget share estimates, at least with this South African data, follow different patterns with regards to log expenditure and household size characteristics, depending on the share in question. On the other hand, even though normative and potentially meaning different things to different households, whether a

⁷ We also estimated binary logit models, limited to households who self-assessed their food, clothing and housing as either less than adequate or adequate. As with the ordered models we discuss here, we also accounted for potential endogeneity in log expenditure and potential peer effects. Qualitatively, the results are quite similar to what is observed under the ordered logit model, and, therefore, they are not presented here; however, they are available upon request.

household has enough food, clothing and/or shelter, has fairly clear welfare implications. An important observation from the adequacy model estimates is that they follow rather similar patterns, even if estimates are not identical across goods. This similarity suggests an advantage to basing equivalence scales on self-assessed basic needs. We now turn our attention to the equivalence scales that arise from these different models, comparing and contrasting them across goods and measures of those goods.

7.1 Deaton Scales

We begin by presenting the scales that arise from the indirect estimation of basic needs budget shares, as outlined in Eq. (4). The results are reported in Appendix Table 8. In Table 1, we present the plausibility results underpinned by the equivalence scale properties listed in Eq. (10). The first conclusion to draw from the results is that neither clothing nor housing share equivalence scales are reasonable, because they violate the assumed plausibility properties in at least 50% of the comparisons. We find that the marginal equivalence cost of both adults and children nearly always exceeds one for clothing in both the exogenous and endogenous settings. For housing, the same is true in the endogenous version of the model. Furthermore, we find that the marginal equivalence costs for adults and children do not follow a consistent diminishing path, while the marginal cost of a child often exceeds that of an adult.

If we look more specifically at the estimated scales in Table 8, we find exogenous housing scales to be less than one and as low as zero in many cases. The implication is extensive economies of scale in housing, which is possible, although the implied economies of scale do not match results from any study of which we are aware. Furthermore, the results do not yield useful equivalence scales. On the other hand, once we control for endogeneity, the housing share scales are often in double digits. In that regard, the estimates are simply not consistent enough to be taken seriously. For clothing, we see estimated scales that are double, triple or an even larger multiple of those estimated from food shares, regardless of whether we controlled for endogeneity in the model. For example, a two-adult and three-child household equivalence is estimated to be 2.6, if based on food shares, but in excess of 8, if based on clothing shares. When controlling for endogeneity, clothing share scales increase even more. Despite the fact that the clothing-based shares suggest implausibly high scales, they mostly increase with household size, along both the adult and child dimensions.

When we turn our attention to food shares, the results are more plausible. For the most part, they increase with household size, but by smaller amounts, suggesting that there are economies of scale; however, the results in Table 1 suggest that child marginal equivalence costs are not always diminishing. There is also some evidence that adult marginal equivalence costs are not monotonically decreasing, while the child marginal cost too often exceeds the adult marginal cost.

In summary Deaton-based scales are neither consistent across goods nor across the endogeneity assumption. The housing share scales are entirely implausible, while the clothing shares do not appear any more reasonable. Food-based shares are the most plausible, with 19% and 26% plausibility violations for the endogenous and exogenous estimates, respectively. The violation percentages for clothing and housing shares are at least double that calculated for food shares across all share models.

7.2 CAQ Scales

We continue by examining the scales that are derived from the categorical basic needs models. The scales are presented in Appendix Table 9, while the scale plausibility results are presented in Table 2. When the approach is based on whether or not household needs are met, at least according to the household, we see rather different results to those derived from shares. In particular, the scales are very similar, regardless of which good's adequacy is considered. For example, for two adults and three children, the scales are estimated to be 2.3, 2.3 and 1.8 for food, clothing and housing adequacy. After controlling for endogeneity, the scales reduce to 1.9 and 1.9 for food and clothing adequacy, respectively, but increase to 1.9 for housing; the food share equivalence scale for the same two-adult and three-child household was 2.6 and 2.1, for the exogenous and endogenous-corrected versions, respectively. Similar levels of consistency are observed for different adult and child combinations. Furthermore, the scales from the ordered adequacy models are similar to the food budget share scales for most adult and child combinations.

Despite the similarities in estimated scales, the categorical model yields greater levels of plausibility than those arising from expenditure shares. The violations proportions range from 0.14 to 0.24, see the bottom row of Table 2, rather than 0.19–0.58, as uncovered using expenditure shares. When comparing the exogenous columns to the endogenous columns, we also see that controlling for reference effects and the potential endogeneity associated with mis-measured reference effects yields a slight reduction in the proportion of failures detected across all needs. However, there are some plausibility differences across needs. We do not find monotonic diminishing marginal child equivalence costs for any basic need, although the performance is relatively better for clothing than it is for either food or housing. On the other hand, adult costs for clothing are more likely associated with a problem: there are more observed decreasing adult costs than expected, which is related to the non-monotonic nature of the diminishing adult marginal equivalence costs.⁸

7.3 Child Cost—Household Economies of Scale Formulation $(A + \kappa K)^\theta$

Given the large number of estimated scales, we undertake a final set of nonlinear estimates. In this nonlinear analysis, we take the scales we have estimated for each model and each good or good adequacy, and place them in the familiar child cost—economies of scale framework: $(A + \kappa K)^\theta$. In this formulation, κ captures the child cost relative to an adult, and is normally less than one. Similarly, θ measures the extent of household scale economies; the typical assumption is that a household is able to consume more at relatively lower cost, due to its increased size, such that the scale parameter is also less than one. We present the results in two tables. Table 3 contains the results underpinned by the expenditure share models, while Table 4 contains the estimates from the ordered adequacy models.

As highlighted in previous subsections, the expenditure share models lead to a range of scales that differ by expenditure share category. The child cost estimates, although different

⁸ In a sensitivity analysis, we applied binary logit models, using those estimates to derive equivalence scales. We found little impact on the resulting scales, at least in comparison with those arising from the ordered model. As was the case with the ordered logit models, the scales are fairly similar regardless of the endogeneity assumption, as well as the needs considered. They are also quite similar to those reported for the ordered models, which is why they are not presented, here. There is, however, a rather minor improvement in the overall share of plausibility violations in the binary models, relative to the ordered models. All of the binary model results are available, upon request.

Table 3 Estimate of child cost and household economies of scale from expenditure share models

	Food share		Clothing share		Housing share	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Child cost	3.9869 (0.41–7.56)	1.3399 (0.76–1.92)	0.8122 (0.49–1.13)	0.8486 (0.50–1.19)	0.9251 (0.82–1.03)	1.1898 (0.72–1.66)
Scale economy	0.3442 (0.26–0.43)	0.3938 (0.35–0.44)	1.6191 (1.50–1.73)	1.9174 (1.78–2.06)	– 3.7844 (– 4.01–3.56)	2.0207 (1.85–2.19)

Child cost κ and economies θ estimated nonlinearly, along with 95% confidence intervals in brackets, assuming equivalence scales of the form: $(A + \kappa K)^\theta$. Estimates arise from expenditure share models

Table 4 Estimate of child cost and household economies of scale from ordered adequacy models

	Food adequacy		Clothing adequacy		Housing adequacy	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Child cost	0.8140 (0.53–1.10)	0.6451 (0.37–0.92)	0.5660 (0.09–1.04)	0.5469 (0.37–0.72)	0.4508 (0.27–0.63)	0.6421 (0.24–1.04)
Scale economy	0.5872 (0.54–0.63)	0.5974 (0.55–0.64)	0.4463 (0.38–0.51)	0.5306 (0.50–0.56)	0.5372 (0.50–0.57)	0.4766 (0.42–0.53)

Child cost κ and economies θ estimated nonlinearly, along with 95% confidence intervals in brackets, assuming equivalence scales of the form: $(A + \kappa K)^\theta$. Estimates arise from ordered categorical basic needs adequacy models

for each category, cannot be statistically separated from one, which suggests that children are at least as expensive as an adult. For food expenditure, the child cost—economy of scale estimates are reasonably consistent with the square-root scale, in agreement with Koch (2022), but not with Daley et al. (2020). However, for both clothing and housing expenditure, the scale economy ranges from large negative values to approximately two, the latter of which suggests that there are no scale economies. We are not aware of any international estimates in agreement with the equivalence scales estimated from these clothing and housing expenditure shares.

For the ordered categorical models—see Table 4—the share estimates, as noted previously, are more consistent. We find relatively small child costs; depending on which category of adequacy, the child costs range from 0.45 to 0.81, with a midpoint of 0.63. In other words, the adequacy models suggest that the cost of a child is approximately 60–65% of the cost of an adult, on average. Furthermore, the scale economies estimates range from 0.44 to 0.60; in only one case does the estimated confidence interval not include 0.5. A scale economy of 0.5 is in agreement with a square-root scale; however, the lower child costs estimated here suggest that such a scale will overstate the income adjustment needed for families with a relatively large number of children.⁹

⁹ We also estimated the child cost—scale economy model for the equivalence scales underpinned by the binary logit model. As with the ordered model, scale economies near 0.5 are within reason. Those results are available, upon request.

8 Discussion

With this research, we have presented the first, of which we are aware, subjective equivalence scales for Africa, based on consumption adequacy. It is also one of the few studies of subjective equivalence scales that is available for developing countries – we are only aware of Rojas (2007), who estimates subjective scales for Mexico and de Ree et al. (2013), who consider the potential for price and utility dependence in equivalence scales using Indonesian data. Rojas (2007) finds that an increase of 40% in household income is required to keep a person's economic satisfaction constant when a second member is added, while a 20% increase is required to keep a person's economic satisfaction constant when a sixth person is added to a five-member household. Although we follow a different approach, our estimates are not directly comparable to the linear 40% estimate. However, our food share equivalence estimates imply a required income increase of 35–40%, while our adequacy scale estimates imply a required income increase of 25–40% for the first additional adult. However, if the second member of the household is a child, the figures are closer to half of that. On the other hand, we report a range of estimates for five-member and six-member households. For example, if the sixth additional member is an adult that has been added to a three-adult and two-child household, the scale estimates (using endogenous food shares) increase from 2.20 to 2.24 or 1.96 to 2.08 (implying only a few percentage points). If we look across food, housing and clothing adequacy scales, the implied required percentage point increase in income ranges from 1.2% (2.617–2.650, exogenous housing adequacy) to 15.1% (2.371–2.736, exogenous food adequacy). Thus, our approach offers a wider number of scales, and, therefore, a less simplistic interpretation.

de Ree et al. (2013) do not present scales in as much detail as we do here, and, therefore, an across the board direct comparison is more difficult to make. However, they suggest that their scales for Indonesia are larger than those implied by the OECD-modified scales. The modified OECD scale (Hagenaars et al., 1994) suggests equivalence weights of 1.0 for the first adult, 0.5 for the second and each person over the age of 14, and 0.3 for each child under 14. Despite the fact that our child/adult threshold is 15, and, therefore, not identical, our most plausible scales—those from food shares, as well as those derived from consumption adequacy—are everywhere below the implied modified OECD adjustment that would be computed for the household. Thus, our consumption adequacy scales are also smaller than those estimated for Indonesia.

Previous literature has presented a range of scale estimates (focusing on expenditure data) for South Africa. Two of the most recent disagree on the appropriateness of the square-root scale (Daley et al., 2020; Koch, 2022). Our adequacy-based scales suggest economies of scale within the square-root region, and, therefore, is in agreement with Koch (2022); however, these same estimates suggest child costs much less than one (nearer 0.5). Thus, when combined, our subjective-based equivalence scales are relatively smaller than any scales previously estimated for South Africa (including the square-root scale). That conclusion is not entirely dissimilar to what has been uncovered by other subjective-scale research. Although Charlier (2002), for example, does find that satisfaction with income yields scales that increase with household size, Kapteyn et al. (1987) find that the subjective evaluations lead to implausibly low family cost parameters. In our view, our estimates are not implausibly low, although they may represent a lower bound. Additional subjective scales comparisons are necessary to offer further insight.

Our basic needs security subjective scales are consistent across types of need, which we did not find with expenditure shares on the same types of need. Possibly, the difference

arises, because subjective needs remove any discretionary expenditure that might be incorporated into objective expenditure share measures (Daley et al., 2020). Furthermore, across the board, we find smaller equivalence scales for housing adequacy, compared to food and clothing adequacy. Such differences are not entirely surprising, due to the fact that both clothing and housing are less private than food; clothing has some durability (across generations, for example), and, is widely available used, while space within a house can be reallocated. For example, although Frazer (2008) focuses on the manufacturing reduction associated with charitable clothing donations, the reduction is extensive and arises from reduced demand. Therefore, at any level of clothing adequacy, we would expect reduced clothing expenses. Such donations, especially if they are not recorded as ‘in-kind’ expenditure, and their impact on clothing expenditure (shares) offers one explanation for the observation that clothing share equivalence scales are not entirely plausible, at least in this analysis.

Furthermore, although we do not have a statistical criteria for judging the following comment, our simple counting approach suggests that clothing and housing share based estimates are implausible. In no case do we find plausibility scores better than 50%. On the other hand, the food share, food need, clothing need and housing need all have similar plausibility scores. As implied from the preceding discussion, the similarity of the scales derived from these different approaches, lends further credence to their plausibility. However, there is an obvious caveat: improved plausibility does not necessarily equate with correct.

Our results also suggest that endogeneity matters, although not enough to yield big differences in the scales, especially when it comes to subjective-based scales. We did find rather large differences in the scale estimates between endogenous and exogenous clothing and housing expenditure share models, however. For clothing and housing expenditure share, controlling for endogeneity increased the estimated scales; in some cases that increase was implausibly large. On the other hand, for food and clothing adequacy, endogeneity led to small increases in the share—the endogeneity effect was also small, but in the opposite direction for housing adequacy.

In the adequacy models, there are two potentially endogenous components. The first is associated with household expenditure, where the endogeneity correction was always negative, and was larger in absolute value for food adequacy than clothing, which was also larger in absolute value than it was for housing. The second was the reference effect correction, which led to the inclusion of the household’s expenditure share, as well as a control function to address the possibility that the expenditure share, as a proxy for reference effects, is measured with error. The sign of the expenditure share effects varied, although the control function component was always positive. Due to the multiple endogeneity components, as well as the signs of the endogeneity corrections, the exact direction of the endogeneity effect was not obvious.

As we have seen, all of the results suggest a non-monotonic pattern to marginal equivalence costs for both adults and children. Although this non-monotonic pattern may simply be a feature of South African households, or this particular data, additional research is needed. Such research can consider other developing countries and non-linearities associated with income/expenditure, the latter of which could even be utility or price dependent.

9 Conclusion

In this research, we have examined equivalence scales in South Africa making use of relatively standard approaches that rely on expenditure shares, as well as on self-assessed basic needs adequacy. Under the assumption that adequate food, clothing and shelter are needed for survival, the adequacy of these basic needs are plausible measures of welfare. Furthermore, they have the potential to be used to determine the required increase in income/expenditure that would allow an average household to reach adequate access to these basic survival needs. We exploit that thinking, and estimate categorical outcome models, which we use to indirectly estimate the aforementioned required increase, and, thus, equivalence scales for different types of households. We present those scales in a series of tables for each of our different measures: (1) actual expenditure shares on basic needs, and (2) self-assessed adequacy of basic needs.

Our approach has offered some diversification to the literature, in the sense that our subjective measures focus on perceived adequacy of basic needs (food, clothing and shelter), rather than on minimum income needs, income satisfaction or general life satisfaction. When using minimum income or life satisfaction, researchers have paid attention to potential reference groups. It was expected that self-assessed adequacy also suffers from reference effects, and, therefore, our diversification was not undertaken to eliminate such effects. Our results also suggest that these effects matter, although they do not materially influence the resulting scales. Approaching the problem via an estimate of the ability of an individual to meet their basic needs has a long history in psychology, however. It has been argued that being on the bottom rung of a hierarchy of needs is an important component of the psyche, and, therefore, welfare (Maslow, 1943); in this research, inadequately met food, housing and clothing represents that bottom rung.

Our results suggest that both housing and clothing expenditure shares are inappropriate welfare indicators, and that scales resulting from such models are more likely implausible than plausible, at least in South Africa. On the other hand, food expenditure shares, as well as food, clothing and housing (in)adequacy, appear to be better candidates. They yield similar scales and similar plausibility scores, regardless of whether we control for potential endogeneity. The adequacy scales are generally less than the food share scales, regardless of household structure, and for the exogenous and endogenous scales. Once controlling for endogeneity, the scale differences across goods are generally lower. Finally, the endogeneity/exogeneity differences between scales tend to be relatively small compared to the overall estimated scale variability across the scales.

A Descriptive Statistics

In this appendix, we describe the data according to differences in food adequacy (or insecurity) levels in the household (Table 5).

Table 5 Summary statistics of household or household head by self-assessed food adequacy

Adequate food	Below (N = 4203)	Adequate (N = 12,518)	Above (N = 1633)
Adequate clothing			
Less than adequate	69.38%	8.70%	3.67%
Just adequate	29.34%	89.38%	14.27%
More than adequate	1.28%	1.93%	82.06%
Adequate housing			
Less than adequate	62.79%	11.18%	6.06%
Just adequate	34.83%	85.86%	15.86%
More than adequate	2.38%	2.96%	78.08%
Adult in household gone hungry			
Never	52.49%	88.90%	96.02%
Seldom	27.31%	8.53%	3.06%
Often	16.32%	2.24%	0.86%
Always	3.88%	0.33%	0.06%
Child in household gone hungry			
Never	45.94%	64.96%	60.62%
Seldom	16.08%	5.04%	1.96%
Often	9.71%	1.30%	0.80%
Always	2.50%	0.24%	0.00%
No children in HH	25.77%	28.46%	36.62%
No money to buy food			
Never	32.67%	74.99%	90.81%
Seldom	32.33%	17.01%	5.94%
Often	35.00%	8.00%	3.25%
Made smaller meals			
Never	35.31%	77.52%	91.67%
Seldom	29.19%	14.09%	5.33%
Often	35.50%	8.39%	3.00%
Needed to skip meals			
Never	45.13%	82.79%	93.82%
Seldom	25.34%	10.94%	4.23%
Often	29.53%	6.27%	1.96%
Less food for meals			
Never	36.57%	77.39%	91.79%
Seldom	27.96%	13.99%	5.14%
Often	35.47%	8.62%	3.06%
Population group			
African	91.22%	81.61%	46.42%
Mixed	6.95%	10.95%	22.66%
Asian	0.64%	1.99%	3.18%
White	1.19%	5.45%	27.74%
Marital status			
Married	24.98%	36.24%	56.22%
Partners	0.00%	0.00%	0.00%

Table 5 continued

Adequate food	Below (N = 4203)	Adequate (N = 12,518)	Above (N = 1633)
Never married	36.93%	30.36%	19.41%
Widowed	0.00%	0.00%	0.00%
Separate	3.40%	2.50%	1.22%
Divorced	2.21%	3.02%	5.63%
Education			
No schooling	15.73%	9.55%	2.88%
Some schooling	41.09%	30.38%	16.72%
Completed grade 9	8.37%	7.21%	5.08%
Completed grade 10	9.92%	10.23%	8.02%
Completed grade 11	9.61%	10.26%	5.57%
Completed grade 12	11.75%	20.17%	25.66%
First year university	1.31%	2.99%	4.78%
Second year university	1.07%	3.80%	8.08%
Completed university	0.71%	3.42%	11.27%
Completed honours	0.21%	1.29%	5.88%
Further postgraduate	0.00%	0.00%	0.00%
Wealth status			
Wealthy	0.45%	0.22%	1.47%
Very comfortable	0.93%	2.88%	13.96%
Reasonably comfortable	4.57%	16.73%	39.93%
Just getting by	31.72%	51.45%	35.58%
Poor	42.56%	23.70%	7.41%
Very Poor	19.77%	5.02%	1.65%
Residence			
Urban formal	44.71%	56.51%	75.93%
Urban informal	9.37%	6.79%	3.00%
Traditional area	41.87%	33.06%	16.90%
Rural formal	4.04%	3.64%	4.16%
Province			
Western Cape	7.23%	11.62%	33.07%
Eastern Cape	14.99%	12.21%	5.82%
Northern Cape	4.43%	5.83%	5.94%
Free State	12.61%	9.58%	9.12%
KwaZulu–Natal	13.25%	17.43%	8.70%
North West	10.40%	8.08%	4.35%
Gauteng	11.78%	14.20%	15.06%
Mpumalanga	11.11%	9.91%	9.31%
Limpopo	14.20%	11.14%	8.63%
Life circumstances scale (1–9)			
mean (sd)	2.90 (1.78)	4.14 (1.84)	5.26 (1.88)
Household head age			
mean (sd)	48.19 (15.76)	48.65 (16.06)	47.99 (14.34)
Household composition			

Table 5 continued

Adequate food	Below (N = 4203)	Adequate (N = 12,518)	Above (N = 1633)
Children: mean (sd)	1.27 (1.26)	1.09 (1.18)	0.84 (1.04)
Adults: mean (sd)	2.56 (1.33)	2.52 (1.29)	2.47 (1.21)
Log income and expenditure			
Expenditure: mean (sd)	7.85 (0.81)	8.43 (0.95)	9.47 (1.05)
Income: mean (sd)	7.80 (1.07)	8.55 (1.13)	9.69 (1.19)
Budget shares			
Food: mean (sd)	0.30 (0.18)	0.24 (0.17)	0.14 (0.13)
Clothing: mean (sd)	0.09 (0.08)	0.08 (0.07)	0.06 (0.06)
Housing: mean (sd)	0.25 (0.17)	0.26 (0.17)	0.28 (0.17)

Categorical variables are presented as the percent of observations in each category within each column. For continuous variables, the mean is presented with its standard deviation, separated by \pm

B Model Estimates

In this appendix, we present the underlying model estimates (Tables 6, 7).

Table 6 Estimates from linear food budget share equation

Variables	Food share		Clothing share		Housing share	
	Exog	Endog	Exog	Endog	Exog	Endog
Intercept	0.7960 ^a (0.016)	1.1147 ^a (0.021)	0.2665 ^a (0.008)	0.2382 ^a (0.010)	0.2410 ^a (0.018)	0.0495 ^c (0.024)
Log expenditure	-0.0633 ^a (0.002)	-0.1063 ^a (0.002)	-0.0199 ^a (0.001)	-0.0161 ^a (0.001)	-0.0062 ^a (0.002)	0.0196 ^a (0.003)
One child	0.0150 ^a (0.003)	0.0160 ^a (0.003)	0.0097 ^a (0.001)	0.0096 ^a (0.001)	-0.0150 ^a (0.003)	-0.0156 ^a (0.003)
Two children	0.0272 ^a (0.003)	0.0298 ^a (0.003)	0.0215 ^a (0.001)	0.0212 ^a (0.001)	-0.0263 ^a (0.003)	-0.0278 ^a (0.003)
Three children	0.0402 ^a (0.004)	0.0448 ^a (0.004)	0.0253 ^a (0.002)	0.0249 ^a (0.002)	-0.0337 ^a (0.004)	-0.0365 ^a (0.004)
Four children	0.0513 ^a (0.005)	0.0572 ^a (0.005)	0.0319 ^a (0.003)	0.0313 ^a (0.003)	-0.0455 ^a (0.006)	-0.0491 ^a (0.006)
Two adults	0.0205 ^a (0.003)	0.0317 ^a (0.003)	0.0164 ^a (0.001)	0.0154 ^a (0.002)	-0.0167 ^a (0.004)	-0.0235 ^a (0.004)
Three adults	0.0228 ^a (0.004)	0.0414 ^a (0.004)	0.0256 ^a (0.002)	0.0240 ^a (0.002)	-0.0200 ^a (0.004)	-0.0312 ^a (0.004)
Four adults	0.0239 ^a (0.004)	0.0481 ^a (0.004)	0.0323 ^a (0.002)	0.0302 ^a (0.002)	-0.0256 ^a (0.005)	-0.0401 ^a (0.005)
Five adults	0.0289 ^a (0.005)	0.0579 ^a (0.005)	0.0362 ^a (0.003)	0.0336 ^a (0.003)	-0.0252 ^a (0.006)	-0.0427 ^a (0.006)

Table 6 continued

Variables	Food share		Clothing share		Housing share	
	Exog	Endog	Exog	Endog	Exog	Endog
Six adults	0.0181 ^c (0.007)	0.0513 ^a (0.007)	0.0470 ^a (0.003)	0.0440 ^a (0.003)	-0.0333 ^a (0.008)	-0.0533 ^a (0.008)
Head age	-0.0005 (0.000)	0.0002 (0.000)	-0.0014 ^a (0.000)	-0.0015 ^a (0.000)	0.0009 ^d (0.000)	0.0005 (0.000)
Head age squared	0.0000 (0.000)	-0.0000 (0.000)	0.0000 ^a (0.000)	0.0000 ^a (0.000)	0.0000 (0.000)	0.0000 ^c (0.000)
Head female	0.0077 ^a (0.003)	0.0033 (0.003)	0.0014 (0.001)	0.0018 (0.001)	0.0063 ^c (0.003)	0.0089 ^a (0.003)
Mixed race	0.0089 ^c (0.004)	0.0180 ^a (0.004)	-0.0133 ^a (0.002)	-0.0141 ^a (0.002)	0.0403 ^a (0.005)	0.0348 ^a (0.005)
Indian/Asian	-0.0387 ^a (0.008)	-0.0158 ^d (0.008)	-0.0211 ^a (0.004)	-0.0232 ^a (0.004)	0.1288 ^a (0.009)	0.1151 ^a (0.009)
White	-0.0070 (0.005)	0.0357 ^a (0.005)	-0.0189 ^a (0.002)	-0.0227 ^a (0.003)	0.1078 ^a (0.006)	0.0821 ^a (0.006)
Eastern Cape	-0.0237 ^a (0.005)	-0.0266 ^a (0.005)	-0.0042 ^d (0.002)	-0.0040 ^d (0.002)	0.0157 ^a (0.005)	0.0174 ^a (0.005)
Northern Cape	-0.0323 ^a (0.005)	-0.0367 ^a (0.005)	0.0068 ^b (0.003)	0.0072 ^b (0.003)	-0.0111 ^d (0.006)	-0.0084 (0.006)
Free State	-0.0483 ^a (0.005)	-0.0522 ^a (0.005)	-0.0013 (0.002)	-0.0009 (0.002)	-0.0407 ^a (0.006)	-0.0384 ^a (0.006)
Kwazulu Natal	-0.0122 ^b (0.005)	-0.0142 ^a (0.005)	0.0012 (0.002)	0.0014 (0.002)	0.0351 ^a (0.005)	0.0363 ^a (0.005)
North West	-0.0465 ^a (0.005)	-0.0474 ^a (0.005)	-0.0115 ^a (0.003)	-0.0114 ^a (0.003)	0.0093 (0.006)	0.0098 (0.006)
Gauteng	-0.0335 ^a (0.005)	-0.0321 ^a (0.005)	-0.0088 ^a (0.002)	-0.0089 ^a (0.002)	0.0608 ^a (0.005)	0.0600 ^a (0.005)
Mpumalanga	-0.0220 ^a (0.005)	-0.0224 ^a (0.005)	0.0121 ^a (0.002)	0.0122 ^a (0.002)	0.0358 ^a (0.006)	0.0360 ^a (0.006)
Limpopo	-0.0451 ^a (0.005)	-0.0472 ^a (0.005)	-0.0023 (0.003)	-0.0021 (0.003)	0.0624 ^a (0.006)	0.0637 ^a (0.006)
Urban informal	0.0196 ^a (0.004)	0.0043 (0.004)	0.0086 ^a (0.002)	0.0099 ^a (0.002)	-0.0797 ^a (0.005)	-0.0705 ^a (0.005)
Traditional area	0.0416 ^a (0.003)	0.0247 ^a (0.003)	-0.0029 ^c (0.001)	-0.0014 (0.001)	-0.0573 ^a (0.003)	-0.0472 ^a (0.004)
Rural formal	0.0430 ^a (0.006)	0.0337 ^a (0.006)	-0.0003 (0.003)	0.0005 (0.003)	-0.0577 ^a (0.006)	-0.0522 ^a (0.006)
Living together	0.0206 ^a (0.004)	0.0130 ^a (0.004)	0.0000 (0.002)	0.0007 (0.002)	-0.0159 ^a (0.004)	-0.0113 ^b (0.004)
Never married	0.0101 ^a (0.003)	-0.0002 (0.003)	0.0037 ^c (0.002)	0.0046 ^a (0.002)	0.0061 (0.004)	0.0123 ^a (0.004)
Widow/widower	0.0034 (0.004)	-0.0018 (0.004)	0.0029 (0.002)	0.0033 ^d (0.002)	0.0067 (0.004)	0.0098 ^c (0.004)

Table 6 continued

Variables	Food share		Clothing share		Housing share	
	Exog	Endog	Exog	Endog	Exog	Endog
Separated	0.0079 (0.007)	0.0014 (0.007)	0.0064 ^d (0.003)	0.0070 ^c (0.003)	-0.0019 (0.008)	0.0020 (0.008)
Divorced	-0.0142 ^c (0.006)	-0.0178 ^b (0.006)	0.0070 ^c (0.003)	0.0073 ^c (0.003)	0.0154 ^c (0.007)	0.0176 ^c (0.007)
Primary education	-0.0224 ^a (0.004)	-0.0172 ^a (0.004)	0.0018 (0.002)	0.0013 (0.002)	0.0252 ^a (0.004)	0.0221 ^a (0.004)
Grade 9	-0.0417 ^a (0.005)	-0.0294 ^a (0.005)	0.0043 ^d (0.003)	0.0032 (0.003)	0.0449 ^a (0.006)	0.0376 ^a (0.006)
Grade 10	-0.0374 ^a (0.005)	-0.0205 ^a (0.005)	0.0058 ^c (0.002)	0.0043 ^d (0.002)	0.0343 ^a (0.006)	0.0241 ^a (0.006)
Grade 11	-0.0431 ^a (0.005)	-0.0234 ^a (0.005)	0.0104 ^a (0.003)	0.0087 ^a (0.003)	0.0306 ^a (0.006)	0.0187 ^a (0.006)
Secondary education	-0.0576 ^a (0.005)	-0.0247 ^a (0.005)	0.0084 ^a (0.002)	0.0055 ^c (0.002)	0.0357 ^a (0.006)	0.0158 ^b (0.006)
First year university	-0.0812 ^a (0.008)	-0.0386 ^a (0.008)	0.0105 ^a (0.004)	0.0067 ^d (0.004)	0.0114 (0.009)	-0.0142 (0.009)
Second year university	-0.0873 ^a (0.007)	-0.0346 ^a (0.007)	0.0085 ^c (0.003)	0.0039 (0.004)	0.0129 (0.008)	-0.0188 ^c (0.009)
Tertiary education	-0.0828 ^a (0.007)	-0.0200 ^c (0.008)	0.0070 ^c (0.004)	0.0015 (0.004)	0.0163 ^d (0.008)	-0.0214 ^c (0.009)
Honours degree	-0.0718 ^a (0.010)	-0.0055 (0.010)	0.0097 ^c (0.005)	0.0038 (0.005)	0.0070 (0.011)	-0.0328 ^b (0.012)
Masters degree or more	-0.0780 ^a (0.011)	-0.0105 (0.011)	0.0099 ^d (0.005)	0.0039 (0.006)	0.0295 ^c (0.013)	-0.0110 (0.013)
Expenditure control function		0.0760 ^a (0.003)		-0.0067 ^a (0.001)		-0.0457 ^a (0.004)

Estimates based on linear models. The standard errors for the models with the control functions are not adjusted for the inclusion of a generated variable, due to the fact that these standard errors are not the main point of the analysis. The following notation and significance levels are listed: ^a-0.005, ^b-0.01, ^c-0.05, ^d-0.1

Table 7 Ordered logit model parameter estimates for self-reported food, clothing and housing adequacy in the household

Variables	Food Adequacy		Clothing Adequacy		Housing Adequacy	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Log expenditure	0.7648 ^a (0.026)	1.3055 ^a (0.043)	0.8578 ^a (0.026)	1.2431 ^a (0.040)	0.7923 ^a (0.025)	1.0441 ^a (0.038)
One child	-0.1656 ^a (0.045)	-0.1863 ^a (0.045)	-0.1528 ^a (0.045)	-0.1514 ^a (0.045)	-0.0936 ^c (0.045)	-0.1304 ^a (0.045)

Table 7 continued

Variables	Food Adequacy		Clothing Adequacy		Housing Adequacy	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Two children	-0.2476 ^a (0.048)	-0.2936 ^a (0.048)	-0.2606 ^a (0.049)	-0.2566 ^a (0.049)	-0.1929 ^a (0.048)	-0.2713 ^a (0.048)
Three children	-0.3561 ^a (0.061)	-0.4295 ^a (0.061)	-0.3930 ^a (0.061)	-0.3968 ^a (0.062)	-0.3031 ^a (0.060)	-0.4260 ^a (0.061)
Four children	-0.4736 ^a (0.082)	-0.5686 ^a (0.083)	-0.4177 ^a (0.084)	-0.4300 ^a (0.085)	-0.3674 ^a (0.082)	-0.5231 ^a (0.083)
Two adults	-0.2810 ^a (0.049)	-0.4275 ^a (0.050)	-0.3080 ^a (0.049)	-0.4110 ^a (0.050)	-0.1615 ^a (0.048)	-0.2467 ^a (0.049)
Three adults	-0.4127 ^a (0.056)	-0.6482 ^a (0.058)	-0.5647 ^a (0.056)	-0.7311 ^a (0.058)	-0.2278 ^a (0.055)	-0.3638 ^a (0.057)
Four adults	-0.5223 ^a (0.065)	-0.8259 ^a (0.067)	-0.5755 ^a (0.066)	-0.7908 ^a (0.068)	-0.2725 ^a (0.064)	-0.4409 ^a (0.067)
Five adults	-0.5312 ^a (0.082)	-0.8906 ^a (0.085)	-0.5449 ^a (0.083)	-0.7898 ^a (0.086)	-0.2656 ^a (0.082)	-0.4665 ^a (0.085)
Six adults	-0.6642 ^a (0.111)	-1.0712 ^a (0.115)	-0.8265 ^a (0.113)	-1.1032 ^a (0.116)	-0.6638 ^a (0.110)	-0.8658 ^a (0.113)
Head age	0.0031 ^c (0.001)	0.0007 (0.001)	0.0050 ^a (0.001)	0.0035 ^c (0.001)	0.0081 ^a (0.001)	0.0070 ^a (0.001)
Head female	0.0329 (0.041)	0.0783 ^d (0.041)	0.0418 (0.041)	0.0811 ^c (0.041)	0.0246 (0.040)	0.0467 (0.041)
Mixed race	0.5036 ^a (0.070)	0.4020 ^a (0.070)	0.6021 ^a (0.070)	0.5008 ^a (0.071)	0.4658 ^a (0.069)	0.4823 ^a (0.069)
Indian/Asian	0.0252 (0.134)	-0.2417 ^d (0.136)	0.0059 (0.135)	-0.2395 ^d (0.136)	-0.3081 ^c (0.134)	-0.1996 (0.136)
White	0.5198 ^a (0.080)	0.0135 (0.085)	0.4908 ^a (0.081)	0.0636 (0.086)	0.5670 ^a (0.080)	0.5541 ^a (0.087)
Eastern Cape	-0.7252 ^a (0.076)	-0.6868 ^a (0.076)	-0.6546 ^a (0.076)	-0.6318 ^a (0.076)	-0.5492 ^a (0.074)	-0.5045 ^a (0.074)
Northern Cape	-0.2748 ^a (0.087)	-0.2084 ^c (0.087)	-0.1468 ^d (0.088)	-0.0942 (0.088)	0.0646 (0.086)	0.0707 (0.086)
Free State	-0.6386 ^a (0.079)	-0.5848 ^a (0.079)	-0.7305 ^a (0.079)	-0.6982 ^a (0.079)	-0.4237 ^a (0.078)	-0.4600 ^a (0.078)
Kwazulu Natal	-0.2169 ^a (0.075)	-0.1907 ^c (0.075)	-0.1576 ^c (0.075)	-0.1344 ^d (0.076)	0.1273 ^d (0.074)	0.1870 ^c (0.074)
North west	-0.7642 ^a (0.083)	-0.7449 ^a (0.084)	-0.6154 ^a (0.084)	-0.6181 ^a (0.084)	-0.3930 ^a (0.082)	-0.3778 ^a (0.083)
Gauteng	-0.5548 ^a (0.074)	-0.5687 ^a (0.074)	-0.4505 ^a (0.074)	-0.4649 ^a (0.074)	-0.2810 ^a (0.072)	-0.1968 ^b (0.073)
Mpumalanga	-0.4158 ^a (0.081)	-0.4042 ^a (0.082)	-0.4350 ^a (0.082)	-0.4217 ^a (0.082)	-0.1794 ^c (0.080)	-0.1336 ^d (0.080)
Limpopo	-0.5575 ^a (0.084)	-0.5243 ^a (0.084)	-0.2949 ^a (0.084)	-0.2752 ^a (0.085)	-0.1402 ^d (0.083)	-0.0357 (0.083)

Table 7 continued

Variables	Food Adequacy		Clothing Adequacy		Housing Adequacy	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Urban informal	0.0294 (0.067)	0.2034 ^a (0.068)	-0.0200 (0.067)	0.1288 ^d (0.068)	-0.0153 (0.066)	-0.0688 (0.068)
Traditional area	0.3142 ^a (0.048)	0.5122 ^a (0.049)	0.2661 ^a (0.048)	0.4208 ^a (0.049)	0.3043 ^a (0.048)	0.3196 ^a (0.049)
Rural formal	0.1085 (0.087)	0.2079 ^c (0.088)	0.0971 (0.088)	0.1851 ^c (0.088)	0.1263 (0.087)	0.0695 (0.088)
Living together	-0.1993 ^a (0.060)	-0.1153 ^d (0.060)	-0.2316 ^a (0.060)	-0.1579 ^b (0.060)	-0.3152 ^a (0.059)	-0.2776 ^a (0.059)
Never married	-0.3107 ^a (0.051)	-0.1895 ^a (0.052)	-0.1993 ^a (0.052)	-0.0909 ^d (0.052)	-0.1282 ^c (0.051)	-0.0542 (0.052)
Widow/widower	-0.2159 ^a (0.059)	-0.1481 ^c (0.059)	-0.1300 ^c (0.059)	-0.0816 (0.059)	-0.0508 (0.059)	0.0109 (0.059)
Separated	-0.3443 ^a (0.106)	-0.2745 ^b (0.106)	-0.2501 ^c (0.107)	-0.1898 ^d (0.107)	-0.1772 ^d (0.106)	-0.1212 (0.106)
Divorced	-0.2163 ^c (0.102)	-0.1669 (0.102)	-0.0808 (0.103)	-0.0479 (0.103)	-0.1432 (0.102)	-0.1004 (0.102)
Primary education	0.1387 ^c (0.059)	0.0785 (0.059)	0.1673 ^a (0.059)	0.1170 ^d (0.060)	0.2164 ^a (0.059)	0.1713 ^a (0.060)
Grade 9	0.2687 ^a (0.084)	0.1367 (0.085)	0.2991 ^a (0.084)	0.1983 ^c (0.085)	0.2441 ^a (0.084)	0.1641 ^d (0.084)
Grade 10	0.3043 ^a (0.079)	0.1135 (0.080)	0.2617 ^a (0.080)	0.1192 (0.081)	0.2631 ^a (0.079)	0.1489 ^d (0.080)
Grade 11	0.3073 ^a (0.081)	0.0794 (0.082)	0.1544 ^d (0.082)	-0.0144 (0.083)	0.2455 ^a (0.081)	0.1128 (0.082)
Secondary education	0.5260 ^a (0.077)	0.1545 ^d (0.080)	0.4762 ^a (0.077)	0.1874 ^c (0.080)	0.3633 ^a (0.076)	0.1452 ^d (0.079)
First year university	0.5627 ^a (0.124)	0.0892 (0.127)	0.4277 ^a (0.125)	0.0451 (0.128)	0.4236 ^a (0.122)	0.1364 (0.125)
Second year university	0.7080 ^a (0.115)	0.1112 (0.120)	0.6339 ^a (0.115)	0.1496 (0.120)	0.6283 ^a (0.113)	0.2819 ^c (0.118)
Tertiary education	0.8031 ^a (0.117)	0.0852 (0.124)	0.7485 ^a (0.117)	0.1717 (0.124)	0.6491 ^a (0.115)	0.2342 ^d (0.122)
Honours degree	0.9676 ^a (0.155)	0.2035 (0.162)	0.8981 ^a (0.156)	0.2896 ^d (0.163)	0.9050 ^a (0.154)	0.4451 ^b (0.160)
Masters degree or more	1.3550 ^a (0.173)	0.5807 ^a (0.179)	1.3979 ^a (0.172)	0.7830 ^a (0.178)	1.1903 ^a (0.172)	0.7402 ^a (0.177)
Expenditure share	-0.5124 ^a (0.113)	-0.3913 ^c (0.199)	2.6261 ^a (0.247)	1.0560 ^b (0.403)	0.9960 ^a (0.104)	-1.0051 ^a (0.206)

Table 7 continued

Variables	Food Adequacy		Clothing Adequacy		Housing Adequacy	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
Log expenditure CF		-0.9148 ^a (0.051)		-0.7101 ^a (0.050)		-0.4397 ^a (0.049)
Expenditure share CF		0.0653 (0.042)		0.1486 ^a (0.032)		0.5353 ^a (0.050)
Below v adequate cut	4.3951 ^a (0.240)	8.5565 ^a (0.369)	5.6065 ^a (0.236)	8.4505 ^a (0.334)	5.7101 ^a (0.227)	7.0629 ^a (0.319)
Adequate v above cut	8.7737 ^a (0.251)	13.0279 ^a (0.381)	9.9865 ^a (0.248)	12.8968 ^a (0.347)	9.9443 ^a (0.240)	11.3348 ^a (0.330)

Coefficient estimates for ordered model without (column 1, 3 and 5) and with controls for potential endogeneity of expenditure and unobserved reference effects via the household GFCOs expenditure share on food, clothing and housing, respectively columns 2, 4 and 6. The standard errors for the models with the control functions are not adjusted for the inclusion of a generated variable, due to the fact that these standard errors are not the main point of the analysis

^a 0.005, ^b 0.01, ^c 0.05 and ^d 0.1

C Equivalence Scales

In this appendix, we present the equivalence scales for all household structures, holding all non-household variables to be the same as for the reference household (Tables 8, 9).

Table 8 Estimate of equivalence scales based on food shares, clothing shares and housing shares by household type, underpinned by linear regression model

Adults	Kids	Food share		Clothing share		Housing share	
		Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
1	0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	0	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1	1	1.2680	1.1620	1.6260	1.8150	0.0880	2.2080
1	1	(0.057)	(0.030)	(0.058)	(0.032)	(0.059)	(0.056)
1	2	1.5380	1.3240	2.9390	3.7390	0.0140	4.1240
1	2	(0.084)	(0.040)	(0.075)	(0.040)	(0.076)	(0.075)
1	3	1.8880	1.5250	3.5670	4.6970	0.0040	6.4060
1	3	(0.129)	(0.058)	(0.122)	(0.059)	(0.127)	(0.135)
1	4	2.2470	1.7130	4.9520	6.9970	0.0010	12.1610
1	4	(0.216)	(0.101)	(0.216)	(0.096)	(0.217)	(0.230)
2	0	1.3830	1.3480	2.2770	2.6010	0.0660	3.3040
2	0	(0.076)	(0.042)	(0.075)	(0.041)	(0.074)	(0.071)
2	1	1.7540	1.5670	3.7030	4.7210	0.0060	7.2940
2	1	(0.110)	(0.058)	(0.115)	(0.059)	(0.112)	(0.112)
2	2	2.1260	1.7840	6.6910	9.7230	0.0010	13.6240
2	2	(0.148)	(0.075)	(0.135)	(0.071)	(0.140)	(0.133)
2	3	2.6110	2.0560	8.1210	12.2160	0.0000	21.1630

Table 8 continued

Adults	Kids	Food share		Clothing share		Housing share	
		Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
2	3	(0.206)	(0.100)	(0.203)	(0.092)	(0.205)	(0.223)
2	4	3.1080	2.3100	11.2770	18.1960	0.0000	40.1760
2	4	(0.322)	(0.144)	(0.332)	(0.143)	(0.322)	(0.335)
3	0	1.4330	1.4770	3.6190	4.4270	0.0390	4.9040
3	0	(0.086)	(0.053)	(0.088)	(0.050)	(0.084)	(0.085)
3	1	1.8170	1.7170	5.8860	8.0360	0.0030	10.8290
3	1	(0.117)	(0.067)	(0.127)	(0.070)	(0.127)	(0.122)
3	2	2.2040	1.9550	10.6350	16.5510	0.0010	20.2260
3	2	(0.158)	(0.084)	(0.154)	(0.081)	(0.153)	(0.148)
3	3	2.7060	2.2520	12.9080	20.7950	0.0000	31.4170
3	3	(0.219)	(0.111)	(0.223)	(0.105)	(0.225)	(0.245)
3	4	3.2210	2.5300	17.9220	30.9740	0.0000	59.6430
3	4	(0.345)	(0.164)	(0.362)	(0.160)	(0.338)	(0.365)
4	0	1.4590	1.5720	5.0700	6.5140	0.0160	7.7050
4	0	(0.102)	(0.062)	(0.105)	(0.061)	(0.106)	(0.096)
4	1	1.8500	1.8280	8.2460	11.8240	0.0010	17.0130
4	1	(0.132)	(0.078)	(0.144)	(0.081)	(0.141)	(0.132)
4	2	2.2430	2.0810	14.8980	24.3550	0.0000	31.7780
4	2	(0.172)	(0.097)	(0.179)	(0.094)	(0.167)	(0.156)
4	3	2.7540	2.3980	18.0820	30.5990	0.0000	49.3610
4	3	(0.237)	(0.128)	(0.253)	(0.120)	(0.235)	(0.255)
4	4	3.2780	2.6940	25.1070	45.5760	0.0000	93.7080
4	4	(0.351)	(0.179)	(0.375)	(0.182)	(0.364)	(0.377)
5	0	1.5770	1.7250	6.1490	8.0500	0.0170	8.7840
5	0	(0.145)	(0.090)	(0.148)	(0.084)	(0.138)	(0.137)
5	1	2.0000	2.0050	10.0010	14.6130	0.0010	19.3950
5	1	(0.188)	(0.106)	(0.204)	(0.106)	(0.187)	(0.185)
5	2	2.4250	2.2830	18.0700	30.0990	0.0000	36.2260
5	2	(0.237)	(0.127)	(0.241)	(0.122)	(0.226)	(0.222)
5	3	2.9770	2.6300	21.9330	37.8160	0.0000	56.2700
5	3	(0.330)	(0.157)	(0.307)	(0.148)	(0.294)	(0.324)
5	4	3.5440	2.9550	30.4540	56.3270	0.0000	106.8240
5	4	(0.439)	(0.223)	(0.456)	(0.209)	(0.458)	(0.483)
6	0	1.3310	1.6210	10.5630	15.3610	0.0040	15.0590
6	0	(0.157)	(0.120)	(0.166)	(0.116)	(0.171)	(0.169)
6	1	1.6880	1.8840	17.1800	27.8830	0.0000	33.2500
6	1	(0.199)	(0.139)	(0.215)	(0.135)	(0.211)	(0.216)
6	2	2.0470	2.1460	31.0410	57.4330	0.0000	62.1050
6	2	(0.255)	(0.157)	(0.266)	(0.156)	(0.263)	(0.262)
6	3	2.5130	2.4720	37.6750	72.1560	0.0000	96.4690
6	3	(0.314)	(0.196)	(0.335)	(0.191)	(0.332)	(0.354)
6	4	2.9910	2.7780	52.3120	107.4770	0.0000	183.1390

Table 8 continued

Adults	Kids	Food share		Clothing share		Housing share	
		Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
6	4	(0.425)	(0.231)	(0.457)	(0.236)	(0.453)	(0.435)

Estimated equivalence scale by household type, and bootstrapped standard error (399 replications). Estimates underpinned by linear model including controls in addition to expenditure and household structure

^a 0.005, ^b 0.01, ^c 0.05 and ^d 0.1

Table 9 Estimate of equivalence scales based on food clothing and housing adequacy by household type, underpinned by ordered logit model controlling for endogeneity

Adults	Kids	Food adequacy		Clothing adequacy		Housing adequacy	
		Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
1	0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	0	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1	1	1.2420	1.1530	1.1950	1.1300	1.1250	1.1330
1	1	(0.075)	(0.040)	(0.067)	(0.042)	(0.065)	(0.048)
1	2	1.3820	1.2520	1.3550	1.2290	1.2760	1.2970
1	2	(0.089)	(0.046)	(0.076)	(0.050)	(0.075)	(0.063)
1	3	1.5930	1.3900	1.5810	1.3760	1.4660	1.5040
1	3	(0.121)	(0.062)	(0.116)	(0.070)	(0.114)	(0.088)
1	4	1.8570	1.5460	1.6270	1.4130	1.5900	1.6500
1	4	(0.199)	(0.101)	(0.159)	(0.101)	(0.168)	(0.136)
2	0	1.4440	1.3870	1.4320	1.3920	1.2260	1.2670
2	0	(0.092)	(0.049)	(0.080)	(0.055)	(0.074)	(0.060)
2	1	1.7930	1.6000	1.7110	1.5720	1.3800	1.4350
2	1	(0.148)	(0.069)	(0.126)	(0.076)	(0.107)	(0.078)
2	2	1.9960	1.7370	1.9400	1.7110	1.5640	1.6420
2	2	(0.167)	(0.081)	(0.145)	(0.087)	(0.122)	(0.099)
2	3	2.3000	1.9280	2.2640	1.9150	1.7980	1.9050
2	3	(0.214)	(0.101)	(0.196)	(0.111)	(0.161)	(0.128)
2	4	2.6820	2.1450	2.3300	1.9670	1.9500	2.0900
2	4	(0.322)	(0.147)	(0.250)	(0.148)	(0.233)	(0.177)
3	0	1.7150	1.6430	1.9320	1.8010	1.3330	1.4170
3	0	(0.119)	(0.067)	(0.116)	(0.081)	(0.086)	(0.073)
3	1	2.1300	1.8950	2.3080	2.0340	1.5000	1.6050
3	1	(0.179)	(0.091)	(0.176)	(0.106)	(0.119)	(0.093)
3	2	2.3710	2.0570	2.6170	2.2130	1.7000	1.8370
3	2	(0.197)	(0.101)	(0.199)	(0.122)	(0.132)	(0.116)
3	3	2.7330	2.2830	3.0540	2.4780	1.9540	2.1310
3	3	(0.257)	(0.133)	(0.268)	(0.154)	(0.182)	(0.152)
3	4	3.1860	2.5400	3.1430	2.5450	2.1200	2.3380
3	4	(0.373)	(0.177)	(0.330)	(0.193)	(0.247)	(0.204)
4	0	1.9800	1.8830	1.9560	1.8890	1.4110	1.5250

Table 9 continued

Adults	Kids	Food adequacy		Clothing adequacy		Housing adequacy	
		Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
4	0	(0.159)	(0.092)	(0.138)	(0.102)	(0.110)	(0.098)
4	1	2.4580	2.1710	2.3370	2.1340	1.5870	1.7280
4	1	(0.221)	(0.112)	(0.196)	(0.122)	(0.144)	(0.116)
4	2	2.7360	2.3570	2.6500	2.3220	1.7990	1.9780
4	2	(0.253)	(0.127)	(0.223)	(0.138)	(0.168)	(0.139)
4	3	3.1530	2.6160	3.0930	2.5990	2.0680	2.2940
4	3	(0.308)	(0.158)	(0.286)	(0.167)	(0.204)	(0.168)
4	4	3.6770	2.9100	3.1830	2.6700	2.2430	2.5180
4	4	(0.464)	(0.211)	(0.348)	(0.217)	(0.279)	(0.229)
5	0	2.0030	1.9780	1.8870	1.8880	1.3980	1.5630
5	0	(0.219)	(0.122)	(0.178)	(0.128)	(0.131)	(0.116)
5	1	2.4870	2.2820	2.2560	2.1320	1.5740	1.7710
5	1	(0.286)	(0.148)	(0.245)	(0.158)	(0.161)	(0.134)
5	2	2.7680	2.4770	2.5580	2.3200	1.7840	2.0270
5	2	(0.324)	(0.164)	(0.270)	(0.170)	(0.186)	(0.168)
5	3	3.1900	2.7490	2.9840	2.5970	2.0500	2.3510
5	3	(0.393)	(0.194)	(0.351)	(0.206)	(0.234)	(0.213)
5	4	3.7200	3.0580	3.0710	2.6680	2.2230	2.5800
5	4	(0.528)	(0.246)	(0.377)	(0.238)	(0.276)	(0.255)
6	0	2.3830	2.2720	2.6210	2.4290	2.3110	2.2920
6	0	(0.352)	(0.192)	(0.301)	(0.213)	(0.310)	(0.230)
6	1	2.9600	2.6200	3.1320	2.7440	2.6010	2.5960
6	1	(0.466)	(0.225)	(0.390)	(0.241)	(0.368)	(0.269)
6	2	3.2940	2.8450	3.5510	2.9860	2.9480	2.9710
6	2	(0.508)	(0.248)	(0.445)	(0.273)	(0.415)	(0.317)
6	3	3.7970	3.1570	4.1440	3.3420	3.3890	3.4460
6	3	(0.589)	(0.288)	(0.540)	(0.308)	(0.499)	(0.369)
6	4	4.4270	3.5110	4.2650	3.4330	3.6750	3.7820
6	4	(0.765)	(0.350)	(0.576)	(0.346)	(0.549)	(0.424)

Estimated equivalence scale by household type, and bootstrapped standard errors (399 replications). Estimates underpinned by ordered logit model either adjusted (Endogenous) for or not adjusted for (Exogenous) potential expenditure endogeneity and unobserved adequacy reference effects

^a 0.005, ^b 0.01, ^c 0.05 and ^d 0.1

Funding Open access funding provided by University of Pretoria. This research received financial support from the University of Pretoria and South Africa's National Research Foundation, the latter through its support for rated research. No grant number is associated with this program. No additional external financial support was received.

Declarations

Conflict of interest The author declares there are no conflicts of interest with this research.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Biewen, M., & Juhasz, A. (2017). Direct estimation of equivalence scales and more evidence on independence of base. *Oxford Bulletin of Economics and Statistics*, 79(5), 875–905. <https://doi.org/10.1111/obes.12166>
- Bishop, J. A., Grodner, A., Liu, H., & Ahamdanech-Zarco, I. (2014). Subjective poverty equivalence scales for euro zone countries. *The Journal of Economic Inequality*, 12(2), 265–78. <https://doi.org/10.1007/s10888-013-9254-7>
- Blackorby, C., & Donaldson, D. (1993). Adult-equivalent scales and the economic implementation of interpersonal comparisons of well-being. *Social Choice and Welfare*, 10, 335–61.
- Blundell, R., Browning, M., & Crawford, I. (2003). Nonparametric Engel curves and revealed preference. *Econometrica*, 71(1), 205–40. <https://doi.org/10.1111/1468-0262.00394>
- Borah, M. (2020). Estimating extended income equivalence scales from income satisfaction and time use data. *Social Indicators Research*, 149(2), 687–718. <https://doi.org/10.1007/s11205-019-02262-1>
- Borah, M., Keldenich, C., & Knabe, A. (2019). Reference income effects in the determination of equivalence scales using income satisfaction data. *Review of Income and Wealth*, 65(4), 736–70. <https://doi.org/10.1111/roiw.12386>
- Boyce, C. J., Brown, G. D. A., & Moore, S. C. (2010). Money and happiness: Rank of income, not income, affects life satisfaction. *Psychological Science*, 21(4), 471–75. <https://doi.org/10.1177/0956797610362671>
- Bradbury, B. (1989). Family size equivalence scales and survey evaluations of income and well-being. *Journal of Social Policy*, 18(3), 383–408. <https://doi.org/10.1017/S0047279400017621>
- Bradbury, B. (2008). Time and cost of children. *Review of Income and Wealth*, 54(3), 305–23. <https://doi.org/10.1111/j.1475-4991.2008.00277.x>
- Charlier, E. (2002). Equivalence scales in an intertemporal setting with an application to the former west Germany. *Review of Income and Wealth*, 48(1), 99–126. <https://doi.org/10.1111/1475-4991.00042>
- Clark, A. E., Frijters, P., & Shields, M. A. (2008). Relative income, happiness, and utility: An explanation for the easterlin paradox and other puzzles. *Journal of Economic Literature*, 46(1), 95–144. <https://doi.org/10.1257/jel.46.1.95>
- Coupré, H., & Ferrant, G. (2015). Welfare comparisons, economies of scale and equivalence scale in time use. *Annals of Economics and Statistics*, 117(118), 185–210. <https://doi.org/10.15609/annaeconstat2009.117-118.185>
- Daley, A., Garner, T., Phipps, S., & Sierminska, E. (2020). Differences across countries and time in household expenditure patterns: Implications for the estimation of equivalence scales. *International Review of Applied Economics*, 34(6), 734–57. <https://doi.org/10.1080/02692171.2020.1781798>
- D'Ambrosio, C., & Frick, J. R. (2012). Individual wellbeing in a dynamic perspective. *Economica*, 79(314), 284–302. <https://doi.org/10.1111/j.1468-0335.2011.00896.x>
- de Ree, J., Alessie, R., & Pradhan, M. (2013). The price and utility dependence of equivalence scales: Evidence from Indonesia. *Journal of Public Economics*, 97, 272–81. <https://doi.org/10.1016/j.jpubeco.2012.09.006>
- Deaton, A. (1997). *The analysis of household surveys: A microeconomic approach to development policy*. The World Bank.
- DeWitt, Peter. (2021). *Qwraps2: Quick Wraps 2*. <https://CRAN.R-project.org/package=qwraps2>.
- Dong, Y. (2010). Endogenous regressor binary choice models without instruments, with an application to migration. *Economics Letters*, 107(1), 33–35. <https://doi.org/10.1016/j.econlet.2009.12.017>
- Dudel, C., Garbuszus, J. M., Ott, N., & Werding, M. (2021). Income-(in)dependent equivalence scales and inequality measurement. *German Economic Review*, 22(2), 235–55. <https://doi.org/10.1515/ger-2020-0008>
- Dudel, C., Garbuszus, J. M., & Schmied, J. (2021). Assessing differences in household needs: A comparison of approaches for the estimation of equivalence scales using German expenditure data. *Empirical Economics*, 60(4), 1629–59. <https://doi.org/10.1007/s00181-020-01822-6>

- Edmonds, E. V., Mammen, K., & Miller, D. L. (2005). Rearranging the family? Income support and elderly living arrangements in a low-income country. *The Journal of Human Resources*, 40(1), 186–207. <http://www.jstor.org/stable/4129570>
- Engel, E. (1857). Die Productions—Und Consumtionsverhältnisse Des Königreichs Sachsen. In E. Engel (Ed.), *Dielebenkostenbelgischerarbeiter-Familien*. C Heinrich.
- Ferrer-i-Carbonell, A. (2005). Income and well-being: An empirical analysis of the comparison income effect. *Journal of Public Economics*, 89(5), 997–1019. <https://doi.org/10.1016/j.jpubeco.2004.06.003>
- Frazer, G. (2008). Used-clothing donations and apparel production in Africa. *The Economic Journal*, 118(532), 1764–84. <https://doi.org/10.1111/j.1468-0297.2008.02190.x>
- Garbuszus, J. M., Ott, N., Pehle, S., & Werding, M. (2021). Income-dependent equivalence scales: A fresh look at German micro-data. *The Journal of Economic Inequality*, 19(4), 855–73. <https://doi.org/10.1007/s10888-021-09494-7>
- Goedhart, T., Halberstadt, V., Kapteyn, A., & van Praag, B. M. S. (1977). The poverty line: Concept and measurement. *Journal of Human Resources*, 12, 503–20.
- Grodner, A., de la Vega, C. L., Salas, R., & Zeager, L. A. (2022). A local equivalence scale and its information basis. *Economics Letters*, 216, 110572. <https://doi.org/10.1016/j.econlet.2022.110572>
- Hagenaars, A., de Vos, K., & Zaidi, M. A. (1994). *Poverty statistics in the late 1980s: Research based on micro-data*. Office for Official Publications of the European Communities.
- Hartog, J. (1988). Poverty and the measurement of individual welfare. *The Journal of Human Resources*, 23(2), 243–66. <http://www.jstor.org/stable/145778>
- Hayfield, T., & Racine, J. S. (2008). Nonparametric econometrics: The np package. *Journal of Statistical Software*. <http://www.jstatsoft.org/v27/i05/>.
- Hlavac, M. (2018). *Stargazer: Well-formatted regression and summary statistics tables*. Central European Labour Studies Institute (CELSI). <https://CRAN.R-project.org/package=stargazer>
- Kapteyn, A., Kooreman, P., & Willemsse, R. (1987). Some methodological issues in the implementation of subjective poverty definitions. *Research Memorandum*, 19, 222–242.
- Klasen, S., & Woolard, I. (2008). Surviving unemployment without state support: Unemployment and household formation in South Africa. *Journal of African Economies*, 18(1), 1–51. <https://doi.org/10.1093/jae/ejn007>
- Koch, S. F. (2022). Equivalence scales in a developing country with extensive inequality. *South African Journal of Economics*, 90(4), 486–512. <https://doi.org/10.1111/saje.12326>
- Li, Q., & Racine, J. S. (2007). *Nonparametric econometrics: Theory and practice*. Princeton University Press.
- Li, Q., & Racine, J. S. (2004). Cross-validated local linear nonparametric regression. *Statistica Sinica*, 14(2), 485–512.
- Lokshin, M., Umapathi, N., & Paternostro, S. (2006). Robustness of subjective welfare analysis in a poor developing country: Madagascar 2001. *The Journal of Development Studies*, 42(4), 559–91. <https://doi.org/10.1080/00220380600680946>
- Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370–96. <https://doi.org/10.1037/h0054346>
- Melenberg, B., & van Soest, A. H. O. (1996). Measuring the costs of children: Parametric and semiparametric estimators. *Statistica Neerlandica*, 50(1), 171–92. <https://doi.org/10.1111/j.1467-9574.1996.tb01486.x>
- Mysíková, M., Želinský, T., Garner, T. I., & Fialová, K. (2022). Subjective equivalence scales in eastern versus western European countries. *Contemporary Economic Policy*, 40(4), 659–76. <https://doi.org/10.1111/coep.12579>
- Nicholson, J. L. (1976). Appraisal of different methods of estimating equivalence scales and their results. *Review of Income and Wealth*, 22, 1–11.
- Pendakur, K. (1999). Semiparametric estimates and tests of base-independent equivalence scales. *Journal of Econometrics*, 80(1), 1–40.
- Pendakur, K. (2018). Welfare analysis when people are different. *Canadian Journal of Economics*, 51(2), 321–60. <https://doi.org/10.1111/caje.12335>
- Posel, D., Casale, D., & Grapsa, E. (2020). Household variation and inequality: The implications of equivalence scales in South Africa. *African Review of Economics and Finance*, 12(1), 102–22. <https://doi.org/10.10520/EJC-1d056a3683>
- Pradhan, M., & Ravallion, M. (2000). Measuring poverty using qualitative perceptions of consumption adequacy. *The Review of Economics and Statistics*, 82(3), 462–71. <https://doi.org/10.1162/003465300558821>
- R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org/>
- Racine, J. S. (2019). Energy, economics, replication & reproduction. *Energy Economics*, 82, 264–75. <https://doi.org/10.1016/j.eneco.2017.06.027>

- Republic of South Africa. (1996). South African Schools Act No. 84.
- Rojas, M. (2007). A subjective well-being equivalence scale for Mexico: Estimation and poverty and income-distribution implications. *Oxford Development Studies*, 35(3), 273–93. <https://doi.org/10.1080/13600810701514845>
- Schwarze, J. (2003). Using panel data on income satisfaction to estimate equivalence scale elasticity. *Review of Income and Wealth*, 49(3), 359–72. <https://doi.org/10.1111/1475-4991.00092>
- Senik, C. (2008). Ambition and jealousy: Income interactions in the ‘Old’ Europe versus the ‘New Europe and the United States’. *Economica*, 75(299), 495–513. <https://doi.org/10.1111/j.1468-0335.2007.00629.x>
- Stats SA. (2017). *Living conditions survey 2014–2015 [dataset]. Version 1.1*. Statistics South Africa (Stats SA).
- Steiger, T., Mainieri, D. M., & Stinson, L. (1997). *Subjective assessments of economic well-being: Understanding the minimum income question*. American Statistical Association.
- Stutzer, A. (2004). The role of income aspirations in individual happiness. *Journal of Economic Behavior & Organization*, 54(1), 89–109. <https://doi.org/10.1016/j.jebo.2003.04.003>
- Summers, R. (1959). A note on least squares bias in household expenditure analysis. *Econometrica*, 27, 121–26.
- van Praag, Bernard M. S., & van der Sar, Nico L. (1988). Household cost functions and equivalence scales. *The Journal of Human Resources*, 23(2), 193–210. <http://www.jstor.org/stable/145775>.
- van Praag, B. M. S. (1971). The welfare function of income in Belgium: An empirical investigation. *European Economic Review*, 2(3), 337–69. [https://doi.org/10.1016/0014-2921\(71\)90045-6](https://doi.org/10.1016/0014-2921(71)90045-6)
- Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with s* (4th edn.). Springer. <https://www.stats.ox.ac.uk/pub/MASS4/>
- Wickham, H., & Miller, E. (2021). *Haven: Import and export ‘SPSS’, ‘Stata’ and ‘SAS’ files*. <https://CRAN.R-project.org/package=haven>
- Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D. A., François, R., Grolemond, G., et al. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, 4(43), 1686. <https://doi.org/10.21105/joss.01686>
- Xie, Y. (2014). Knitr: A comprehensive tool for reproducible research in R. In V. Stodden, F. Leisch, & Peng (Eds.) *Implementing reproducible computational research*, Chapman Hall/CRC. <http://www.crcpress.com/product/isbn/9781466561595>
- Xie, Y., Dervieux, C., & Riederer, E. (2020). *R markdown cookbook*. Chapman Hall/CRC. <https://bookdown.org/yihui/rmarkdown-cookbook>
- Yatchew, A., Sun, Y., & Deri, C. (2003). Efficient estimation of semiparametric equivalence scales with evidence from South Africa. *Journal of Business & Economic Statistics*, 21(2), 247–57.
- Zhu, H. (2021). *kableExtra: Construct complex table with ‘Kable’ and pipe syntax*. <https://CRAN.R-project.org/package=kableExtra>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.