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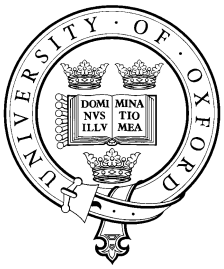

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A Robust Multidimensional Poverty Profile for Uganda

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Abstract
We compute a national multidimensional poverty index (MPI) for Uganda following the approach proposed by Alkire and Foster (2007). Using household survey data, we show how the incidence of multidimensional poverty has fallen in recent years, and we use the decomposability features of the index to explain the drivers of the reduction in multidimensional poverty. We extend the standard application of the MPI to distinguish between domains and dimensions, which is particularly important given the high degree of multiple deprivations within the standard-of-living domain. We also compare the results from Uganda with other countries for which the MPI has been computed, and we note some caveats in such a comparison. The robustness of our estimates is tested in a stochastic dominance framework as well as through statistical inference. Notably, we extend the one-dimensional analysis of stochastic dominance to take into account household size in a second dimension, which is particularly important as some of the MPI indicators are sensitive to the number of household members. By exploiting a unique sub-sample of the integrated household survey programme in Uganda, which has not previously been analysed, we are also able to match the data set used for the MPI with data used to compute the conventional estimates of monetary poverty. This enables a more robust assessment of the complementarities of the two types of poverty measures than has been previously possible.

Keywords: multidimensional poverty, poverty measurement, identification, Uganda

JEL classification: I31, I32, O1

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The Oxford Poverty and Human Development Initiative (OPHI) is a research centre within the Oxford Department of International Development, Queen Elizabeth House, at the University of Oxford. Led by Sabina Alkire, OPHI aspires to build and advance a more systematic methodological and economic framework for reducing multidimensional poverty, grounded in people's experiences and values.

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Introduction

Uganda has reached a critical milestone in its fight against poverty. With the release in early 2011 of the final data from the 2009/2010 household survey, the incidence of income poverty was estimated at 24.5% of the total population (Uganda Bureau of Statistics 2010). While this number is clearly unacceptably high, when compared with a baseline estimate of 56% from a similar survey conducted in 1992/1993, it is a sign of significant progress (Uganda Bureau of Statistics 1999). Indeed the progress has been so great that the government has pronounced that the country has reached the Millennium Development Goal (MDG) target of cutting the poverty level in half by 2015—and done so well ahead of time.[1] A cursory overview of national MDG progress reports prepared by African countries, gives evidence to the rarity of such an accomplishment.[2] The striking success of Uganda's poverty reduction, however, stands in contrast to its performance on other MDGs. Out of the 17 targets, which were reported in Uganda's 2010 MDG report, progress on 10 were considered insufficient to meet the adopted target, including two cases where the situation was actually deteriorating (Ministry of Finance, Planning and Economic Development 2010). In particular, progress towards targets in health, education and environmental sustainability were considered 'off-track'. In this way the Uganda MDG report affirms that progress in one dimension of human wellbeing is not necessarily associated with improvements in others and that, in order to be comprehensive, any assessment of human deprivation needs to be done in a multidimensional framework.

Defining poverty as a phenomenon of multiple dimensions goes back to the seminal work of Amartya Sen (1979, 1985 and 1987). In practice, however, the vast majority of empirical work on poverty uses a one-dimensional measure of wellbeing, usually household income or expenditure. This is also the case in Uganda although the conceptualisation of poverty in the country has steadily evolved since the introduction of the Poverty Eradication Action Plan (PEAP) in 1997. Prior to this, the main empirical basis for informing national development policy was national accounts aggregates, notably indicators on annual output changes. Since the introduction of the PEAP and its successor, the National Development Plan, poverty reduction has featured as a core development challenge and corresponding targets for poverty reduction have been set. This has been facilitated by the establishment of a 'cost-of-basic-needs' poverty line (Appleton 1997) and several data collection exercises by the Uganda Bureau of Statistics (1999, 2006 and 2010). Both in terms of policy and measurement there has been recognition of the multiple dimensions of human welfare, but typically these have been treated separately, i.e. income/consumption by itself, education by itself, health by

[1] According to *The Daily Monitor* on 8 December 2010, the State Minister for Planning in the Ministry of Finance, Prof. Ephraim Kamuntu, was reported as saying at the launch of Uganda's MDG progress report, "At a poverty rate of 23.3%, we have actually met our target ahead of schedule. But our aim is not to combat poverty but to eliminate it." The estimate reported by the Minister of State was preliminary; the one reported above is the final one as reported by Uganda Bureau of Statistics (2010), which explains the slight difference.

[2] In Africa, only Ghana appears to have experienced a comparable degree of rapid and sustained reduction in poverty and is probably the first country on continent to have registered attainment of the MDG poverty target. All the MDG country progress reports, including those from Uganda and Ghana, are available at http://www.undg.org/index.cfm?P=87.

itself and so on. A forerunner of a more integrated analysis of the multidimensionality of poverty was the participatory poverty assessments that Uganda pioneered since the late 1990s. A defining feature of these qualitative studies was their extension of the concept of poverty to include non-monetary dimensions; their results have been considered to deepen and complement the information contained in the consumption-based poverty measures (McGee 2004). Another example is the UNDP's Human Poverty Index (2007), a composite index which weighs and aggregates district-level indicators of deprivation in material wellbeing and indicators on educational attainment and mortality.

The launch of the latest income poverty estimates and the 2010 MDG progress report has fuelled new discussions in Uganda about the need for measures that better reflect the multiple dimensions of poverty and deprivation. The purpose of such new measures should not be to replace or diminish the importance of the conventional consumption-based measure of poverty. Even if narrowly defined, the monetary measure reflects critical aspects of human deprivation and remains a useful tool for policy makers, planners and advocates. Rather, the purpose should be to complement existing measures, provide more tools for designers and implementers of anti-poverty programmes, and bring new perspectives to the debate.

In terms of defining such a multidimensional poverty measure, several possibilities have been proposed in the theoretical and empirical literature (Tsui 2002; Atkinson 2003; Bourguignon and Chakravarty 2003). In this paper we apply the family of multidimensional poverty measures proposed by Alkire and Foster (2007), which is useful for several reasons. Notably, in identifying who is multidimensionally poor the approach uses two thresholds or cutoffs, one that is dimension-specific and another that relates to the number of dimensions in which an individual has to be deprived to be considered poor. The approach also satisfies several desirable properties, or axioms, including decomposability, which makes it particularly suitable for policy analysis and targeting.

In particular we use one specification of the Alkire-Foster approach, which is referred to as the Multidimensional Poverty Index (MPI). This index was computed for 104 countries in Alkire and Santos (2010) and launched as a prominent feature of the annual UNDP Human Development Report, replacing the previous Human Poverty Index (UNDP 2010). This way we apply this new methodology for measuring multidimensional poverty in Uganda and seek to move the national debate about poverty measurement in multiple dimensions forward. At the same time we are able to create a link to the global work on multidimensional poverty and enable cross-country comparisons.

We make several methodological and empirical contributions in this paper. The first methodological contribution is through the formal distinction between 'domains' and 'dimensions' in the development and analysis of the MPI. This is particularly important given the high degree of correlation of several dimensional indicators related to the domain of standard of living. The second methodological contribution is through the expansion of robustness tests of the MPI to include tests for statistical inference and stochastic dominance. Our stochastic dominance analysis is conducted first in one dimension and across a range of background variables. We go on to add household size as a second dimension in the stochastic dominance analysis. This is important and does affect the robustness of some of the results, as some of the indicators used in the MPI are positively correlated with the number of members of the household. We go on to exploit a unique sub-sample of the

Ugandan household data that enables us to match the MPI data set with the data set on household consumption used to compute the conventional monetary poverty measure. This makes it possible to assess directly the extent to which, and in which way, the two types of poverty measures are complementary. This is a significant value-addition compared to previous studies, which have relied on survey data with very limited consumption modules.

The next section of the paper presents the methodology for computing the MPI in more detail. The results from the Uganda multidimensional poverty profile are then presented with international and inter-temporal comparisons. We go on to present robustness tests and then a comparison of the monetary and multidimensional measures, before we conclude with a discussion of some of the implications for poverty reduction policies and the measurement of poverty in the country.

2. Methodology and data

This section presents the main methodology underlying the multidimensional poverty index, the methods we apply to test for robustness of our results, and the data used for the empirical analysis.

2.1 The Multidimensional Poverty Index (MPI)

The MPI is an extension of the one-dimensional class of decomposable poverty measures proposed by Foster, Greer and Thorbecke (1984) and emerged from the *dimension-adjusted poverty headcount ratio* proposed by Alkire and Foster (2007) . The index is made up of two components: the poverty headcount, *H*, and an adjustment measure, *A*, that represents the number of deprivations suffered, on average, by the poor.

$$MPI = H \times A$$

where:

$$H = \frac{q}{n}$$

Which is simply the total number of poor, q , divided by the total population, n . Since we are using data from a representative household survey, and since we want to adjust for variations in household size (notably to ensure that our measurement takes into account that poorer households typically have more members) we apply a weight $w_i = s_i h_i$ where s_i is the sample weight and h_i the household size. w_i could be normalized so that $\sum_{i=1}^{n} w_i = n$.

The total number of poor is given by:

$$q = \sum_{i=1}^{n} w_i \rho_k \left(y_i ; z \right)$$

This is the sum of individuals identified as poor using a dual cutoff approach represented by $\rho_k(y_i;z)$, where $y_i=(y_{i1},...,y_{ij},...,y_{id})$ represents the profile of household i's achievements across d 'dimensions'. The first cutoff is given by z_j, which is the deprivation threshold in each dimension, $j=1,...,d$ of poverty that separates the deprived from the non-deprived, for instance a cost of basic needs poverty line that is used for measuring monetary poverty or a Body Mass Index (BMI) threshold that defines malnutrition. The second cutoff is represented by k, which is the number of deprivations required in order for the individual to be considered multidimensionally poor. At one extreme when $k=1$, the identification cutoff is equal to the union approach whereby poverty is defined as being deprived in just one dimension. At the other extreme $k=d$ is equal to the intersection approach, where one is defined as multidimensionally poor only if deprived in all dimensions. The poverty status of an individual is defined as a dichotomous variable equal to 1 if the number of deprivations counted, c_i, for each individual $c_i \geq k$ and 0 if not.

It is useful to organise the multiple dimensions d according to T partitions with respective sizes: $d_1,d_2,...,d_t,...d_T$, with $d=d_1+d_2+\cdots+d_T$. Each partition can be thought of as representing a domain containing d_t nested dimensions. Domains, or broad dimensions, considered in multidimensional welfare analysis vary in terms of how many are included and how these are defined, but the MPI uses three: health, education and material standard of living. Previously the terms domains and dimensions have been used interchangeably, a practice that this paper seeks to depart from. Specifically we introduce a formal distinction between domains and dimensions to extend the use of the MPI.[3] This enables us to differentiate between deprivations that occur exclusively within one domain as opposed to deprivations that occur across several domains. This is particularly important, as we shall show, for the MPI, which has several indicators within a single domain, notably the one capturing material standard of living, that tend to be highly correlated in the case of Uganda. In our extended application of the MPI, we first define the multidimensional poverty status by the condition $c_i \geq T$, when the multidimensional cutoff k is equal to the number of domains T, and we then include an additional condition in which the number of deprivations counted c_i includes non-zero values for each dimension. Formally, c_i can be decomposed by dimension as $c_i^{d_1},c_i^{d_2},...,c_i^{d_T}$, with $c_i=c_i^{d_1}+c_i^{d_2}+...+c_i^{d_T}$. The second condition holds if $c_i^{d_t}>0 \ \forall\, t$. This definition is more restrictive than the one based only on the first condition since it excludes individuals with T deprivations but without deprivation in at least one dimension indicator of any domain. The multidimensional cutoff for this alternative will be denoted by $\hat{k}$ and an individual is considered to be multidimensionally poor when $c_i \geq \hat{k}$.

Since H is insensitive to the number of dimensions in which a poor person is deprived, as a poverty measure on its own it violates a principle that Alkire and Foster (2007) refer to as 'dimensional monotonicity', which states that if a poor person becomes newly deprived in an additional

[3] Alkire and Santos (2010) do not make the distinction explicitly but refer to 'broad dimensions' and 'indicator dimensions', which correspond to the 'domains' and 'dimensions' that we develop formally here and use for the analysis.

dimension, then overall poverty should increase.[4] Therefore *H* is adjusted by a measure of the number of deprivations that a poor person suffers, reflecting the *intensity* A of poverty:

$$A = \frac{1}{qd}\sum_{i=1}^{n} w_i c_i^*$$

where c_i^* indicates that we are only counting deprivations for individuals for whom $c_i \geq k$. It is possible to assign different weights, ω^d, to the dimensional deprivations in order to reflect differences in the importance attached to each of the multiple dimensions of poverty. In that case, c_i is the weighted number of deprivations in which the individual is deprived and the MPI is automatically adjusted to reflect the weighting scheme:

$$c_i = \sum_{j=1}^{d} p_{z_j}\left(y_i, \omega_j^d\right) \quad (1)$$

where

$$p_{z_j}\left(y_i, \omega_j^d\right) = \begin{cases} \omega_j^d \text{ if } y_{ij} < z_j \\ 0 \text{ otherwise} \end{cases}$$

Like the FGT index, the MPI can be decomposed by sub-group:

$$MPI = \sum_{l=1}^{L} \varphi^l MPI^l \quad (2)$$

Where φ^l is the population share of sub-group *l* (i.e. n^l/n). This type of decomposition is useful for developing poverty profiles as it allows for identifying which subgroups have higher levels of poverty. In turn this is useful for purposes of targeting anti-poverty interventions. Equation (1) can also be used to evaluate the contribution, Π_l, of each sub-group to overall poverty:

$$\Pi_l = \frac{\varphi^l MPI^l}{MPI} \quad (3)$$

A useful complementary analysis is to decompose MPI by dimension and assess the contribution to overall poverty levels by each dimension:

$$\Pi_j = \frac{\frac{1}{nd}\sum_{i=1}^{n} c_{i,j}^*}{MPI} \quad (4)$$

[4] The MPI satisfies other important axioms such as symmetry, replication invariance, subgroup consistency and decomposability (Alkire and Foster 2008).

where $c^*_{i,j}$ is the same as $p_{z_j}\left(y_i, \omega^d_j\right)$ when $c_i \geq k$ and equals zero otherwise. While the MPI is sensitive to the number of deprivations of poverty, it is not sensitive to the depth of poverty. If a person becomes more deprived in one dimension the measure will not change. The depth and severity of poverty can be assessed using other members of the Alkire and Foster (2007) class of poverty measures or others such as those suggested by Bourguignon and Chakravarty (2003) and Tsui (2002). But for purposes of this paper we focus on the incidence of poverty as represented by the MPI.

2.2 Robustness tests

We deepen the empirical analysis by presenting a combination of robustness tests for our results. The first is simply to test for sensitivity to changes in *k* to assess the extent to which our conclusions are sensitive to the number of deprivations required to qualify as multidimensionally poor. We also test for statistical significance of our results and stochastic dominance. To check whether the different estimated values of multidimensional poverty are significant, the statistical inference is performed under the null hypothesis that $MPI = 0$ against the alternative that $MPI \neq 0$ (the details for computing the t-statistics based on this null are outlined in Annex A).

Since the MPI is a member of a class of poverty indices that obey properties such as *monotonicity* and *weak transfer* (Alkire and Foster 2007), checking the rankings of distributions against this measure may be seen as a dominance analysis. In fact, as suggested by Atkinson (2003) and Batana (2008), robustness analyses could be performed by comparing multidimensional poverty in two populations along k in a way that is consistent with welfare comparisons. Our dominance analysis focuses on testing spatial and inter-temporal robustness. In both cases we test for one-dimensional (Atkinson 1987; Foster and Shorrocks 1988a, 1988b) and two-dimensional dominance (Duclos, Sahn and Younger 2006a, 2006b; Batana and Duclos 2010a, 2010b). The one-dimensional dominance test is based on only one dimension, represented by the poverty count c_i, and the robustness refers to comparison at each k.

However, and as will be discussed further below, we find that multidimensional poverty depends to a large degree on household size. One reason for this is that larger households tend to be poorer, which is a standard result in welfare analysis. But household size may also play a role given the design of the multidimensional poverty measure. Notably, the use of a unitary household model implies that the poverty status of the members of the household is derived from an assessment of whether one or more members of the household are considered deprived. For those indicators related to the individuals, it follows that the more household members, the more likely one is to be deprived, and thus the more likely it is that the entire household will be considered multidimensionally poor. Consider a household composed of just one adult male. The measure here will be restricted largely to household-level indicators of standard of living, as in the case of the typical MPI measure health and education indicators are drawn from information about the women and children of the household. For both the health and education indicators there is a tendency for the severity of the deprivation to

increase with the size of the household. There are therefore compelling reasons for checking whether the rankings are unchanged when household size is taken into account as a second dimension. The technical details for performing these tests are outlined in Annex B.

2.3 Data

The data used for the analysis is from the Uganda Demographic Health Surveys (DHS), conducted by the Uganda Bureau of Statistics and Macro International (2007, 2002). As noted, our choice of data is guided by the objective of establishing comparability with the global MPI estimates presented in Alkire and Santos (2010) and UNDP (2010).[5] A key advantage of the MPI methodology is that it is based on a consistent methodology and seeks to use comparable data that facilitates international comparison.[6] A secondary objective was to ensure comparability over time considering changes in the methodologies underlying the four DHS surveys that have been conducted in Uganda since 1988. These criteria led to the selection of the two most recent rounds of the DHS conducted in 2000/2001 and 2005/2006.[7] The primary purpose of the DHS is to provide policymakers and planners with detailed information on the status of the population on a range of indicators in mortality, morbidity, fertility, nutrition and other demographic or health aspects. The surveys also collect data on educational attainment, labour market outcomes, physical features of the household and other areas of social and material wellbeing. The DHS are nationally representative surveys using a two-stage probability sample and with specific questionnaires for the household women (aged 15-49) and men (aged 15-54). However, in 2000/2001 the districts of Bundibugyo, Gulu, Kasese, Kitgum and Pader were not accessible to field officers of the Uganda Bureau of Statistics due to insecurity from the low-intensity civil conflict that has plagued northern Uganda for decades. For the 2005/2006 survey all areas of the country were accessible as peace has been gradually restored. It is therefore important for purposes of inter-temporal comparison to assess the impact on the poverty measures of excluding these districts, which we will do below.

For purposes of the MPI, three domains or broad dimensions are considered, namely health, education and standard of living. Two dimensions or indicators are retained in the health domain and the education domain, while six dimension indicators are considered for the standard-of-living domain. These indicators and the original relative weights assigned to each of them are presented in Table 1. Some of the indicators are drawn from the individual sections of the surveys and others from the household sections. The MPI thus applies a unitary definition of the household whereby all members of a given household are afforded the same poverty status and intra-household inequality is not considered. As shall be discussed further below, the unitary household definition poses certain

[5] We also looked at the 1995 DHS but decided to not include it in the present analysis as it did not have anthropomorphic data needed to compute the BMI for women, which is one key indicator in the MPI.

[6] This is not the case with the current one-dimensional poverty measure used by the World Bank and other international agencies, which is based on the USD 1.25 international poverty line expressed in 2005 Purchasing Power Parities. As documented in Levine (2011) a series of methodological issues, e.g. differences in poverty thresholds, adjustments for household composition, and price adjustments, in the computation of the national and international poverty measures generate different results and conclusions about the poverty levels in Uganda.

[7] In the earlier surveys, indicators such as energy for cooking and nutritional status of women were not collected.

challenges when it comes to comparing two distributions of multidimensional poverty when household sizes are different.

The weights are set such that each broad dimension is weighed equally at 1/3 and, using nested weights, each indicator dimension also is weighted within each broad domain. The issue of which weights to apply is of considerable importance in compiling multidimensional indices (Decanq and Lugo 2010). For purposes of the MPI we follow the Alkire and Santos (2010) approach of using equal weights across domains to ensure a methodology that enables international comparability. In the implementation of a more Uganda-specific multidimensional index, the weighting scheme should be revisited. In terms of selecting the number of deprivations, *k,* that are required for a household to be considered multidimensionally poor we also follow Alkire and Santos by mainly focusing on *k = 3.* However, and as explored later, we check the robustness of our conclusions using alternate values of *k.*

For the nutrition indicator, an adult is considered to be deprived when the BMI is below 18.5, while a child is considered malnourished when the weight-for-age z-score is below -2. Further, two alternative z-scores will be specified to check the effect of changes in the choice of indicators. These are the weight-for-height and the height-for-age z-scores. For the analysis, we keep only households with available data in all indicators for at least one member. This means that 34,425 individuals are included out of a total of 36,702 in the 2000/2001 data, which corresponds to 93.8% of the original sample. The number of households is reduced from 7,878 to 7,437 or 94.4% of the original sample. For the 2005/2006 data, a total of 42,893 individuals are retained out of 43,920 (97.7%) and 8,644 households out of 8,867 (97.5%).[8]

For purposes of comparing the MPI with the conventional monetary poverty measure, we make use of a sub-sample of 2,177 households that were common in the 2005/2006 DHS and the Uganda National Household Survey, which was conducted in the same year. This latter survey contains a large module on household consumption and is the survey instrument used to calculate poverty levels.

3. A multidimensional poverty profile for Uganda

In this section we present a multidimensional poverty profile of Uganda comparing changes in the individual MPI indicators, presenting MPI results for 2000/2001 and 2005/2006, decomposing the MPI into contributions by subgroups and dimensions, and making international comparisons.

3.1 Levels and changes in MPI indicators

Table 2 shows the values of the deprivation indicators that are used in the MPI analysis. Several features stand out. First, it is clear that Ugandans face severe deprivations across a range of basic

[8] In the aggregation of the MPI the difference in the level of indicators is accounted for in the weighting scheme by multiplying s_i by household size (in case of household level indicators) and not (in the case of individual level indicators).

needs. For instance, according to the 2005/2006 data, 89% lived in households where the sanitation facility is either shared or not improved, and 74% lived in households without access to safe water. Practically all individuals live in households that cook with dung, wood or charcoal. Most individuals are also without material assets, such as a telephone, television and motor vehicle. The health indicators show that in 43% of households a child has died within the past five years.

There have been some changes in the deprivation status between the two surveys. In most cases the development has been positive, as the level of deprivation has fallen. This is the case in particular for the sanitation, nutrition and education indicators, where there have been improvements in both rural and urban areas. It is noteworthy that most of the increases in deprivation have been in urban areas and in many of the variables related to material standard of living. This could be a reflection of the impact of rural-to-urban migration and raises some concerns about increasing urban poverty and the living conditions of dwellers in informal settlements.

3.2 The MPI for Uganda

The main results for MPI and H are reported in

Table **3** for $k = 3$. In 2005/2006 the poverty headcount, H, was 0.727 indicating that around 73% of the population were deprived in at least three of the indicator dimensions. Once this is adjusted for the number of deprivations suffered, A, the MPI is computed as 0.369. This is somewhat lower than the MPI value for 2000/2001, which was 0.41. The lowering of the MPI in 2005/2006 is a result of both a reduction in the headcount and the intensity of poverty.

The table also includes a decomposition of the MPI results by sub-groups. It is clear that multidimensional poverty in terms of both headcount and intensity are higher in rural areas than in urban areas. However, the gap seems to be narrowing as the MPI has fallen in rural areas and increased slightly among individuals living in urban households. For rural areas the decline in the MPI is attributable to falling values of both headcount and intensity, whereas for urban areas the headcount has increased, while the intensity has declined marginally. This could be an indication that the decline in certain household asset variables has increased the number of poor people rather than added to the plight of the already-poor.

In terms of the regional distribution of poverty, the results from the MPI present a pattern that is well known from other poverty studies in Uganda: the Northern region is the most deprived and the Central region is the least. The Northern region ranks highest on both the headcount and intensity of multidimensional poverty. Almost 85% of individuals living in Northern households were deprived in three or more of the ten dimensions in 2005/2006 compared to 54% among individuals in the Central region. All regions have seen an improvement in both components of the MPI.

3.3 Decomposition of the MPI

The results of decomposition by sub-group using Equation (3) shows slightly higher levels of the MPI among households headed by females than by males although the level of MPI has declined

between the two surveys. It should be noted that these results reflect poverty status related to the head of the household and that potential important differences between the two sexes within households are not captured. Figure 1 shows the contributions to MPI by each of the main sub-groups. Male-headed households contribute 73% to the MPI compared to 27% for female-headed households. The contribution by female-headed households has increased between the two surveys. The MPI is almost exclusively, 95%, determined by multidimensional poverty in rural households, confirming that poverty, beyond its monetary dimension, is very much a critical rural development issue. The Western region has the highest contribution to the MPI, 29%, compared to 16% in the Central region. The contribution to MPI has decreased in the Central and Eastern regions between the two surveys and increased in the Western and especially Northern regions.

The second type of disaggregated results presented here is the dimensional contribution to the MPI using Equation (4). Figure 2 shows that the standard of living dimension makes the largest overall contribution to MPI, almost 50%, in 2005/2006, and that the education dimension contributes the least, less that 20%. The reason that the standard of living group of indicators dominate is not because there are six of them, as they still only weigh a combined one third of the total MPI. The reason is rather that the degree of deprivation in these indicators is so high, e.g. 92% of households are deprived of modern electricity. The higher contribution to multidimensional poverty of the standard of living dimension is also a typical result from elsewhere. Among the 104 countries for which the MPI was computed in Alkire and Santos (2010) standard of living was the biggest contributor to multidimensional poverty in 55 countries, compared to 25 countries for health deprivation and 22 countries for deprivation in education.

In Uganda the contribution of standard of living to MPI seems to be increasing between the two surveys, a pattern which is found in both urban and rural areas. This is a reflection of the slight deterioration across most of the standard of living indicators mentioned above. Within each dimension it is also clear that the dimension indicators contribute differently to the overall MPI score. Child mortality and cooking without electricity, in particular, contribute more than their equally weighted share. The BMI indicator of nutrition contributes disproportionately less.

Given the dominance of the standard of living variables in the MPI it is interesting to further restrict the MPI criteria such that the deprivation condition applies across the three domains. In other words, in order for a person to be considered poor, not only must that person be poor in three indicator dimensions, but these three have to be in each of the domains as well. As noted above, we refer to this new condition as $\hat{k} = 3$. Results for this computation of the MPI are presented in Table 4. The results are quite striking, especially when compared to those of *k = 3* in

Table **3**. The headcount value is 18% in 2005/2006 for the $\hat{k}$ measure that is restricted by the domain instead of 73% when *k* applied only to indicator dimensions. Similar large differences exist for the MPI and the disaggregated values. The ordering and general directions since the 2000/2001 survey remain unchanged, but the levels are significantly lower. The main cause of the lower levels of poverty is that the poverty levels are now less affected by the large degree of deprivation in several of the standard of living indicators, as only one deprivation within the domain counts towards the poverty status. Obviously, with three domains it is possible to conduct this analysis for all $\hat{k} \geq 3$.

Conditioning the poverty measure could be one way of avoiding the measure being overly sensitive to deprivations in standard of living. Choosing other and fewer indicators is another way that should be pursued at the country level as part of the next steps of customisation of the multidimensional poverty measure.[9]

3.4 Multidimensional poverty when k varies

The choice of *k*, or the number of indicator dimensions in which a person should be deprived in order to qualify as poor, is set at 3 in Alkire and Santos (2010). This choice is largely based on a normative assessment of what is a plausible range given that $k \geq 4$ is irrelevant for developed countries. Nevertheless, this parameter can be customized to country contexts and as shown below, irrespective of the value of *k*, it is important that sensitivity analysis is conducted to check that conclusions about rankings (e.g. between regions) and changes (e.g. between two surveys) is robust to the choice of value for *k*.

In

Table 5 we present the results for the MPI and its two sub-components for the two surveys at various levels of *k*. At $k = 1$ the poverty indices follow the union approach and as *k* increases the poverty values fall as expected. In 2005/2006 the value of H is 0.99 for $k = 1$, signifying that all but 1% of Ugandans are deprived in at least one of the poverty dimensions. At the other extreme, using the intersection approach, $k = 10$, yields a value for H of 0.2%, suggesting that a negligible share of the population is deprived in all the indicator dimensions. It is interesting to note that the big impact of changes in *k* on H occurs in the range 2–7. The implication is that the MPI value in Uganda is quite sensitive to the choice of *k* in that range.

In Figure 3 we disaggregate the contributions of the three broad MPI dimensions according to the value of *k*, which gives a clear indication that, irrespective of the number of cutoffs, the standard of living dimension contributes the largest share to poverty and the education dimension the least. It is only from $k \geq 7$ that there are relatively comparable contributions from each of the three dimensions. It is interesting to note that within the standard of living dimension, the contribution of each of the indicator dimensions changes in importance. At lower levels of *k*, it is the energy for cooking and toilet facility indicators that contribute most to the MPI.

3.5 MPI and household size

[9] Several Ugandan stakeholders consulted in the preparation of this study have voiced their concern regarding the inclusion of the cooking fuel indicator. A more country-specific approach to developing the MPI could take this and other concerns into account. The type and number of indicators is relatively easily incorporated within the framework presented here.

Uganda has one of the highest population growth rates in the world, and while the rate of fertility has declined in recent years, the decline has been much slower than for other countries in the region.[10] The high population growth has been found to have significantly constrained economic growth, as well as contributed to the limited progress in areas such as education, health, and inequality reduction (Klasen 2004). We also find a positive correlation between multidimensional poverty and household size. For instance, the headcount for households with just one individual was 63% in 2005/2006 but 76% in households with nine members. A similar increase is observed in the previous survey.

What is unclear, however, is the extent to which these differences across household size represent real differences in the level of welfare or are a result of the way the MPI is constructed. Multidimensional poverty status is assigned to individuals based on the experience of the household as a whole, which in turn depends on the experience of just one member. Therefore the more household members, the more likely that someone in the household will have experienced that deprivation. For instance, the larger the household, the greater is the probability that it has one an adult or a child who is malnourished or that someone in the household has lost a child in the previous five years. By using a unitary model of the household all members will be classified as poor as a result. Another example is the indicator of years of schooling. With more members of the household, the higher is the likelihood that at least one member has completed five years of schooling. Conversely, indicators that are related to the physical features of the household tend to be less directly affected by a change in the number of household members.

These points are illustrated in Figure 4, which shows that the child mortality indicator contributes only 4% to the MPI in households of just one individual but 26% in households with 12 members. For one-person households, the years of schooling indicator contributes 28% to the MPI compared to just 2% among households that are made up of 12 persons. For the variable on access to electricity, the changes are less dramatic as household size on its own induces less variation.[11] As we shall explore further below, when comparing MPI values from different distributions, it is important to account for the impact of differences in household size.

3.6 International comparison of Uganda's MPI

We can compare the results for Uganda with the results for the other countries presented in Alkire and Santos (2010) and reported in the *Human Development Report 2010* (UNDP 2010).[12] Figure 5

[10] According to the UN Population Division online database: http://esa.un.org/unpd/wpp/ (accessed July 2011), Uganda's population almost doubled after 1990, reaching 33 million in 2010. Using medium variant assumptions, the country's total fertility rate for the period 2005–2010 was estimated at 6.38, the sixth highest in the world.

[11] Since the deprivation in each dimension does not follow the same trajectory depending on the household size, it is also likely that the weights assigned to these dimensions impact the household poverty. Thus, an increase in, for example, the weight of the health dimension will change the deprivation contributions and increase the MPI of large household. It would be a sound idea, when making poverty comparisons, to take into account the differences in size. Another advantage of doing this is the fact that the comparisons performed in this way will be robust to the changes in dimensional weights.

[12] These multi-country studies did not include MPI for Uganda but subsequent revisions do.

presents the values of H and A for all the countries, including Uganda. There is generally a linear relationship between the two but also with some outliers. For instance, Suriname and Myanmar appear to have higher levels of intensity of multidimensional poverty than what would be expected based on the headcount. For Uganda there is some difference in the country's performance according to the two measures. Using the 2005/2006 data, the country ranked 71 out of the 105 countries when using the intensity measure and 97th when using the poverty headcount. This suggests that while Uganda has a large proportion of people who are deprived in three dimensions, these tend not to be deprived in more dimensions. On the figure we have highlighted the over-representation of countries from sub-Saharan Africa among the countries scoring the highest on both the headcount and intensity values of the MPI. The 2005/2006 MPI value for Uganda gives it a rank of 92 among the 105 countries (ranked from lowest to highest value) just after Madagascar, Comoros and Benin, and just before Rwanda, Angola and Mozambique. However, such a ranking is problematic since the MPI indicators for the other countries are produced from data that ranges from 2000–2007, depending on availability in each country. For 50 countries the MPI estimate is based on data for either 2005 or 2006 making, and among these Uganda is ranked 40th.

4. Robustness tests

In this section we complement the empirical analysis by presenting a combination of robustness tests for our results. Specifically we test for sensitivity to choice of indicator, statistical significance of our results and stochastic dominance. Implicit in these tests is to check for robustness to variations in *k*. Moreover, in testing for stochastic dominance we extend the one-dimensional analysis to also take into account household size in the second dimension. This way, we are able to test the robustness of the MPI results taking into account that different samples can have different distributions in terms of household size. As discussed above this matters because of the unitary definition of the household and the indicators used in the MPI.

4.1 Robustness to choice of indicator

Our first check is on whether changes in the choice of indicators and in dimensional weights could induce significant changes in individuals' deprivation. Concerning the choice of indicators, two alternative nutritional variables are considered: the weight-for-height and the height-for-age z-scores in place of the actual weight-for-age z-score. As the same weight is actually assigned to the three dimensions (health, education and standard of living), three scenarios are considered where each dimension is more valued than others. The distribution of the dimensional weight into the nested dimensions (indicators) remains equal. Moreover, other measures are considered such as the wealth index, provided by the DHS surveys, and an index of deprivation in each of the three dimensions. A positive correlation is expected between the actual deprivation count and the other specifications, where a significant coefficient means that the poverty measure is robust to the changes. The robustness results are provided as Spearman tables (Table 6) of rank correlation for both DHS 2000/2001 and DHS 2005/2006.

4.2 Testing for stochastic dominance

For the stochastic dominance analysis, spatial dominance is considered first. It involves testing whether, at each survey, there is a robust ranking of poverty between areas (rural and urban) and between regions. A given region is said to dominate another in multidimensional poverty if its poverty value is always lower whatever the value of *k*. The inter-temporal dominance is the second dominance analysis to be considered. It compares multidimensional poverty between 2000/2001 and 2005/2006 at national, regional and rural/urban levels. Statistical significance is computed using the methodology outlined in Annex 1.

Table **7** shows that for one-dimensional dominance of H, only three relations prove to be significant. These are the dominance of rural by urban and the dominance of the Northern region by Central and Western regions. For MPI, two additional dominance relations are obtained: the dominance of the Northern and Western regions by the Eastern region. However, in two-dimensional dominance analysis, that is when household size is considered, none of these relations is proved to be significant. Table 8 reports the inter-temporal dominance results. At one-dimensional analysis level, only three dominance relations are significant in terms of H: the 2005/2006 sample dominates the 2000/2001 sample at national level, rural areas dominate urban and the Central region dominates other regions. Concerning MPI, except for urban areas where no dominance is observed, significant dominance relationships are found for all other pairs -- meaning that, on the whole, multidimensional poverty has decreased between the two periods. However, as was true in the case of spatial dominance, the two-dimensional dominance analysis reduces the number of pairs with significant dominance relations. For H, only the dominance between Central regions is maintained. When one considers MPI, an additional dominance is obtained: the Northern region in 2005/2006 dominates the one in 2000/2001.

These results suggest that the rankings of poverty obtained in the one-dimensional case are to a large extent explained by the household size distributions within the various groups we compare. That is why most of these dominances vanish when the analysis is extended to the two-dimensional case where household size is the second dimension. To make more acute poverty comparisons, it is appropriate to take account of the household size.

An important additional issue should be considered in terms of inter-temporal comparison. This relates to differences in sampling between the two surveys conducted in 2005/2006 and 2000/2001. As noted earlier, in the latter survey not all districts were covered due to insecurity as a result of the long-running civil war that made especially northern parts of Uganda no-go areas for survey enumerators in 2000/2001. A more correct comparison between the two surveys is thus one that only includes the same districts in 2005/2006 as were covered in 2000/2001. Table 9 compares the values of MPI and H for two samples in 2005/2006. The full sample includes all districts and the limited sample includes only those that were also covered in 2000/2001 and thus excludes Bundibugyo, Gulu, Kasese, Kitgum and Pader. The differences are small: between 0.7 and 1.7 % points for H and 2–4 in the ranges of *k*. However, these slightly higher levels of multidimensional poverty are enough to turn the two pairs in the two-dimensional dominance test for MPI significant: those comparing 2000/2001 and 2005/2006 national and rural (

Table **10**). There is no change in the significance of the pairs of H.

On this basis we can thus conclude that multidimensional poverty index for Uganda has improved between the two surveys. This conclusion is robust to the changes in sampling methodology between the two surveys and takes into account the effects from different household sizes in the distributions and the effect this has on the computation of the MPI.

5. Comparing multidimensional and monetary poverty

As noted above the conventional method for measuring poverty in Uganda is the monetary approach whereby household consumption is assessed against a cost of basic needs poverty line (of 21,135 in 1997 Uganda Shilling). This poverty line includes a food and a non-food component, and takes into account regional price differences. Households where the consumption per adult equivalent is less than the poverty line are considered poor and households where consumption exceeds the poverty threshold are considered non-poor. An important question arises as to whether the multi- and one-dimensional monetary poverty measures identify the same households as poor or not. This is of particular interest and policy relevance, since poverty measures are often used to target transfers and services to those considered to be most needy. We are able to explore that question much more robustly than previous studies by drawing on a unique sub-sample of households that featured in both the Demographic Health Survey (DHS), on which the MPI is based, and the Uganda National Household Survey (UNHS), which was carried out at the same time. Unlike the DHS, the UNHS has a comprehensive section that deals with household consumption, and this is the survey instrument that is traditionally used for measuring monetary poverty. This analysis has relevance in a larger context as it represents a significant improvement to the comparisons of MPI and monetary poverty included in Alkire and Santos (2010), which relied on the consumption modules in the World Health Surveys for a limited number of countries (Chad, China and Sri Lanka). The main challenge using these surveys is they use a much shorter questionnaire for household expenditure items. As a consequence, the World Health Surveys have been found not to provide accurate estimates of average household expenditure when compared to much more comprehensive household income and expenditure surveys such as the UNHS (Xu et al. 2009).

Based on the sub-sample of households for which we have measures of poverty, in both monetary and multidimensional forms, it is possible to create four sub-groups to study the extent to which they overlap or are different in their identification of the poor. In Table 11 these sub-groups are categorised for: (1) monetary poor only; (2) MPI poor only; (3) both; and (4) neither. Along the rows, the percentages of these sum to 100. Column percentages are in brackets and shares of disaggregated variables are included in the hard brackets in the first column to enable comparison.

All in all the MPI measure seems to overlap well with the monetary measure: less than 5% of households are only monetary poor. A much larger share of the population, 44%, are only MPI poor, which is a reflection that the MPI at k=3 is a much bigger group (67%) compared to the group of

monetary poor (28%). This is even the case for MPI at k=4 (47%).[13] This result implies that by using the monetary poverty measure only for targeting, a large number of people who are poor in a multidimensional sense are bypassed. On the other hand, if the multidimensional measure were used for targeting, most of the monetary poor would be covered. The results also confirm that between nearly one in five (18%) and one in four (23%) are deprived according to both measures when using k=4 and k=3, respectively. These groups suffer from a particularly severe degree of deprivation that cuts across physical assets, health, education and household expenditure.

As k increases from 3 to 4, the overlaps and differences change. Notably, the share of those who are 'MPI poor only' falls, as a result of some increased mis-targeting (the share of 'monetary poor only' increases) but mostly because fewer households fall into either of the two poverty categories (the share in the category 'neither' increases).

There are some notable differences according to key household characteristics. First, the category of 'both' is relatively higher for female-headed households than for male-headed households. In the former, 26% are considered deprived according to both poverty measures, which is higher than their 22% share of all household heads. These figures refer to the head of the household and thus mask other potentially important intra-household differences between the two sexes. The large differences between urban and rural areas are primarily a result of the much higher rate of both MPI and monetary poverty in rural areas. While the urban areas held about 18% of the total population at the time of the survey, less than 4% of those deprived in both poverty measures lived in urban areas. Almost 90% of the MPI poor only *and* the monetary poor only live in rural areas, which suggests that applying a combination of the two measures would greatly improve targeting. There are also large differences across the different administrative regions of the country. The Western region appears to have a disproportionately large number of people who are monetary poor but not multidimensionally poor, which could be an indication of some achievements in asset accumulation and access to public services even among the most deprived. In this region, the monetary poverty measure will thus work better as a targeting mechanism than in the Northern region where a disproportionately high share of those who are MPI poor only live.

Our final comparison between the two poverty measures displayed in Figure 6 shows the share of MPI poor in each decile using household expenditure and ranks households from poorest (decile 1) to richest (decile 10). The falling slope of the bars confirms that MPI poverty is higher at lower levels of household expenditure for MPI with both three and four deprivations. For k=3 between 86 and 89% are MPI poor in the two lowest deciles. In the third decile there is a drop to 71%, which is actually lower than for the next three deciles up to decile 6. After that the shares drop to 23% for decile 10. This confirms once again that large shares of households that are considered non-poor using the monetary measure, basically in the decile 3 and above (given that 28% of the population are monetary poor using the sub-sample of households), are MPI poor. The pattern on Figure 6 also seems to suggest that it would probably make sense to distinguish between two categories of poor. Those in the first category of deciles 1 and 2 suffer from severe deprivations according to both

[13] These figures for MPI poverty and monetary poverty differ slightly from elsewhere in the text as the ones reported here are from a sub-sample of both the two household surveys.

measures. Those in the second category, from decile 3 to 6, are less deprived in monetary terms but the vast majority are still MPI poor even when using the stricter k=4 criteria. This could also be taken as further evidence that the current monetary poverty line is set too low, and that by raising it, the monetary poverty measure would correspond better to the wider range of deprivations that the Ugandan population experience.

5. Conclusions

In this paper we have sought to broaden the discussion on Uganda's very successful poverty reduction experience by going beyond the conventional measures of monetary poverty. By following the approach to multidimensional poverty analysis proposed by Alkire and Foster (2007), we were able to compare our MPI results for Uganda to the 104 other countries as computed by Alkire and Santos (2010) and included in the global Human Development Reports of UNDP. We found that in 2005/2006 the poverty headcount for Uganda was 0.727, indicating that around 73% of the population were deprived in at least three of the indicator dimensions included in the MPI. This figure stands in stark contrast to the 31% who were found to be monetary poor in the 2005/2006 UNHS.

Once the multidimensional measure is adjusted for intensity, or the number of deprivations suffered, the MPI is computed as 0.369. This is somewhat lower than the MPI value for 2000/2001, which was 0.41. The lowering of the MPI in 2005/2006 is a result of both a reduction in the headcount and the intensity of poverty and conforms with the decline in the monetary measure seen over the period. In our extended application of the MPI we imposed a further restriction on its computation and only considered deprivations that occur simultaneously across the three broad domains, thus eliminating the effects from multiple deprivations within domains. This reduces the level of MPI poverty significantly, a reduction which is mainly a result of the high degree of deprivation across the six dimensions in the standard of living domain, which dominate the MPI.

Indeed in the standard application, the main contribution to multidimensional poverty comes from deprivation in the standard of living domain variables, especially in the use of energy for cooking and toilet facility, whereas the contribution from the health and education domain variables is much lower. This is a probably a reflection of the greater availability of health and education-related public services in Uganda, which have been expanded in recent years (e.g. with the introduction of Universal Primary Education in the late 1990s). The contribution to multidimensional poverty among the poor from deprivation in standard of living variables has increased between the two surveys. This is somewhat surprising given improvements in household monetary welfare but suggests a greater role for the public in targeting key services such as safe water and sanitation towards the poorest as an important way of reducing multidimensional poverty. The general deterioration in the deprivation indicators for urban areas is probably a reflection of the growing rate of urbanisation in Uganda. As urbanisation continues and the very high share of the population that lives in rural areas falls correspondingly, special efforts will be needed to avoid a rise in multidimensional poverty in urban areas.

The MPI value for 2005/2006 for Uganda gives it a rank of 92 among the 105 countries (ranked from lowest to highest value), or the 88th percentile, for which the MPI is available (drawing on Alkire and Santos 2010). This is just after Madagascar, Comoros and Benin, and just before Rwanda, Angola and Mozambique. This would tend to confirm Uganda's position among the poorest and least developed countries in the world, using the multidimensional definition of poverty and data collected at household level. We did note one important caveat with regards to the international comparison in that the MPI indicators for the other countries were constructed using from surveys conducted in years between 2000 and 2007 depending on availability in each country. For those 50 countries, where the MPI estimate is based on data for either 2005 or 2006, Uganda was ranked 40th or in the 80th percentile.

We also discussed another important set of caveats for the analysis. Since the MPI is constructed using a unitary definition of the household, the number of household members will affect the degree of deprivation. This is so because the greater the household size the more likely it is that one member will have experienced deprivation in the indicators that are drawn from the individual-specific sections of the surveys and hence the more likely it is that all the members of that household will be classified as multidimensionally poor. To overcome this potential bias we conducted a two-dimensional dominance analysis that combined the tests for robustness of our results, first in the spatial and inter-temporal dimensions and second according to household size. The results showed that the rankings of poverty obtained in the one-dimensional case are to a large extent explained by the household-size distributions within the various groups under comparison. That is why most of these dominances vanish when the analysis is extended to the two-dimensional case. To make more acute poverty comparisons, it is appropriate to take account of the household size.

We went on to extend the inter-temporal analysis to correct for a change in sample between the two surveys as a result of the lack of access to some districts in 2000/2001 due to insecurity in the northern parts of the country. On this basis we concluded that multidimensional poverty index for Uganda has improved between the two surveys. By combining the MPI data with that from the consumption-based survey, we furthermore showed that targeting of households for public services and other benefits using the monetary measure would tend to exclude a large group of people who are considered poor when using the multidimensional poverty measure. We also noted that the monetary poverty measure might be particularly ill-suited for targeting of the poor in the Northern region of the country.

A process of designing a more country-specific multidimensional poverty measure for Uganda would need to revisit the choice of indicators, which in turn could rebalance the contribution from the various dimensions. This work would also include a re-consideration of the weights applied to the different dimensions, which in this study were kept equal, primarily in the absence of information that could guide the setting of weights and in order to facilitate the international comparison. A more ambitious agenda would also seek to depart from the unitary household model and develop multidimensional poverty measures that are based more directly on the deprivations experienced by individuals. This would enable a more direct comparison between different distributions and begin to address critical issues of intra-household allocation of welfare from a multidimensional perspective, which are not considered in the current approaches.

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Annex A: Statistical inference

Suppose that P_α^* is the true value of the poverty in the society. It could be expressed as follows:

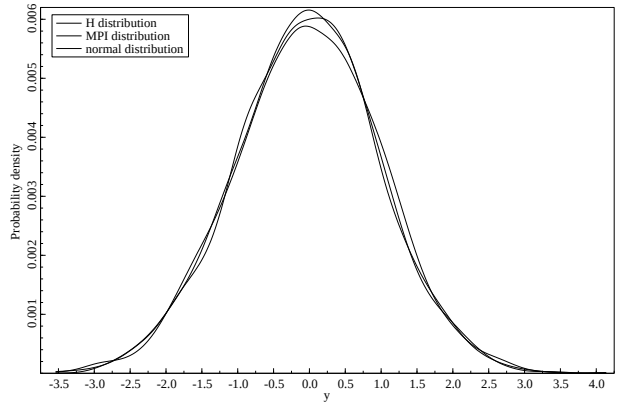
$$P_\alpha^* = \int_k^d y^\alpha f(y)\,dy$$

where $f(y)$ is the probability density function of a continuous random variable, *y*, denoting the deprivation suffered by an individual. Given that the population of *n* individuals is randomly drawn from a society, we could suppose that the deprivation count *c*, derived from the multivariate distribution of achievements *x*, is a random variable. When $y = c$, it is straightforward that a consistent estimation of P_α^* is given by $P_\alpha(x,z,k)$. If we assume that the observations $c_i\,(i = 1,...,n)$ are independently distributed, as suggested that Kakwani (1993), applying the central limit theorem results in the expression $\sqrt{n}\left(P_\alpha(x,z,k) - P_\alpha^*\right)$ being asymptotically normally distributed with zero mean and variance $\hat{Var}(P_\alpha^*)$. With unequal probability random sampling, a consistent sample estimate of $\hat{Var}(P_\alpha^*)$ is the one proposed by Deaton (1997):

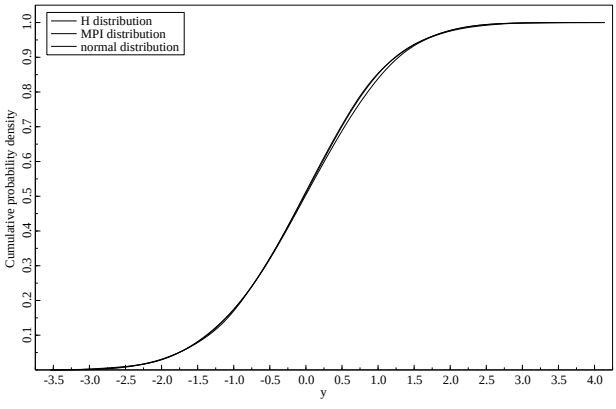
$$\hat{Var}(P_\alpha(x,z,k)) = \frac{n}{n-1}\sum_{i=1}^{n}\left(\frac{w_i}{\sum_{i=1}^{n} w_i}\right)^2 \left[\bar{c}_i^{\,\alpha}\rho_k(x_i,z) - P_\alpha(x,z,k)\right]^2 \qquad \text{(A1)}$$

Figure A1: Kernel density and cumulative density functions

A. Kernel density function



B. Cumulative density function



To check whether the poverty measure could be accurately modelled by a normal distribution, a density function and a cumulative density function (cdf) are plotted for *H* and *MPI* when $k = 4$. First, the poverty measure is estimated from the initial sample. Assuming that the estimated value $\hat{P}$ is the true one, the approach is to generate the distribution for $\tilde{P} - \hat{P}$, where $\tilde{P}$ is the poverty

measure estimated from a bootstrap sample. The distribution of $\tilde{P} - \hat{P}$ is expected to follow a normal distribution with mean 0 and variance $Var(\tilde{P})$ calculated using the equation (A1) above. Then the random variable $\frac{\tilde{P} - \hat{P}}{Var(\tilde{P})}$ is expected to have a standard normal distribution $N(0,1)$. A total of 2000 bootstrap samples are drawn from the initial distribution of c_i. The results are reported in the Figure A1.

Annex B: Stochastic dominance

Let *F* and *G* be the cumulative density functions of two distributions we would like to compare and n^F and n^G their respective sample sizes. Multidimensional poverty[14] is said to be greater for *F* than in *G*, for a given *k*, if $P_\alpha^F\left(x^F,z,k\right) > P_\alpha^G\left(x^G,z,k\right)$. Then, *G* dominates *F* in poverty if the previous condition holds for all *k*. The dominance relation can be tested by setting the null hypothesis of non-dominance against the alternative of dominance. This formulation allows, according to Davidson and Duclos (2006), testing for unambiguous dominance. The hypotheses are as follows:

H_0: $P_\alpha^F\left(x^F,z,k\right) - P_\alpha^G\left(x^G,z,k\right) \leq 0$ for some k;

H_1: $P_\alpha^F\left(x^F,z,k\right) - P_\alpha^G\left(x^G,z,k\right) > 0$ for all k

The expression $P_\alpha^F\left(x^F,z,k\right) - P_\alpha^G\left(x^G,z,k\right)$ is assumed to follow a normal distribution with zero mean and a variance obtained by summing the estimated variances of $P_\alpha^F\left(x^F,z,k\right)$ and $P_\alpha^G\left(x^G,z,k\right)$ using Equation A1.

However, the poverty profile according to household size suggests that c_i and therefore the poverty level are significantly dependent on the household size. Then, the fact that a distribution *G* dominates another distribution *F* based on the test of H_1 could simply be due to a difference in the distributions of household size. Several studies provide conditions for comparing welfare and poverty that take into account the differences in household size and composition (Bourguignon 1989; Atkinson 1992; Jenkins and Lambert 1993; Chambaz and Maurin 1998; Duclos and Makdissi 2005). Applications are done by Duclos, Sahn and Younger (2007) and Batana and Duclos (2010b).

Let h, with $h = 1,...,H$ be the household size. From Batana and Duclos (2010b), it follows from the MPI analysis by household size that thegreater the size of a household, the greater its needs are. Let define $P_\alpha\left(x,z,k,\bar{h}\right)$ as follows:

$$P_\alpha\left(x,z,k,\bar{h}\right) = \sum_{h=\bar{h}}^{H} \phi_h P_{\alpha,h}\left(x_h,z_h,k\right) \qquad \text{(B1)}$$

where ϕ_h is the proportion of individuals living in households with size equal *h* and $P_{\alpha,h}\left(x_h,z_h,k\right)$, their respective poverty measure. The deprivation cutoff z_h for each group *h* simply reflects the fact that, depending on the dimension, this cutoff could be decisive or not for identifying deprived households. For example, when considering only one-person households, it is not possible to identify some of them as deprived in terms of child enrolment or child mortality. The poverty comparisons

[14] The dominance analysis here comes down to a simple one-dimensional dominance since all dimensions are aggregated in a vector *c* of deprivation counts.

are then more accurate if the size of the household is taken into account. This leads to the sequential or multidimensional poverty dominance analysis.

Now, *G* is said to dominate *F* in poverty if $P_\alpha^F\left(x^F, z, k, \bar{h}\right) > P_\alpha^G\left(x^G, z, k, \bar{h}\right)$ for all *k* and all $\bar{h}$. The multidimensional poverty dominance is tested from H_1 by replacing $P_\alpha^F\left(x^F, z, k, \bar{h}\right)$ and $P_\alpha^G\left(x^G, z, k, \bar{h}\right)$ by their expression in Equation B1. This time, H_0 is not rejected if its condition holds for some pairs (*k* , $\bar{h}$). The variance is computed using Equation A1.

Table 1 : Selection of dimensions, indicators, deprivation cutoffs and weights

Domain	Dimension, *j*	Deprived if:	Weights*
1. Education			1/3
	Years of schooling	No household member has completed five years of schooling	(1/6)
	School enrolment	Any school-aged child is not attending school in years 1 to 8	(1/6)
2. Health			1/3
	Child mortality	Any child has died in the household in the last five years	(1/6)
	Nutrition	Any adult or child is malnourished	(1/6)
3. Standard of living			1/3
	Electricity	Household has no electricity	(1/18)
	Sanitation	Household's sanitation facility is not improved or is shared	(1/18)
	Water	Household does not have access to drinking water or when the time to access water exceed 30 minutes	(1/18)
	Floor	Household has dirt, sand or dung floor	(1/18)
	Cooking	Household cooks with dung, wood or charcoal	(1/18)
	Assets	Household does not own a car and more than one radio, TV, telephone, bike or motorbike	(1/18)

Note: Nested weights in brackets.

Table 2: MPI indicators of deprivation for Uganda 2000/2001 and 2005/2006

	National		Rural		Urban		Central		Eastern		Northern		Western	
	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006	2000/ 2001	2005/ 2006
Radio	43.8	37.0	47.6	39.1	18.4	22.5	27.3	22.4	50.2	24.2	65.9	17.8	43.3	32.6
Telephone	96.9	99.4	99.1	99.8	81.5	96.3	91.6	99.1	99.4	99.4	99.4	92.8	99.0	99.6
Television	93.0	93.8	97.1	97.1	65.3	71.1	81.9	86.0	96.8	92.7	99.3	53.1	98.4	95.2
Refrigerator	97.4	96.7	99.6	98.6	82.8	83.4	93.0	91.9	99.3	97.7	99.6	69.3	99.2	99.2
Bicycle	54.4	56.0	51.3	53.3	75.5	73.8	55.7	56.0	48.6	43.4	48.6	88.0	62.9	34.6
Motorbike	96.9	96.8	97.4	97.1	93.3	94.8	93.9	94.1	98.7	91.9	99.2	96.0	97.1	97.5
Car	97.7	97.9	98.8	99.0	89.6	90.4	94.6	95.8	98.9	97.3	99.5	85.8	98.8	99.1
Assets	62.9	60.8	65.4	62.1	46.1	51.9	50.1	50.4	67.1	46.4	72.1	47.7	68.1	48.0
Electricity	91.6	92.4	97.4	97.3	52.3	59.3	79.8	84.8	95.7	92.5	97.9	39.3	97.5	97.0
Toilet	97.4	89.3	98.8	90.9	87.9	78.7	94.8	76.9	98.8	73.2	98.3	74.1	98.4	84.5
Water	66.2	74.1	72.8	79.5	21.9	37.7	60.3	78.1	64.4	75.1	71.2	18.4	72.4	76.9
Floor	80.2	78.6	88.5	86.1	24.7	27.8	58.5	63.3	88.0	66.6	94.2	10.4	89.5	75.7
Cooking	97.7	99.6	99.0	99.9	88.8	97.4	95.6	99.1	98.9	99.8	98.0	95.2	98.9	99.8
Children enrolled in school	23.9	20.7	25.2	22.5	14.8	8.7	17.7	13.0	20.3	11.6	36.4	7.1	27.8	18.9
5 years of education	25.1	21.0	27.8	22.9	7.5	8.3	18.4	18.2	22.9	17.3	34.8	2.9	30.0	19.2
Child mortality	40.5	42.5	42.7	44.7	25.6	27.6	33.8	39.7	42.8	39.3	50.0	22.0	40.3	43.8
Nutrition (1)	22.8	8.6	24.6	9.2	10.7	4.6	15.7	5.4	26.5	5.3	32.6	3.7	21.1	12.5
Nutrition (2)	13.8	6.1	14.7	6.4	7.1	3.7	8.1	3.7	17.1	3.9	21.2	3.4	12.1	8.5
Nutrition (3)	38.1	13.2	40.4	14.0	21.7	7.8	28.5	11.0	41.2	9.0	45.3	6.5	41.4	14.6
BMI	10.0	9.9	10.7	10.6	5.3	4.6	5.6	4.7	12.5	6.1	17.1	3.4	7.9	12.7

Table 3: Multidimensional poverty measures, *k = 3*

	2000/2001			2005/2006		
	MPI	H	A	MPI	H	A
Uganda	0.410	0.761	0.539	0.369	0.727	0.508
Female	0.429	0.788	0.544	0.386	0.754	0.512
Male	0.405	0.752	0.539	0.363	0.718	0.506
Rural	0.445	0.818	0.544	0.398	0.779	0.511
Urban	0.163	0.355	0.459	0.167	0.369	0.453
Central	0.306	0.601	0.509	0.252	0.537	0.469
Eastern	0.426	0.807	0.528	0.371	0.746	0.497
Northern	0.526	0.900	0.584	0.453	0.848	0.534
Western	0.443	0.808	0.548	0.408	0.791	0.516

Table 4: MPI and Headcount (H) for $\hat{k} = 3$

	2000/2001		2005/2006	
	MPI	H	MPI	H
Uganda	0.166	0.233	0.121	0.176
Rural	0.182	0.254	0.133	0.193
Urban	0.051	0.083	0.037	0.060
Central	0.107	0.155	0.063	0.097
Eastern	0.146	0.208	0.110	0.163
Northern	0.269	0.366	0.172	0.242
Western	0.193	0.268	0.145	0.209

Table 5: Multidimensional poverty by number of deprivations, 2005/2006

Cutoff (k)	Uganda				Urban Area				Rural Area			
	H		MPI		H		MPI		H		MPI	
	Value	t-statistics	value	t-statistic	Value	t-stat	Value	t-stat	Value	t-stat	Value	t-stat
1	0.985*	1686.89	0.428*	463.03	0.996*	2456.22	0.451*	475.99	0.915*	254.99	0.275*	112.42
2	0.924*	667.34	0.420*	413.45	0.962*	855.20	0.446*	440.79	0.663*	97.19	0.240*	80.13
3	0.727*	308.62	0.369*	275.94	0.779*	329.62	0.398*	288.46	0.369*	50.86	0.167*	48.20
4	0.539*	204.40	0.303*	196.72	0.587*	210.27	0.331*	201.38	0.208*	33.26	0.109*	32.61
5	0.401*	154.96	0.242*	151.67	0.441*	157.19	0.266*	153.55	0.125*	24.36	0.072*	24.05
6	0.212*	98.51	0.146*	98.25	0.235*	98.57	0.162*	98.28	0.051*	14.78	0.034*	14.75
7	0.054*	47.05	0.044*	47.14	0.061*	46.67	0.049*	46.75	0.010*	6.89	0.008*	6.90
8	0.033*	37.05	0.028*	37.09	0.037*	36.68	0.031*	36.72	0.006*	5.56	0.006*	5.59
9	0.004*	12.53	0.003*	12.60	0.004*	12.29	0.004*	12.36	0.001*	2.45	0.001*	2.45
10	0.002*	9.84	0.002*	9.84	0.002*	9.53	0.002*	9.53	0.001*	2.45	0.001*	2.45

* = poverty value is significant at 1% level.

Table 6: Spearman rank correlation between various deprivation measures

2000/2001										
	depr	depr1	depr2	depr3	depr_n1	depr_n2	wealth	depr_ed	depr_he	depr_sl
depr	1.00	-	-	-	-	-	-	-	-	-
depr1	0.95*	1.00	-	-	-	-	-	-	-	-
depr2	0.99*	0.94*	1.000	-	-	-	-	-	-	-
depr3	0.99*	0.93*	0.97*	1.00	-	-	-	-	-	-
depr_n1	0.97*	0.93*	0.97*	0.95*	1.00	-	-	-	-	-
depr_n2	0.95*	0.91*	0.94*	0.93*	0.93*	1.00	-	-	-	-
wealth	-0.52*	-0.63*	-0.52*	-0.49*	-0.52*	-0.51*	1.00	-	-	-
depr_ed	0.68*	0.62*	0.76*	0.61*	0.70*	0.66*	-0.34*	1.00	-	-
depr_he	0.68*	0.55*	0.62*	0.77*	0.62*	0.63*	-0.15*	0.13*	1.00	-
depr_sl	0.65*	0.83*	0.62*	0.60*	0.65*	0.63*	-0.67*	0.32*	0.17*	1.00
2005/2006										
	depr	depr1	depr2	depr3	depr_n1	depr_n2	wealth	depr_ed	depr_he	depr_sl
Depr	1.00	-	-	-	-	-	-	-	-	-
depr1	0.95*	1.00	-	-	-	-	-	-	-	-
depr2	0.99*	0.93*	1.00	-	-	-	-	-	-	-
depr3	0.99*	0.92*	0.97*	1.00	-	-	-	-	-	-
depr_n1	0.99*	0.94*	0.98*	0.97*	1.00	-	-	-	-	-
depr_n2	0.98*	0.93*	0.97*	0.97*	0.97*	1.00	-	-	-	-
wealth	-0.58*	-0.68*	-0.57*	-0.53*	-0.58*	-0.57*	1.00	-	-	-
depr_ed	0.71*	0.64*	0.79*	0.63*	0.72*	0.70*	-0.40*	1.00	-	-
depr_he	0.63*	0.49*	0.56*	0.73*	0.60*	0.61*	-0.14*	0.09*	1.00	-
depr_sl	0.59*	0.80*	0.57*	0.54*	0.60*	0.58*	-0.69*	0.28*	0.10*	1.00

Notes: * = coefficient is significant at 5% level. Variables definition: depr = actual deprivation count; depr1 = deprivation count with standard of living more valued; depr2 = deprivation count with education more valued; depr3 = deprivation count with health more valued; depr_n1 = deprivation count with weight-for-height z-score as children nutritional indicator; depr_n2 = deprivation count with height-for-

age z-score as children nutritional indicator; wealth = wealth index provided by DHS survey; depr_ed = deprivation count for education; depr_he = deprivation count for health; depr_sl = deprivation count for standard of living.

Table 7: T-statistics for spatial dominance (*k = 3*). 2005/2006

Dominance relation	One-dimensional dominance		Two-dimensional dominance	
	H	MPI	H	MPI
Rural vs Urban	2.13*	2.13*	1.25	1.25
Eastern vs Central	-2.45	-2.45	-2.45	-2.45
Northern vs Central	8.28*	8.28*	-2.31	-1.02
Western vs Central	1.81	1.81	1.32	1.47
Northern vs Eastern	1.83	7.56*	-12.97	-12.68
Western vs Eastern	-0.67	2.62*	-7.53	-4.24
Northern vs Western	2.37*	4.61*	-9.80	-10.66

* = poverty value is significant at 5% level.

Table 8: T-statistics for inter-temporal dominance (*k = 3*)

Dominance relation	One-dimensional dominance		Two-dimensional dominance	
	H	MPI	H	MPI
National 2000 vs National 2005	4.68*	13.39*	-8.99	0.32
Rural 2000 vs Rural 2005	8.85*	13.41*	-9.63	0.62
Urban 2000 vs Urban 2005	-2.18	-1.78	-4.26	-3.47
Central 2000 vs Central 2005	4.98*	4.98*	2.57*	4.24*
Eastern 2000 vs Eastern 2005	-4.25	4.68*	-6.04	-0.64
Northern 2000 vs Northern 2005	-3.41	8.01*	-6.57	2.31*
Western 2000 vs Western 2005	-2.08	8.64*	-13.25	-11.16

* = poverty value is significant at 5% level.

Table 9: Poverty Headcount (H) and MPI in limited† and full sample (*k = 3*)

	Limited sample†		Full sample		Difference	
	H	MPI	H	MPI	H	MPI
k=2	0.924	0.42	0.917	0.413	0.007	0.007
k=3	0.727	0.369	0.710	0.360	0.017	0.009
k=4	0.539	0.303	0.523	0.294	0.016	0.009

† = limited sample excludes Bundibugyo, Gulu, Kasese, Kitgum and Pader from the 2005/2006 data as these districts were not covered in the 2000/2001 survey due to insecurity in these parts of the country.

Table 10: T-statistics for inter-temporal dominance limited† sample (*k = 3*)

Dominance relation	One-dimensional dominance		Two-dimensional dominance	
	H	MPI	H	MPI
National 2000 vs National 2005	6.19*	12.60*	-5.43	2.56*
Rural 2000 vs Rural 2005	9.15*	12.59*	-6.53	2.74*
Urban 2000 vs Urban 2005	-1.83	-1.83	-4.23	-3.54
Central 2000 vs Central 2005	4.98*	4.98*	2.57*	4.24*
Eastern 2000 vs Eastern 2005	-4.25	4.68*	-6.04	-0.64
Northern 2000 vs Northern 2005	-2.18	7.04*	-4.33	1.96*
Western 2000 vs Western 2005	-3.97	7.94*	-9.80	-7.44

* = poverty value is significant at 5% level. † = limited sample excludes Bundibugyo, Gulu, Kasese, Kitgum and Pader from the 2005/2006 data as these districts were not covered in the 2000/2001 survey due to insecurity in these parts of the country.

Table 11: Overlap and differences in MPI headcount (H) and monetary poverty† 2005/2006

	k=3				*k=4*			
	(1) Monetary Poor, only	(2) MPI Poor, only	(3) Both	(4) Neither	(1) Monetary Poor, only	(2) MPI Poor, only	(3) Both	(4) Neither
Uganda	4.5	44.1	23.2	28.2	9.7	29.5	18.0	42.8
Gender								
Female	3.3	44.5	27.3	24.8	9.3	26.5	21.4	42.9
[21.8]	(22.0)	(16.0)	(25.6)	(19.1)	(19.5)	(20.8)	(25.8)	(21.8)
Male	4.8	43.9	22.1	29.2	9.8	30.3	17.1	42.8
[78.2]	(78.0)	(84.0)	(74.4)	(80.9)	(80.5)	(79.2)	(74.2)	(78.2)
Zone								
Rural	4.9	48.2	27.2	19.7	11.0	33.8	21.1	34.0
[82.2]	(89.9)	(89.8)	(96.3)	(57.5)	(94.3)	(93.3)	(96.3)	(65.4)
Urban	2.6	25.1	4.8	67.5	3.7	9.4	3.7	83.2
[17.8]	(10.1)	(10.2)	(3.7)	(42.5)	(5.7)	(6.7)	(3.7)	(34.6)
Region								
Central	5.4	36.0	10.6	48.1	8.4	19.4	7.6	64.7
[36.0]	(29.4)	(42.7)	(16.5)	(61.4)	(23.6)	(31.1)	(15.2)	(54.5)
Eastern	3.8	42.4	33.3	20.4	11.9	30.5	25.2	32.4
[20.6]	(19.9)	(17.4)	(29.6)	(15.0)	(21.3)	(25.3)	(28.9)	(15.6)
Northern	8.1	32.6	47.5	11.8	15.7	25.7	39.8	18.7
[12.6]	(9.3)	(22.5)	(25.7)	(5.2)	(10.9)	(20.4)	(27.8)	(5.5)
Western	2.5	59.3	21.3	16.9	7.3	42.2	16.5	34.0
[30.8]	(41.4)	(17.3)	(28.2)	(18.4)	(44.1)	(23.2)	(28.2)	(24.4)

† = Defined using the monetary Poverty Line threshold of Uganda Shilling 21,135 (in 1997 prices).

Figure 1: Sub-group contributions to MPI, with *k* = 3

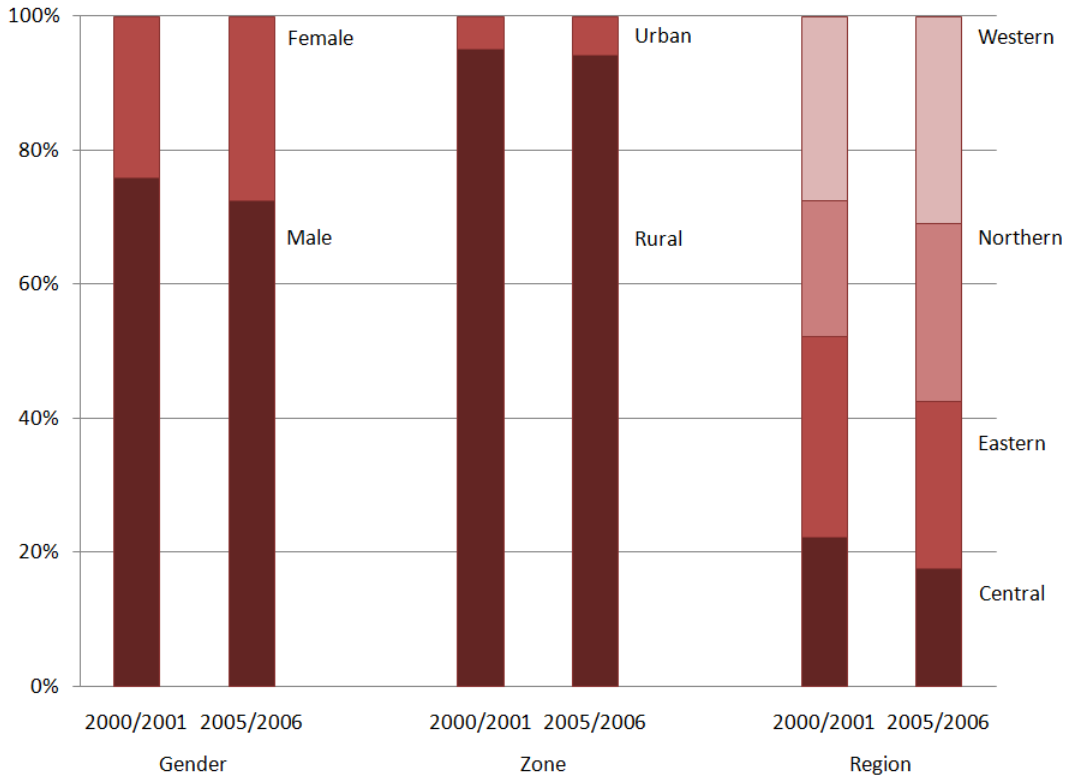


Figure 2: Dimensional contributions to MPI, with *k = 3*

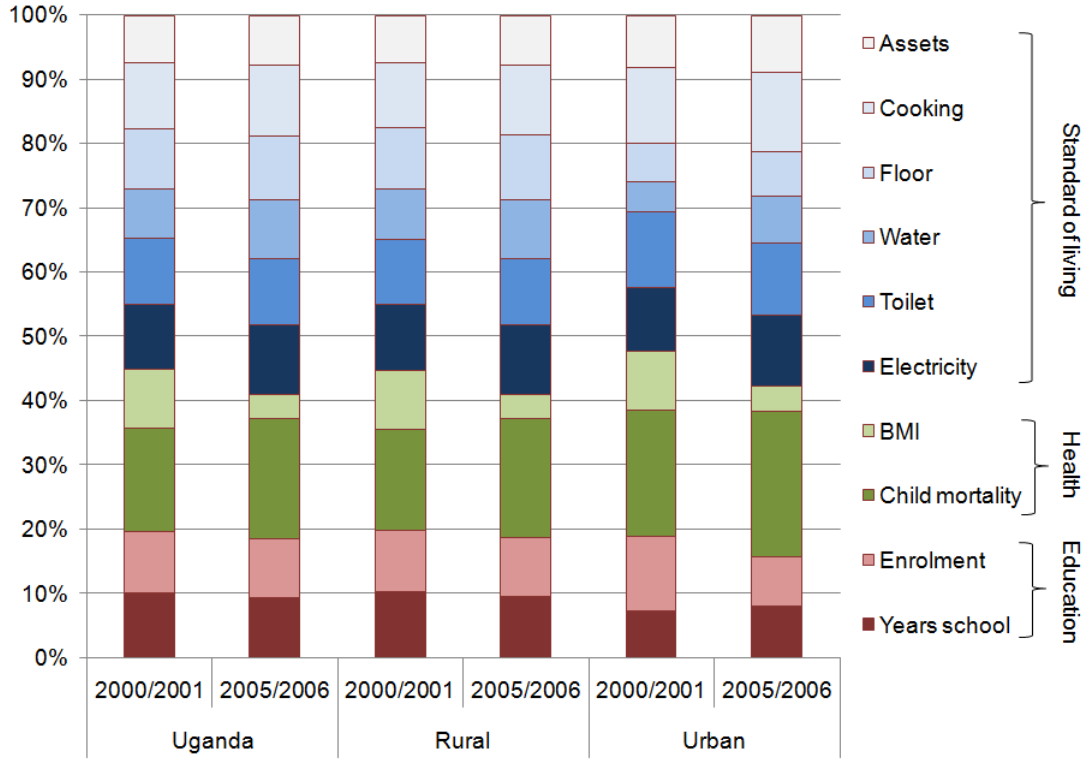


Figure 3: Contributions to MPI by dimension 2005/2006

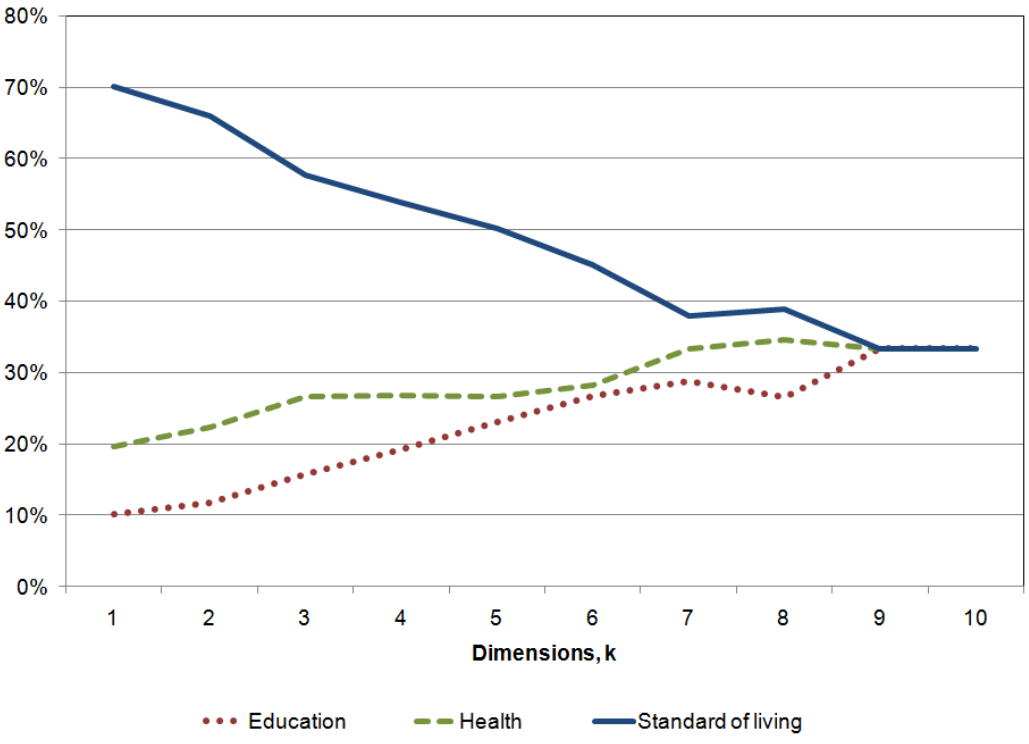


Figure 4: Contributions by indicator dimensions to MPI by household size (*k = 3*)

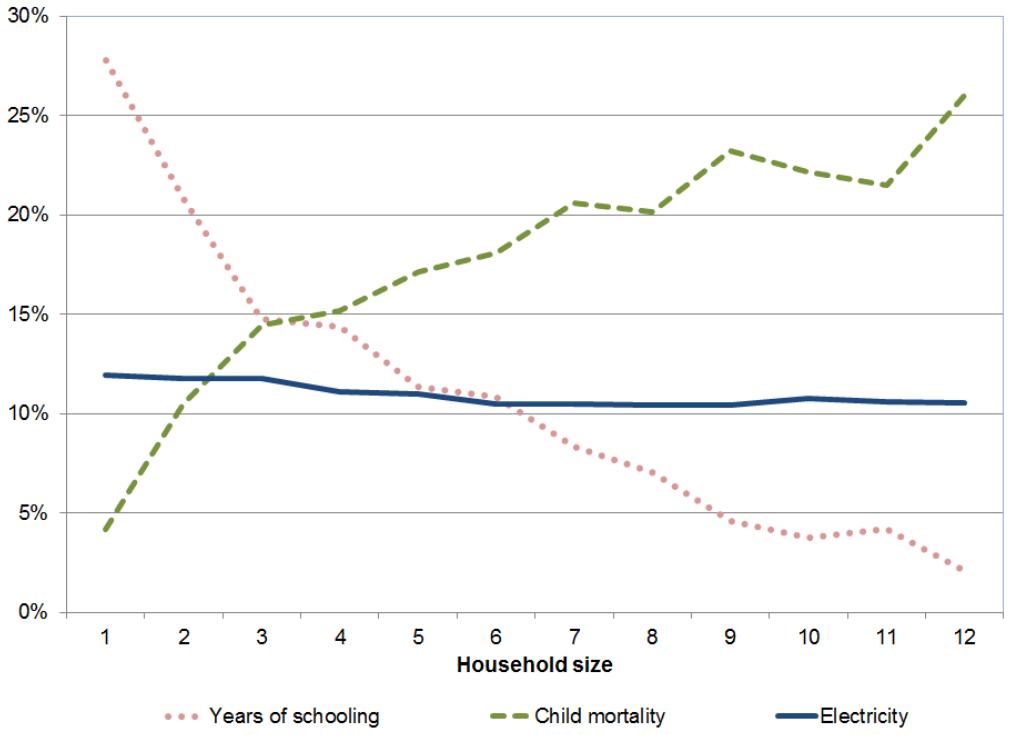
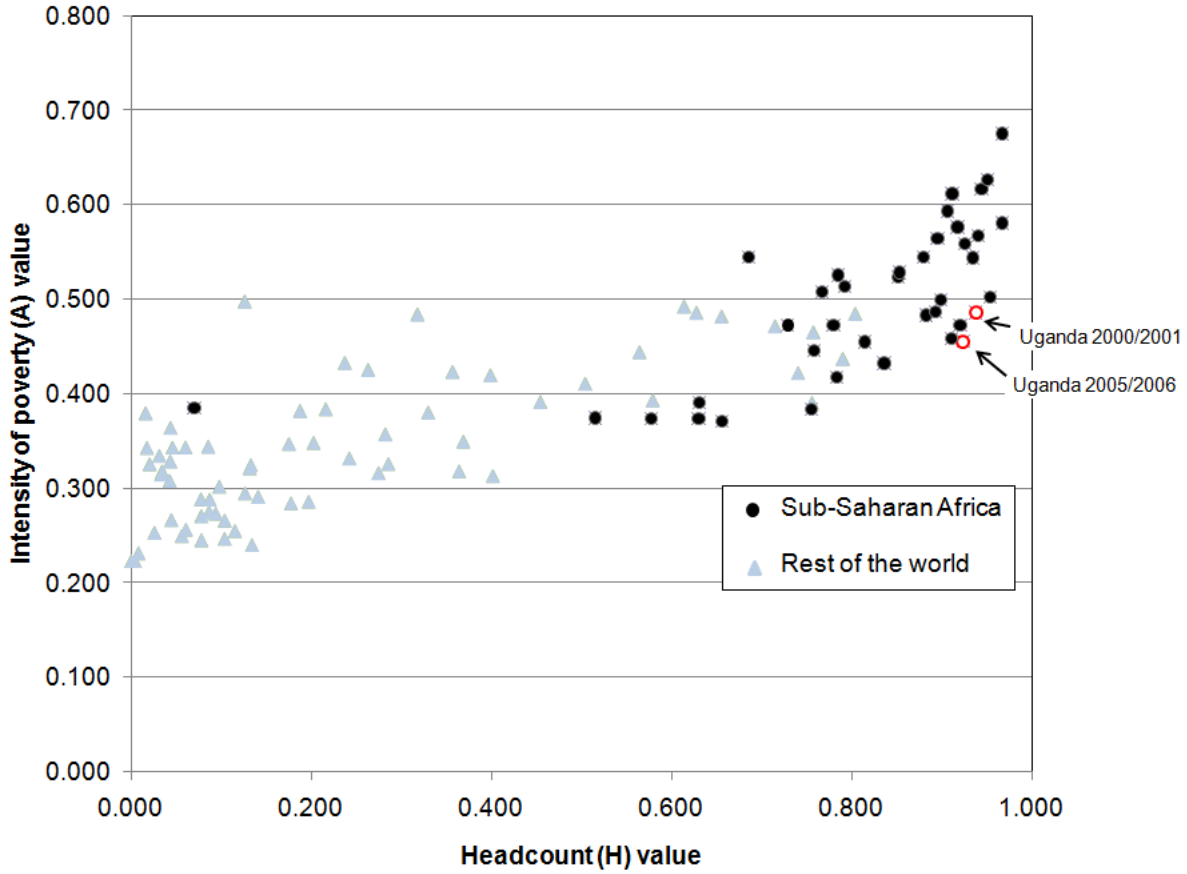


Figure 5: Multidimensional poverty headcount and intensity for 105 countries including Uganda (*k = 3*)



Source: Own computations for Uganda. Alkire and Santos (2010) for other countries.

Figure 6: MPI poverty status by monetary expenditure decile 2005/2006