



# **Does the Equivalence Scale Matter? Equivalence and Out-of-Pocket Payments**

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# Does the Equivalence Scale Matter?

## Equivalence and Out-of-Pocket Payments\*

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### Abstract

We evaluate the effects of different equivalence scale parameter estimates on the distribution of catastrophic health payments in South Africa. Our analysis makes use of Xu et al.'s (2003) initial estimate, which underscores the World Health Organization's methodology (Xu, 2005). We also update it using more recent data for one of the original countries included in Xu et al. (2003), South Africa. South Africa is considered, because the data used in Xu et al. (2003) was collected before the end of Apartheid, and the end of Apartheid has led to extensive social and economic changes, which could have influenced equivalence. We extend the empirical exercise by estimating a base-independent equivalence scale via semiparametric methods. Using these equivalence scales, we examine their effect on the distribution of catastrophic health payments using thresholds of 5%, 10% and 15%. The revised estimates suggest that the initial equivalence estimates were overstated by as much as 35%, such that poverty lines in the country were understated by as much as 17%. However, despite these large differences, the distribution of catastrophic health expenditures were unaffected.

**Keywords:** Catastrophic Health Payments, Equivalence Scales, Semiparametric Estimation

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# 1 Introduction

Adult equivalence is an important component in the financial risk protection and equity literatures, as it used, in part, to determine poverty lines within a country (Xu et al., 2003). Those poverty lines do not require purchasing power parity or the need for other sorts of cross-country adjustments, and, therefore, the resulting financial risk measures, such as catastrophic health expenditure, are comparable across countries. The equivalence scale used in this literature is underpinned by Xu et al.'s (2003) cross-country regression model, and the World Health Organization methodology (Xu, 2005). Defining  $E$  as the equivalence scale,  $A$  as the number of adults in the household and  $K$  as the number of children in the household, the equivalence scale is based on estimation of (1), ignoring country fixed effects, where  $\hat{\gamma} = 0.56$  from Xu et al. (2003).

$$E = (A + K)^\delta \tag{1}$$

As the methodology is well-established, it is commonly applied. Recent research, for example, is available for Viet Nam (Van Minh et al., 2013), Kenya (Buigut et al., 2015), China (Li et al., 2014), India (Misra et al., 2015), Nigeria (Ataguba, 2012), South Africa (Harris et al., 2011) and Zambia (Masiye et al., 2010), amongst others.

Although the history of equivalence scale estimation is relatively long, the methods relate to Engel's (1857) argument that the share of food expenditure in the household budget is a useful indicator of household welfare; thus, an equivalence scale is an expenditure ratio. It is the ratio of expenditure in a comparator household to that in a reference household, where the comparator expenditure is the amount required to match its household budget share on food to the reference household's food share. As Nicholson (1976) notes, however, Engel (1857)-type equivalence scales are likely to over-estimate the cost of a child, since children, especially young children, primarily consume only food and clothing. Furthermore, such methods ignore behavioural aspects associated with childbirth.<sup>1</sup> Finally, estimating equivalence scales following the Engel method is

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<sup>1</sup>Presumably, households that plan to have a (another) child, believe such an addition to the household will bring both joy and additional costs. Since equivalence scales generally only focus on costs, they are likely to further overstate the (net) cost of children.

complicated by the fact that even though we can observe the household structure, i.e., the number of adults and children, and food expenditure shares in that household, it is not possible to directly estimate (1). The actual equivalence value is not observed; it must be inferred from a different estimation model.

The Xu et al. (2003) approach simplifies Engel's (1857) argument. According to them, it is not the food share that determines household welfare; instead, it is (equivalized) per capita food consumption that determines welfare. Such a simplification, which is easier to estimate than the Engel-type equivalence scale, might not provide a particularly appropriate estimate of equivalence. Furthermore, it would be reasonable to assume that household food purchase behaviour, and even household structure, has changed rather significantly in the intervening years. Citing just one example, the South African data used by Xu et al. (2003) was collected in 1993 – nearly one-quarter of a century ago and one year before the post-Apartheid period began. Wittenberg and Collison (2008), for example, show that households were nearly one person smaller in 2003 than in 1992, in at least one area of South Africa, while Leibbrandt and Levinsohn (2011) suggest a larger national decline had occurred between 1993 and 2008. Given such a large change in household structure, it is reasonable to assume that Xu et al.'s (2003) estimate of adult equivalence for South Africa are no longer representative of South Africa.

Within the financial risk protection methodology, if the equivalence estimate is incorrect, estimates of the poverty line, subsistence spending in the household, and, therefore, estimates of capacity-to-pay could be incorrect. If each of those is incorrect, reported catastrophic health expenditure and social determinants of that expenditure could be incorrectly estimated. Therefore, in this research, we empirically investigate whether or not the Xu et al. (2003) equivalence scale estimate remains appropriate in South Africa; we estimate with 2010-11 data, rather than 1993 data. We further extend that comparison to an Engel-type equivalence scale estimate following Yatchew et al.'s (2003) semiparametric formulation. Given the well-established observation that equivalence scales differ – see Nicholson (1976) for an early discussion and Posel et al. (2016) for a recent discussion applied to South Africa, we expect to find differences in the estimates.

Although Posel et al. (2016) examine differences in equivalence scales, they do not provide any estimates; rather, they examine the effect of a range of hypothesized values on poverty rates. Thus, our analysis provides the most recent equivalence scale update that is available. Finally, we ask whether these equivalence scale differences affect the poverty lines, subsistence levels, capacities-to-pay, and, eventually, the catastrophic health care payments that would arise.

As expected, we find that equivalence scales in South Africa are no longer similar to those estimated by Xu et al. (2003); South Africa has changed, and so has its households' behaviours. Our semiparametric Engel (1857)-type estimates suggests smaller equivalence scales both compared to those reported in Xu et al. (2003) and those that would be estimated applying Xu et al.'s (2003) methodology to more recent data. We further find that reduced equivalence scales yield increases in the estimated poverty lines of up to 17%. However, the increased poverty line has very little impact on the estimated subsistence level, capacity-to-pay or catastrophic health expenditure. In other words, the choice of equivalence scale does not appear to matter all that much, at least in the case of South Africa, when determining the degree of financial risk protection afforded by the health care sector in a country.

## 2 Methods

Out-of-pocket payments and total expenditures are extracted from the 2010 South African Income and Expenditure Survey (Statistics South Africa, 2013) following the World Health Organization methodology (Xu, 2005). In addition to those, we also extract household size (the total number of children and adults) and the race of the household head, the latter of which is used to see whether or not equivalence scales and effects related to adult equivalence differ across race.

### 2.1 WHO Methodology

The Income and Expenditure Survey (IES) uses classification of individual consumption by purpose (COICOP) categories, and our primary interest is in category 06.<sup>2</sup> All

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<sup>2</sup>See <https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5> for additional detail.

expenditures on COICOP category 061 are coded as medical products, which includes medicines (with and without prescription), medical products (such as bandages and syringes) and therapeutic devices (including spectacles, hearing aids and braces). However, if medicines or bandages, for example, are given to outpatients or to inpatients, those expenses are not recorded in 061; instead, they would lie in 062 or 063. Expenditures on COICOP category 062 are coded as outpatient services, which is further separated into medical, dental and paramedical. It is expected that these services are delivered at home or in clinics. Expenditures in category 063 are coded as hospital services. Importantly, and somewhat confusingly, this last category often does not include surgeries, as many surgeries are managed as outpatient services. COICOP also includes categories 13.2 and 14.2, health expenditures made for households by either non-profit institutions (13.2) or by government (14.2); however, there are no such observations in the South African IES. Expenditures from 061-063 are aggregated to determine the total, which we denote as  $O$ .

Total household consumption expenditure  $x$  includes all monetary and in-kind consumption expenditures, including home-made products. To calculate capacity-to-pay, we subtract either subsistence expenditure from total expenditure, (if the household's food expenditure exceeds their subsistence level) or food expenditure (if not); subsistence expenditure is determined by household equivalent food expenditures for households in the middle of the food expenditure share distribution. To get to these values, a number of steps are required. Initially, household food expenditure, denoted by  $f$  is constructed.<sup>3</sup> In addition, we calculate equivalent household size. This equivalence will be further discussed below.<sup>4</sup> We denote the share of food expenditure as  $w_f = f/x$ , as well as equivalized food expenditure, which is the ratio of food expenditure to equivalent household size, i.e.,  $f_e = f/E$ . We pull out the middle 10% of the  $w_f$  distribution and calculate a weighted average in the following manner. We define an indicator,  $\mathbb{I}(w_f^{45} < w_{f,i} < w_f^{55})$ , which is true (and therefore equal to one) if household  $i$ 's food

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<sup>3</sup>It is taken from COICOP category 01, but excludes categories 02 and 11, because we are asked to ignore alcohol and tobacco (category 02) along with food away from home (category 11), although it is necessary to include food production at home, such as garden produce. Unfortunately, home food production is not necessarily well-measured in the survey.

<sup>4</sup>We make use of a variety of estimates in this research, and we calculate capacity-to-pay for each of those equivalence estimates. However, we rely on (1), allowing for potentially different values of  $\theta$ .

share,  $w_f$  lies between the 45<sup>th</sup> and 55<sup>th</sup> percentile of all food shares in the sample. The sample weighted average of equivalized food expenditure within this percentile range is referred to as the poverty line,  $\ell$ . In the following equation,  $\Omega_i$  refers to the household weight, or the inverse of the probability that the household could be expected to be included in the survey, given the sample frame used, corrected for non-response and other sampling problems.

$$\ell = \frac{\sum_{i:\mathbb{I}=1} \Omega_i f_{e_i}}{\sum_{i:\mathbb{I}=1} \Omega_i} \quad (2)$$

That poverty line determines the subsistence level  $s$  for the household, which is the poverty line multiplied by the number of equivalent adults.

$$s = \ell \times E \quad (3)$$

The previously defined subsistence level is paramount to the development of the final capacity-to-pay. Specifically, where  $C$  is capacity-to-pay,

$$C = \begin{cases} x - s & \text{if } s \leq f \\ x - f & \text{otherwise} \end{cases} \quad (4)$$

Given capacity-to-pay and out-of-pocket payments, the share of the capacity devoted to out-of-pocket payments is simply the ratio,  $w_o = O/C$ . Once the share of capacity-to-pay devoted to out-of-pocket expenditures has been calculated, whether or not the household has been seriously affected by these payments can be calculated; however, it depends on an arbitrary threshold. For example, given a proportion,  $\kappa$ , a household is defined as facing catastrophic payments if their  $w_o$  share is too high, or exceeds  $\kappa$ . Recalling the indicator function, we define  $k$  as a binary indicator of catastrophic payments; thus,  $k = \mathbb{I}(w_o \geq \kappa)$ . Since out-of-pocket expenditure is fairly low in South Africa (Koch, 2015), our analysis will focus on  $\kappa = \{0.05, 0.1, 0.15\}$ .

## 2.2 Extracting Equivalence Scales

Xu et al. (2003) applied a simple cross-country model (with country fixed effects) to estimate (1). In order to update that initial estimate, since we are working with only

one country, we will drop the fixed effects and regress the natural log of total food expenditures  $f$  against the natural log of household size  $(A + K)$ .

$$\ln f = \delta_0 + \delta_1 \ln(A + K) + \epsilon \quad (5)$$

In the original formulation,  $\hat{\delta}_1 = 0.56$ . Thus, we estimate (5) on newer data to see if the estimate of 0.56 remains a reasonable approximation.

In addition, we estimate an Engel-type equivalence scale underpinned by equivalence-scale-exactness, or base-independence (see Lewbel, 1989; Blundell and Lewbel, 1991; Blackorby and Donaldson, 1993; Pendakur, 1999; Donaldson and Pendakur, 2003, for details). Intuitively, base-independence requires the equivalence scale to remain the same for all levels of utility, and, therefore, it cannot depend on expenditure. Defining  $w_f$  as before,  $p$  as prices,  $x$  as before and  $z$  as household demographic information, while the superscript  $r$  connotes the reference household, a base-independent equivalence scale can be implicitly defined from the following relationship.

$$\begin{aligned} w_f(p, x, z) &= w_f(p, x^r, z^r) + \eta(p) \\ &= w_f\left(p, \frac{x}{\Theta(z)}, z^r\right) + \eta(p) \end{aligned} \quad (6)$$

Unfortunately, there are no prices in the data, further simplifying the model.

$$w_f(x, z) = w_f\left(\frac{x}{\Theta(z)}, z^r\right) + \eta \quad (7)$$

The model in (7) is highly nonlinear; log-linear models do not allow for the identification of the equivalence scale in this setting (Blackorby and Donaldson, 1993). Thus, one is left trying to estimate the equivalence scale using semiparametric methods, as in Pendakur (1999) or Yatchew et al. (2003). For our analysis, we follow the latter. Rewrite (7) as a partial linear model, where the function  $g$  is not known, and  $X = \ln x - \theta \ln(A + K)$ .

$$w_f(x, z) = g(X) + (A + K)\eta + \epsilon \quad (8)$$

The model to be estimated is not a pure partial linear model, because  $X$  contains an



additional parameter to be estimated, as in a linear index model. In order to estimate (8), we undertake a grid search over  $\theta$  and estimate  $\eta$  at each value of  $\theta$  following the double-residual method (Robinson, 1988). Thus, (i) we fix  $\theta$ , (ii) nonparametrically estimate  $w$  against  $X$ , (iii) collect the residuals, (iv) nonparametrically estimate  $(A+K)$  against  $X$ , (v) collect the residuals, and (vi) regress the first set of residuals against the second set of residuals. We repeat this process over plausible values of  $\theta$  and choose the  $\theta$  that minimizes the sum of squared errors.<sup>5</sup> This formulation yields a household economies of scale parameter, like that in (1), which mimicks the application in Xu et al. (2003); thus, the two estimates are directly comparable.

### 2.3 Data

As discussed above, data for the analysis was taken from the 2010/11 South African IES (Statistics South Africa, 2013). This survey was designed to analyze the consumption basket that underpins the Consumer Price Index. For that reason, the survey contains detailed information about household consumption, including out-of-pocket expenditures. The survey also contains a fair bit of information about individuals within the households, which we will highlight, below. Statistics South Africa switched to COICOP in 2005/06. In addition to the COICOP switch, 2005/06 saw the arrival of a rolling timeline – different households were surveyed at different points in time during a 12-month cycle – and consumption diaries.

The IES is based on multi-stage stratified random samples; thus, each response comes with a weight, defined at the level of the household, that can be used to create population relevant statistics.<sup>6</sup> Those weights are used in the analysis; see (2).

Descriptive statistics are presented in Table 1. The first column contains summary statistics for all households in the sample, which includes Asian households; as a sub-

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<sup>5</sup>We use linear least-squares cross-validated local linear regression (Li and Racine, 2004) for the nonparametric estimators. The models are estimated in Hayfield and Racine’s (2008) nonparametric package for R Core Team (2016). Additional details and results are available upon request from the authors.

<sup>6</sup>The household weight,  $\Omega_i = (p_s \times p_h \times a)^{-1}$ , where  $p_s$  refers to the probability that PSU “ $s$ ” was chosen from the set of all PSUs demarcated by Statistics South Africa,  $p_h$  is the probability that household “ $h$ ” was chosen from all of the households in the PSU, and  $a$  is the non-response adjustment. According to Statistics South Africa, the weights are benchmarked to the population in five year age groups and across race using the SAS macro CALMAR.

Table 1: Descriptive Statistics of 2010 IES Data

	All HH	Black HH	Coloured HH	White HH
Household Size	3.75	3.79	3.84	2.67
Food Expenditure	951.72	831.98	1272.54	1623.81
Food Share	0.25	0.27	0.25	0.09
Total HH Expenditure	6630.26	4585.65	7766.59	23048.87
OOP Expenditure	88.78	51.23	107.58	398.09

Total expenditure, food expenditure and out-of-pocket (OOP) health expenditure calculated according to Xu (2005) methodology using 2010 South African Income and Expenditure Survey Statistics South Africa (2013); however, the food share is the ratio of food expenditure to total household expenditure. All monetary figures are presented in March 2011 South African Rand (ZAR6.77/\$US1.00).

group, there are not enough Asian households to undertake a further separate analysis. In the remaining columns, data is reported by household population group. Only in 1994 was complete suffrage (for all citizens aged 18 and above) the law of the land. Preceding that election, individuals were discriminated against based only on population group. That discrimination advantaged whites, over coloureds over blacks, and, as can be seen in the table, there remains little sense of equality across races, yet. White households are the smallest, on average; they also spend the most on food, health care and all goods. Furthermore, using Engel's criteria, white households spend the least on food as a share of their budget, and, therefore, white households have the highest level of welfare; Leibbrandt and Levinsohn (2011) reach fairly similar conclusions following more careful methods.

### 3 Results

#### 3.1 Updated Equivalence Scale Estimates

The first set of results for the analysis are presented in Table 2, which contains semiparametric estimates of (8), as well as updated estimates of (5). The table contains eight rows, two each for all households, black households, coloured households and white households. In other words, separate models were estimated across each population group (for which there was enough data) and for the entire sample. The table also contains seven columns, which includes the estimates  $\theta$  and  $\eta$  in (8), along with the

cross-validated bandwidths from the separate nonparametric regressions required for Robinson’s (1988) double-residual method; the bandwidths are cross-validated via least squares (Li and Racine, 2004). The columns also include the coefficient of determination  $R^2$ , sum of squared residuals  $s^2$  (from the double-residual model), and the number of observations in the sample or subsample.

A number of implications arise from these estimates. Firstly, food expenditure, as modeled by Xu et al. (2003) is not well explained; the semiparametric model in (8) is better at explaining the share of food expenditure than (5) is at explaining the natural log of total food expenditure. However, the coefficient of determination is not comparable across model types. Secondly, the updated values for Xu et al.’s (2003) log-linear food expenditure model (5) are smaller than the original estimates reported therein, the reductions are statistically significant for the entire sample, black households and coloured households. Thirdly, the semiparametric estimate (8) is smaller than even the updated estimates; again, with the exception of white households, the differences are statistically significant, when compared to the initial estimate of 0.56 (from Xu et al., 2003).

### 3.2 Equivalence Scales and WHO Methodology Components

Given the definition of the poverty line (2), one would expect to see poverty lines vary with equivalence scale. Given the definition of the subsistence level, see (3), one would also expect it to vary with equivalence. However, the scale influences the subsistence level directly in one direction, but indirectly (through the poverty line) in the opposite direction; thus, the overall effect is an empirical question. Because it is not entirely clear whether the subsistence level will increase or decrease with the equivalence scale parameter, it is an open question whether or not capacity-to-pay and/or catastrophic health payments will be affected in any one particular direction. Our empirical analysis addresses these questions.

We report our estimates of the effect of the equivalence scale parameter on all three of the aforementioned components for all households (see Table 3), as well as black households, coloured households and white households (see Table 4). Each table includes

Table 2: Equivalence Compared to Single-Adult Households

Race	$\hat{\theta}$ (s.e.)	$\hat{\eta}$ (s.e.)	bandwidth $\ln x$	bandwidth $(A + K)$	$s^2$	$R^2$	N
Black HH SP	0.3664 (0.004)	0.0053 (0.000)	0.3401	0.2439	0.0202	0.2785	19473
Black HH LM	0.4684 (0.008)	N/A	-	-	-	0.1482	
Colour HH SP	0.3641 (0.045)	0.0054 (0.005)	0.5800	0.3313	0.0172	0.3831	2581
Colour HH LM	0.5214 (0.027)	N/A	-	-	-	0.1229	
White HH SP	0.5121 (0.126)	-0.0020 (0.006)	1.2728	0.3216	0.0051	0.2128	1960
White HH LM	0.5126 (0.035)	N/A	-	-	-	0.0997	
All HH SP	0.4157 (0.004)	0.0044 (0.000)	0.3752	0.2181	0.0186	0.1590	24619
All HH LM	0.4504 (0.008)	N/A	-	-	-	0.1227	

Semiparametric (SP) and linear (LM) estimates of equivalence across population groups assuming  $E = (A + K)^\theta$ , where  $A$  is the number of adults and  $K$  is the number of children in the household; see (8) and (5) for additional details. Semiparametric estimates follow Robinson's (1988) double-residual method, underpinned by local linear estimates; optimal bandwidths computed via least-squares cross validation (Li and Racine, 2004).

Table 3: Catastrophic Payments for All Households

	Semiparametric Xu (2005)	Updated LM Xu (2005)	Original Xu (2005)	Per Capita
Estimated $\theta$	0.42	0.45	0.56	1.00
Poverty Line	556.77	535.19	474.07	308.33
Subsistence Level	918.47	923.63	946.51	1156.20
Capacity-to-Pay	5969.41	5967.67	5961.39	5929.20
5% Threshold	9.14	9.13	9.15	9.15
10% Threshold	2.90	2.90	2.93	2.93
15% Threshold	1.14	1.14	1.15	1.14

Catastrophic payments and various components underpinning the catastrophic payments for all households in the data. Estimates for all of the values in the table are dependent upon the estimated equivalence parameter  $\theta$ . Column 1 and 2 figures are underpinned by estimates using 2010 IES data in – see (5) and (8) for details. The estimate of 0.56 is taken from Xu et al. (2003), which includes data from the 1993 South African PSLSD; those figures are reported in Column 3. The figures in Column 4 are based on the assumption that there are no equivalence scale adjustments.

the estimated scale equivalence parameter for that sample and model. Four models are considered within each of the four samples. We include the semiparametric and updated results from Table 2 – these are denoted “Semiparametric Xu (2005)” and “Updated LM Xu (2005)” – along with the “Original Xu (2005)”, which is 0.56, and a per capita assumption, which assumes a unit scale parameter. In all of these tables, we use the entire data set to calculate the underlying poverty line, determined by the estimated scale parameter,<sup>7</sup> as well as the scale-specific subsistence level, capacity-to-pay and three catastrophic expenditure proportions; one is based on a threshold of 5%, another on a threshold of 10% and the last is based on a threshold of 15%.

For all households, see Table 3, the poverty line falls with the scale parameter, while the average household subsistence level rises with the scale parameter. Because average subsistence rises, average capacity-to-pay falls. Since capacity-to-pay remains in the denominator for determining potential catastrophic payments, one would expect a non-decreasing pattern (from left to right), when considering catastrophic payments. Although that pattern does not hold completely at the 15% threshold, the difference from expectation is quite small (1.15 for 15% in Column 3 and 9.13 for 5% in Column

<sup>7</sup>We have also estimated the poverty line separately across all samples, reaching the same general conclusion as we report here. Results available from the authors upon request.

1). Despite the fact that the poverty line differs (smallest to largest) by about 64%, there are very few differences in the catastrophic health expenditures distributions; the difference in poverty line between that underpinned by the initial estimate of 0.56 and that of the semiparametric estimate of 0.42 is on the order of 17%. The remaining sets of results, see Table 4, lead to the same overall conclusion, although the relationship between the national poverty line and the race-specific subsistence level is not as clear cut as was reported in Table 3.<sup>8</sup>

The underlying results suggest that black and white households, the poorest and the richest, are subject to the highest proportions of catastrophic expenditures; more than 9% of households from these samples spend more than 5% of their capacity-to-pay on health care, while approximately 3% of the households spend 10% of that capacity and just more than 1% spend 15% of that capacity. For black households, only, the subsistence level increases with the equivalence scale parameter  $\theta$ . However, direct relationship is empirically uncovered between equivalence scale and catastrophic payments or capacity-to-pay. Furthermore, the size of the estimated equivalence scale parameter has very little affect on the reported catastrophic payment proportions. For black and coloured households, adopting the semiparametric scale parameter estimate over Xu et al.'s (2003) initial estimate leads to a reduction of about 0.1% in catastrophic health payments at the 5% threshold; the reduction is from 9.62 to 9.51 and 5.95 to 5.80 for black and coloured households, respectively. However, the direction of that comparison does not remain the same for higher threshold levels. Thus, there is little evidence to suggest that the choice of equivalence scale used in calculating catastrophic health payments within the Xu (2005) methodology matters to financial risk protection conclusions, at least in the case of South Africa in 2010/11.

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<sup>8</sup>When the race-based samples are used to create race-specific poverty lines and subsistence levels, both decrease with the scale parameter, as seen in Table 3. Regardless of whether we estimate race-specific or national poverty lines, we find the same levels of catastrophic health expenditure within race groups. Thus, we do not report these additional estimates. Results are available upon request.

Table 4: Catastrophic Payments for Different Subsamples

(a) Catastrophic Payments for Black Households

	Semiparametric Xu (2005)	Updated LM Xu (2005)	Original Xu (2005)	Per Capita
Estimated $\theta$	0.37	0.47	0.56	1.00
Poverty Line	556.77	535.19	474.07	308.33
Subsistence Level	864.27	949.11	951.08	1170.02
Capacity-to-Pay	3969.73	3940.83	3941.73	3915.52
5% Threshold	9.51	9.63	9.62	9.60
10% Threshold	2.97	3.04	3.05	3.06
15% Threshold	1.17	1.19	1.20	1.17

(b) Catastrophic Payments for Coloured Households

	Semiparametric Xu (2005)	Updated LM Xu (2005)	Original Xu (2005)	Per Capita
Estimated $\theta$	0.36	0.52	0.56	1.00
Poverty Line	556.77	535.19	474.07	308.33
Subsistence Level	882.63	1046.79	977.24	1184.18
Capacity-to-Pay	7025.29	6936.68	6972.45	6895.45
5% Threshold	5.80	6.03	5.95	5.99
10% Threshold	1.96	2.00	1.96	1.96
15% Threshold	0.65	0.73	0.73	0.81

(c) Catastrophic Payments for White Households

	Semiparametric Xu (2005)	Updated LM Xu (2005)	Original Xu (2005)	Per Capita
Estimated $\theta$	0.51	0.51	0.56	1.00
Poverty Line	556.77	535.19	474.07	308.33
Subsistence Level	891.01	856.90	795.62	822.28
Capacity-to-Pay	22287.64	22310.62	22353.64	22346.01
5% Threshold	9.22	9.22	9.17	9.22
10% Threshold	3.12	3.12	3.12	2.97
15% Threshold	1.24	1.24	1.24	1.24

Catastrophic payments and various components underpinning the catastrophic payments calculation for black households (Panel 4a), coloured households (Panel 4b) and white households. Estimates for all of the values in the table are dependent upon the estimated equivalence parameter  $\theta$ . Column 1 and 2 figures are underpinned by estimates using 2010 IES data in – see (5) and (8) for details. The estimate of 0.56 is taken from Xu et al. (2003), which includes data from the 1993 South African PSLSD; those figures are reported in Column 3. The figures in Column 4 are based on per capita equivalence.

## 4 Concluding Remarks

This research has examined the effect of equivalence scale estimation on the various components (especially, the poverty line, subsistence level and capacity-to-pay), as well as the resulting catastrophic health care payments distribution, of the World Health Organization's methodology for measuring financial risk protection in health care. The research applied the initial estimate from Xu et al. (2003) that determines equivalence within the WHO's method (Xu, 2005), updated the estimate following the regression structure outlined by Xu et al. (2003), and updated the estimate through the estimation of base-independent equivalence scales via semiparametric methods (Yatchew et al., 2003). The estimates were updated using the 2010/11 South African IES (Statistics South Africa, 2013) for all households, as well as for three population subgroups. Preceding the end of Apartheid in South Africa, individuals were discriminated against according to race, and this policy was being slowly dismantled in 1993. The South African data included in Xu et al. (2003) was from 1993; thus, it was expected that household behaviour, as measured by equivalence scales would differ substantially from the initial estimate.

Our results support this expectation, as updated equivalence scales were statistically significantly lower for all households, black households and coloured households, although not for white households. In some cases, the reduction was as much as 35%, in terms of the actual equivalence scale parameter. Given the large differences in equivalence scales, this research further examined the impact on the estimated poverty line, subsistence level, capacity-to-pay and catastrophic health care payments. Although the estimated poverty line increased by as much as 17%, the effect on the subsistence level, capacity-to-pay and catastrophic payments was unimportant. Thus, when applying the WHO method, although we would recommend considering whether or not the choice of equivalence scale is important in the resulting catastrophic health care payment distribution, our analysis suggests that it is unlikely to lead to extensive differences. And, if differences are uncovered, estimating updated equivalence scale parameters, as done here, is a fairly innocuous task.



## References

- Ataguba, J. O. E. (2012), ‘Reassessing catastrophic health-care payments with a Nigerian case study’, *Health Economics, Policy and Law* **7**, 309–326.
- Blackorby, C. and Donaldson, D. (1993), ‘Adult-equivalent scales and the economic implementation of interpersonal comparisons of well-being’, *Social Choice and Welfare* **10**, 335–361.
- Blundell, R. and Lewbel, A. (1991), ‘The information content of equivalence scales’, *Journal of Econometrics* **50**, 49–68.
- Buigut, S., Ettarh, R. and Amendah, D. A. (2015), ‘Catastrophic health expenditure and its determinants in Kenyan slum communities’, *International Journal for Equity in Health* **15**.
- Donaldson, D. and Pendakur, K. (2003), ‘Equivalent-expenditure functions and expenditure-dependent equivalence scales’, *Journal of Public Economics* **88**, 175–208.
- Engel, E. (1857), Die productions- und consumtionsverhaltnisse des konigreichs sachsen, in E. Engel, ed., ‘Dielebenskostenbelgischerarbeiter-familien’, C Heinrich, Dresden.
- Harris, B., Gouge, J., Ataguba, J. O. E., McIntyre, D., Nxumalo, N., Jikwana, S. and Chersich, M. (2011), ‘Inequities in access to health care in South Africa’, *Journal of Public Health Policy* **32**, S102–S123.
- Hayfield, T. and Racine, J. S. (2008), ‘Nonparametric econometrics: The np package’, *Journal of Statistical Software* **27**(5).  
**URL:** <http://www.jstatsoft.org/v27/i05/>
- Koch, S. F. (2015), ‘Out-of-pocket payments on health: The 2005-06 and 2010-11 South African income and expenditure surveys’, Report to the World Health Organization.
- Leibbrandt, M. and Levinsohn, J. (2011), ‘Fifteen years on: Household incomes in South Africa’, NBER Working Paper No. 16661.

- Lewbel, A. (1989), ‘Household equivalence scales and welfare comparisons’, *Journal of Public Economics* **39**, 377–391.
- Li, Q. and Racine, J. S. (2004), ‘Cross-validated local linear nonparametric regression’, *Statistica Sinica* **14**(2), 485–512.
- Li, Y., Wi, Q., Liu, C., Kang, Z., Xie, X., Yin, H., Jiao, M., Liu, G., Hao, Y. and Ning, N. (2014), ‘Catastrophic health expenditure and rural household impoverishment in China: What role does the new cooperative health insurance scheme play?’, *Plos One* **9**, e93253.
- Masiye, F., Kaonga, O. and Kirigia, J. M. (2010), ‘Does user fee removal policy provide financial protection from catastrophic health care payments? Evidence from Zambia’, *Plos One* **11**, e0146508.
- Misra, S., Awasathi, S., Singh, J. V., Agarwal, M. and Kumar, V. (2015), ‘Assessing the magnitude, distribution and determinants of catastrophic health expenditure in urban Lucknow, North India’, *Clinical Epidemiology and Global Health* **3**, 10–16.
- 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.
- Posel, D., Casale, D. and Grapsa, E. (2016), ‘Re-estimating gender differences in income in South Africa: The implications of equivalence scales’, *Development Southern Africa* **33**(4), 425–441.
- R Core Team (2016), *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria.  
**URL:** <https://www.R-project.org/>
- Robinson, P. M. (1988), ‘Root- $n$ -consistent semiparametric regression’, *Econometrica* **56**, 931–954.

- Statistics South Africa (2013), ‘Income and Expenditure Survey, 2010/11 [Computer File]. SADA0193’, Pretoria: Statistics South Africa [producer], 2013. Pretoria: South African Data Archive, National Research Foundation [distributor], 2013.
- Van Minh, H., Kim Phong, N. T., Saksena, P., James, C. D. and Xu, K. (2013), ‘Financial burden of household out-of-pocket health expenditure in Viet Nam: Findings from the national living standard survey 2002-2010’, *Social Science & Medicine* **56**, 258–261.
- Wittenberg, M. and Collison, M. (2008), ‘Restructuring of households in rural South Africa: Reflections on average household size in the Agincourt sub-district 1992-2003’, South Africa Labour and Development Research Unit Working Paper No. 12.
- Xu, K. (2005), ‘Distribution of health payments and catastrophic expenditures: Methodology’, World Health Organization Discussion Paper 2-2005.
- Xu, K., Evans, D. B., Kawabata, K., Zeramdini, R., Klavus, J. and Murray, C. J. L. (2003), ‘Household catastrophic health expenditure: A multicountry analysis’, *the Lancet* **362**, 111–117.
- Yatchew, A., Sun, Y. and Deri, C. (2003), ‘Efficient estimation of semiparametric equivalence scales with evidence from South Africa’, *Journal of Business & Economic Statistics* **21**(2), 247–257.

## A Out-of-Pocket Payments Distributions

To provide additional evidence of the limited effect of differing equivalence scale parameter, we illustrate the underlying distribution of the ratio of out-of-pocket payments over capacity-to-pay,  $w_o$ , for all households.<sup>9</sup> These illustrations are available in Figure A.1. As can be seen, there is nothing to distinguish the distribution functions, which further supports our conclusion.

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<sup>9</sup>Similar results are found for the remaining subsamples. Those distribution functions are available upon request.

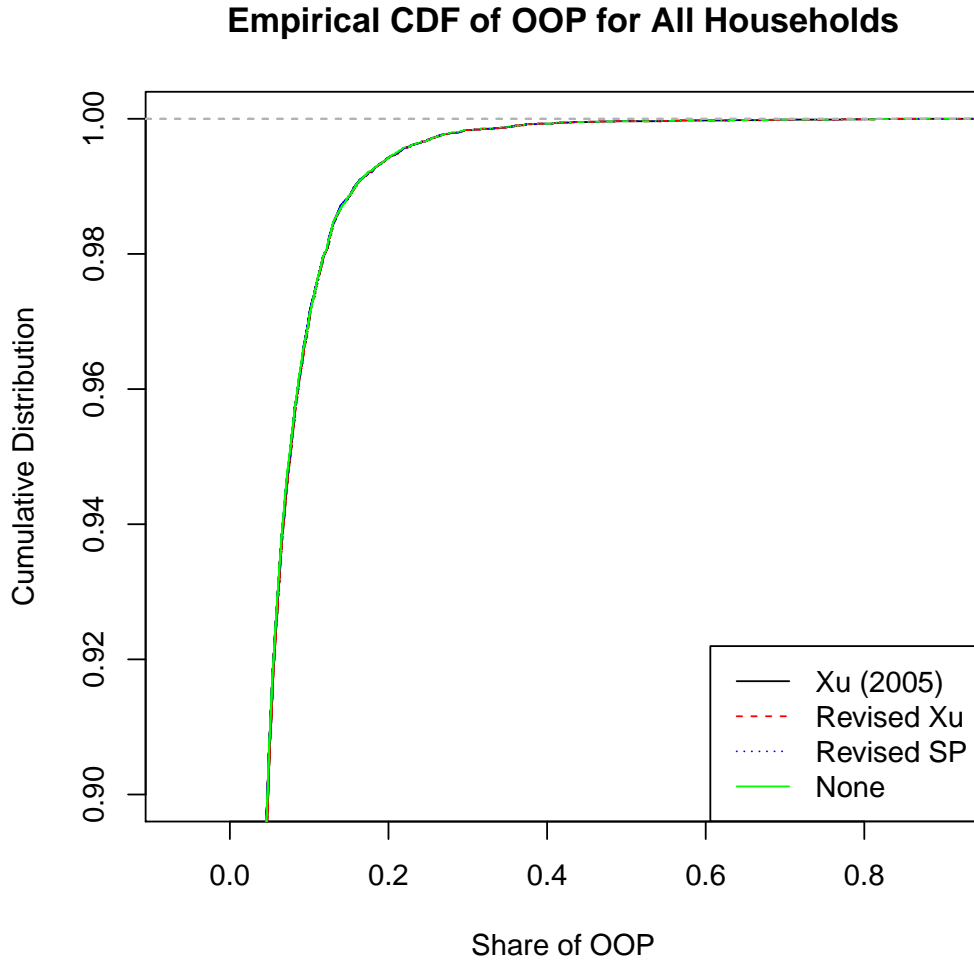


Figure A.1: Empirical cumulative distribution function of out-of-pocket payments covering all households in the data. Xu (2005) represents the ECDF that would arise following Xu (2005). Revised Xu represents the ECDF that would arise following Xu (2005), but using the Updated LM  $\hat{\theta}$  value from Table 2. The revised SP ECDF arises from following Xu's (2005), but using the Semiparametric  $\hat{\theta}$  value from Table 2. The None ECDF arises from ignoring household economies of scale in the calculation of OOP shares, assuming  $\hat{\theta} = 1$ .