UNIVERSITÀ DEGLI STUDI DI SIENA

QUADERNI DEL DIPARTIMENTO
DI ECONOMIA POLITICA E STATISTICA

Vincenzo Salvucci
Gianni Betti
Francesca Gagliardi

Multidimensional and Fuzzy Measures of Poverty and Inequality at National and Regional Level in Mozambique

n. 649 – Luglio 2012

Abstract - This study provides a step-by-step account of how fuzzy measures of non-monetary deprivation and also monetary poverty may be constructed based on survey data such as those from the Mozambican Household Budget Survey 2008-09 (IOF08). For nonmonetary deprivation, six dimensions are identified using explanatory and confirmatory factor analyses, and a weighting system is applied for the aggregation of individual items into the dimension they represent. An application on Mozambique is conducted using the Household Budget Survey 2008-09 (IOF08) data: estimates are provided at national level and also disaggregated at provincial and urban/rural level. Standard errors are provided using a recent methodology based on Jack-knife Repeated Replication. Our results contrast with previous findings based solely on Head Count statistics and give a more complete mapping of poverty in Mozambique. Monetary and non-monetary deprivation seem to have very different distribution patterns, especially when analysed at sub-national level and by area of residence. Disaggregated Head Count statistics produce rankings of provinces and urban/rural areas that greatly differ from estimates based on non-monetary dimensions. In particular, the Northern and Central provinces suffer from non-monetary deprivation significantly more than the South, and the urban/rural deprivation gap widens in favour of urban areas when non-monetary dimensions are considered. Housing conditions and quality, and possession of less affordable durable goods emerge as the most unequally distributed non-monetary dimensions.

Keywords: well-being, poverty, regional indicators, standard errors, Mozambique

JEL Classification: D63, I32, R13

Vincenzo Salvucci, Department of Economics and Statistics, University of Siena
Gianni Betti, Department of Economics and Statistics, University of Siena
Francesca Gagliardi, Department of Economics and Statistics, University of Siena

1. Introduction

This study provides a step-by-step account of how fuzzy measures of non-monetary deprivation and also monetary poverty may be constructed based on the Mozambican Household Budget Survey 2008-09 (IOF08). To our knowledge, this is the first attempt to apply Fuzzy Set Theory to poverty measurement in Mozambique.

The dataset we use is the most recent budget survey available for Mozambique and it is representative at the national, regional (North, Centre, South), provincial and urban/rural level.

In order to construct a Fuzzy Set index of poverty, monetary as well as non-monetary indicators are considered, and two different measures of deprivation are subsequently constructed: the Fuzzy Monetary (FM) and Fuzzy Supplementary (FS). For purposes of comparability with the official poverty analyses for Mozambique (INE, 2010; MPD-DNEAP, 2010), we use per capita (real) daily consumption as our monetary poverty indicator.

For non-monetary deprivation, we identify six dimensions, including housing conditions; more widespread and affordable durable goods; less common, more expensive durable goods; housing quality; income-related deprivation; health and education. The dimensions are identified using explanatory and confirmatory factor analyses, and a weighting system is applied for the aggregation of individual items into the dimension they represent.

In the Chapter we present monetary and non-monetary poverty estimates at national, provincial and urban/rural level. Standard errors are provided using a recent methodology based on Jack-knife Repeated Replication (Verma and Betti, 2011). This methodology allows us to present reliable estimates, especially at sub-national level, where the sample size is smaller.

In particular, we compute more precise poverty estimates at provincial level and urban/rural level for each province, thus providing a finer poverty mapping for Mozambique.

We believe that including non-monetary dimensions in the analysis of poverty in Mozambique is important and informative for several reasons: a large part of Mozambicans lives close to the poverty line, so that small changes in their income levels are likely to produce sensible modification in the Head Count statistics. For example, using consumption per adult equivalent instead of consumption per capita for the computation of the Head Count Ratio retrieves very different results.

Poverty estimates based on Head Count statistics solely are thus not very robust. Moreover, the official poverty analyses based on Mozambican Budget Survey data generally retrieved strange or non-robust results at provincial level, with huge jumps up and down in the Head Count Ratio and re-ranking of

poor and rich provinces (Van den Boom, 2011; pp. 7-8).

The study proceeds as follows: in Section 2 we present previous studies and official statistics about poverty in Mozambique; Section 3 illustrates the concept of multidimensional poverty, as well as the Fuzzy Set technique and its application to poverty estimation. In Section 4 we introduce the dataset that is used throughout the study, while in Section 5 we set out the empirical analysis and the resulting poverty estimates. In this section we also include a discussion on the use of Jackknife Repeated Replication (JRR) for variance estimation, and its application to Mozambican data. Section 6 concludes.

2. Poverty in Mozambique

Mozambique is among the poorest countries in the world, with a per capita income level (about $428) that is ranked 197 out of 210 by the World Bank (World Bank, 2010). After the end of the civil war in 1992, Mozambique underwent a process of sustained growth and poverty reduction that led the country to be considered as a success story by the World Bank and international donors (World Bank, 2008).

Nevertheless, poverty levels remain very high and poor living conditions are widespread in the country. The process of poverty reduction has been deeply monitored and analysed by three official national assessments (MPF, 1998; MPF, 2004; MPD-DNEAP, 2010) and several other studies by both Mozambican and international analysts (Hanlon, 2007; Castel-Branco, 2010; Ossemane, 2010; Van den Boom, 2011).

What emerges from the three main household surveys conducted in the 1996-2008 period and from other field-specific surveys, is that Mozambican citizens substantially improved their situation with respect to some non-monetary dimensions: access to education and health services, household asset ownership, and quality of housing. On the other hand, monetary poverty remained fairly stable between 2002 and 2008: the Head Count Ratio slightly increased from a value of 54.1% in 2002-03 to 54.7% in 2008-09. However, it is important to note that this stabilisation followed a sharp fall from the levels of 1996-97 (69%).

The most recent available figures about poverty reduction can be found in the Third National Poverty Assessment (MPD-DNEAP, 2010), which is based on the results of the Mozambican Household Budget Survey 2008-09 (IOF08). In this document an analysis of monetary poverty and non-monetary poverty is outlined.

As introduced, monetary and non-monetary poverty are different phenomena, non-monetary indicators

being recognised as dimensions that capture long-term poverty trends more than household consumption measures. The Mozambican Government and international donors invested considerably in reducing non-monetary poverty. In particular, education and health are considered as key intervention areas, and progressively more people have been granted access to schools and health facilities in urban as well as rural areas (Chao and Kostermans, 2002; Government of Mozambique, 2005; Republic of Mozambique, 2006). Nonetheless, monetary poverty was not reduced between 2002 and 2008. The Third National Poverty Assessment lists different causes that contribute to maintain such a high level of monetary poverty, notwithstanding the improvements in non-monetary dimensions. Most of them are related to the agricultural sector, since agriculture remains the main economic activity and source of income for most Mozambicans. In particular, MPD-DNEAP (2010) points out that the harvest of 2008 was affected by unexpected whether shocks, which reduced the amount of disposable food, especially for Central provinces. Moreover, households had to deal with higher transportation and imported food costs due to the rise in international food and fuel prices. Such a high dependence from climate shocks and international prices contributed to the low and stable agricultural productivity registered between 2002 and 2008, and to maintaining large part of the Mozambican population in a state of great vulnerability (MPD-DNEAP, 2010; pp. xii-xiii).

When the analysis is conducted at sub-national -provincial and urban/rural- levels, the pattern of poverty reduction becomes less clear. For what concerns monetary poverty, between 2002 and 2008 the Southern provinces and some of the rural areas in the North experienced a sharp fall in their Head Count Ratio, while Central regions witnessed an increase. More precisely, monetary poverty decreased in 5 provinces (Niassa, from 52% to 32%; Cabo Delgado, from 63% to 37%; Tete, from 60% to 42%; Inhambane, from 81% to 58%; Maputo City, from 54% to 36%); it remained stable in three provinces (Maputo Province, 68%; Nampula, 54%; Gaza, 61%); and it increased in the remaining 3 provinces (Zambezia, from 45% to 71%; Manica, from 44% to 51%; Sofala, from 36% to 58%). Nationwide, rural poverty increased from 55.3% in 2002-03 to 56.9% in 2008-09, whereas urban poverty decreased from 51.5% to 49.6% in the same period.

For non-monetary dimensions, the Assessment compares the results for 2008-09 with those from 2002-03. Each of the three dimensions considered -housing conditions, ownership of durable goods, access to public goods and services- is separately compared with the same dimension six years before, without computing a general composite welfare indicator. This approach -we believe- is less informative than the one used in the present study. In what follows we consider all the available information about

durable goods, housing conditions, health and education, and compute dimension-specific deprivation indexes plus a general indicator also for non-monetary poverty. Nonetheless, we are particularly interested in this official analysis as it constitutes a possible benchmark.

The results of the Assessment indicate that on average housing conditions improved between 2002 and 2008, though differences at sub-national level remain high. Ownership of durable goods increased, too, with an average 5.7% higher proportion of households owning a radio, a TV, a fridge, a mobile, a telephone, a car, a bike or a motorbike. Turning to the access to public goods and services, it emerges that access to education peaked such that in 2008-09 more than 76% of all children aged 6-13 were attending school. A big jump if compared with a figure of 66.8% in 2002-03. Moreover, geographic inequality in access to education decreased over time. Access to health facilities improved, too. The average proportion of household at less than 45 minutes from the nearest health facility went up from 54.5% to 65.2%, and it enormously increased in rural areas (from 31.5% to 69.7% in the North and from 35.0% to 47.6% in the Centre, while in the South it only increased from 48.8% to 53.6%). On the other hand, other non-monetary dimensions of deprivation did not improve in a substantial way: access to safe water remained more or less stable, while chronic malnutrition (stunting) is still suffered by 46.4% of under-five children, among the highest percentages in the world (WHO, 2011).

3. Multidimensional poverty and fuzzy set theory

In order to understand poverty and social exclusion, it is necessary to consider deprivation simultaneously in its multiple dimensions - low income as well as different non-monetary aspects of deprivation. The need to adopt a multidimensional approach has been noted, among others, by Kolm (1977); Atkinson and Bourguignon (1982); Maasoumi (1986); Tsui (1995); Sen (1999). Moreover, the multidimensional nature of poverty is a widely recognised fact, not only by the international scientific community, but also by many official statistical agencies (e.g. Eurostat, Istat) as well as by international institutions (United Nations, World Bank).

In the present work we go beyond the conventional study of poverty based simply on the poor/non-poor dichotomy defined in relation to some chosen poverty line. Instead, poverty and multidimensional deprivation are treated as matters of degree determined in terms of the individual's position in the distribution of income and other aspects of their living condition. The state of deprivation is thus seen in the form of 'fuzzy sets' to which all members of the population belong but to varying degrees. This fact implies a more complete and realistic vision of this phenomenon and also an increased complexity

at both the conceptual and the analytical levels.

A number of authors have applied the concepts of fuzzy sets in the analysis of poverty and living conditions, for instance Chiappero Martinetti (1994); Vero and Werquin (1997). Our application is based on the specific methodology developed by Cerioli and Zani (1990); Cheli (1995); Cheli and Lemmi (1995); Betti and Verma (1999); Betti et al. (2006).

In the so-called traditional approach poverty is characterized by a simple dichotomization of the population into poor and non-poor defined in relation to some chosen poverty line, *z*. This approach presents two main limitations: firstly, it is unidimensional, i.e. it refers to only one proxy of poverty, namely low income or consumption expenditure, and secondly it divides the population into a simple dichotomy. However, poverty is a complex phenomenon that cannot be reduced solely to monetary dimension but it must also take account of non-monetary indicators of living conditions; moreover it is not an attribute that characterizes an individual in terms of presence or absence, but is rather a vague predicate that manifests itself in different shades and degrees.

The fuzzy approach considers poverty as a matter of degree rather than an attribute that is simply present or absent for individuals in the population. In this case, two additional aspects have to be introduced:

i. The choice of membership functions (m.f.), i.e. quantitative specifications of individuals' or households' degrees of poverty and deprivation;
ii. The choice of rules for the manipulation of the resulting fuzzy sets.

The traditional approach can be seen as a special case of the fuzzy approach, where the membership function may be seen as $\mu_i^H = 1$ if $y_i < z$, $\mu_i^H = 0$ if $y_i \geq z$, where y_i is the income of individual *i* and *z* is the poverty line.

An early attempt to incorporate the concept of poverty as a matter of degree at methodological level was made by Cerioli and Zani (1990) who drew inspiration from the theory of *Fuzzy Sets* initiated by Zadeh (1965). Subsequently, Cheli and Lemmi (1995) proposed the so called Totally Fuzzy and Relative (TFR) approach in which the m.f. is defined as the distribution function $F(y_i)$ of income, normalized (linearly transformed) so as to equal 1 for the poorest and 0 for the richest person in the population.

3.1 Income poverty: the Fuzzy Monetary (FM) measure

In the present study we make use of a fuzzy monetary indicator as found in Betti et al. (2009). The

proposed FM Indicator is defined as a combination of the (1-$F_{(M),i}$) indicator, the proportion of individuals less poor than the person concerned, proposed by Cheli and Lemmi (1995), and of the (1-$L_{(M),i}$) indicator, the share of the total income received by all individuals less poor than the person concerned, proposed by Betti and Verma (1999). Formally:

$$\mu_i = FM_i = (1 - F_{(M),i})^{\alpha-1}(1 - L_{(M),i}) = \left(\frac{\sum_{\gamma=i+1}^{n} w_\gamma \mid y_\gamma > y_i}{\sum_{\gamma=2}^{n} w_\gamma \mid y_\gamma > y_1} \right)^{\alpha-1} \left(\frac{\sum_{\gamma=i+1}^{n} w_\gamma y_\gamma \mid y_\gamma > y_i}{\sum_{\gamma=2}^{n} w_\gamma y_\gamma \mid y_\gamma > y_1} \right) \quad (1)$$

where y_γ is the income, $F_{(M),i}$ is the income distribution function, w_γ is the sample weight of individual of rank γ (γ = 1,…, n) in the ascending income distribution, $L_{(M),i}$ represents the value of the Lorenz curve of income for individual i. The parameter α is estimated so that the overall FM indicator (which is calculated simply as the weighted mean of the individual FM_i), is equal to the Head Count Ratio computed for the official poverty line.

3.2 Non-monetary poverty: the Fuzzy Supplementary (FS) measure

In addition to the level of monetary income, the standard of living of households and individuals can be described by a host of indicators, such as housing conditions, possession of durable goods, health conditions, education, and perception of hardship. To quantify and put together diverse indicators of deprivation several steps are necessary. In particular, decisions are required for assigning numerical values to the ordered categories, weighting the score to construct composite indicators, choosing their appropriate distributional form and scaling the resulting measures in a meaningful way.

First, from the large set which may be available, a selection has to be made of indicators which are substantively meaningful and useful for a given analysis. Secondly, it is useful to group different indicators into statistical components (also called dimensions) in order to reduce dimensionality. Whelan et al. (2001) suggest, as a first step in an analysis of life-style deprivation, to systematically examine the range of deprivation items to see whether the items cluster into distinct groups. Factor analysis can be used to identify such clusters of interrelated variables. To quantify and put together diverse indicators several steps are necessary.

1. Identification of items;
2. Transformation of the items into the [0, 1] interval;
3. Exploratory and confirmatory factor analysis;

4. Calculation of weights within each dimension (each group);
5. Calculation of scores for each dimension;
6. Calculation of an overall score and the parameter α;
7. Construction of the fuzzy deprivation measure in each dimension (and overall).

Aggregation over a group of items in a particular dimension h (h = 1, 2, …, m) is given by a weighted mean taken over j items: $s_{hi} = \sum w_{hj} \cdot s_{hj,i} \Big/ \sum w_{hj}$ where w_{hj} is the weight of the j-th deprivation variable in the h-th dimension. An overall score for the i-th individual is calculated as the unweighted mean:

$$s_i = \frac{\sum_{h=1}^{m} s_{hi}}{m} \tag{2}$$

Then, we calculate the FS indicator for the i-th individual over all dimensions as:

$$FS_i = (1-F_{(S),i})^{\alpha-1}\,(1-L_{(S),i}) \tag{3}$$

As for the FM indicator, the estimates of α is determined so as to make the overall non-monetary deprivation rate (which is calculated simply as the weighted mean of the individual FS_i) numerically identical to the Head Count Ratio computed for the official poverty line. The parameter α estimated is then used to calculate the FS indicator for each dimension of deprivation separately. The FS indicator for the h-th deprivation dimension and for the i-th individual is defined as combination of the $(1-F_{(S),hi})$ indicator and the $(1-L_{(S),hi})$ indicator.

$$\mu_{hi} = FS_{hi} = \left(1 - F_{(S),hi}\right)^{\alpha-1}\left(1 - L_{(S),hi}\right) = \left[\frac{\sum_{\gamma=i+1}^{n} w_{h\gamma} \mid s_{h\gamma} > s_{hi}}{\sum_{\gamma=2}^{n} w_{h\gamma} \mid s_{h\gamma} > s_{h1}}\right]^{\alpha-1}\left[\frac{\sum_{\gamma=i+1}^{n} w_{h\gamma} s_{h\gamma} \mid s_{h\gamma} > s_{hi}}{\sum_{\gamma=2}^{n} w_{h\gamma} s_{h\gamma} \mid s_{h\gamma} > s_{h1}}\right], \tag{4}$$

$$h = 1,2,...,m; i = 1,2,...,n; \mu_{hn} = 0$$

The $(1-F_{(S),hi})$ indicator for the i-th individual is the proportion of individuals who are less deprived, in the h-th dimension, than the individual concerned. $F_{(S),hi}$ is the value of the score distribution function evaluated for individual i in dimension h and $w_{h\gamma}$ is the sample weight of the i-th individual of rank γ in the ascending score distribution in the h-th dimension.

The $(1-L_{(S),hi})$ indicator is the share of the total lack of deprivation score assigned to all individuals less deprived than the person concerned. $L_{(S),hi}$ is the value of the Lorenz curve of score in the h-th dimension for the i-th individual.

As for the Fuzzy Monetary and the Fuzzy Supplementary indicators, the overall index corresponding to each dimension FS_h is calculated simply as the weighted mean of the individual FS_{hi}. Here it is interesting to note that the overall ranking of the *FS* indicator cannot directly be obtained from the rankings in each dimension; however, the ranking obtained with FS_i is consistent with the ranking obtained from FS_{hi} [1].

4. Data

The dataset used in the study is the Mozambican Household Budget Survey 2008-09 (IOF08) (*Inquerito aos Agregados Familiares sobre Orçamento Familiar 2008-09*), which is a nationally representative household survey conducted by the National Institute of Statistics (INE). The IOF08 was conducted from August 2008 to September 2009. The survey has a stratified structure with three steps of selection: i) selection of the primary sampling units (PSUs), ii) selection of the enumeration areas[1] within the PSUs, iii) selection of the households within the enumeration areas.

Nine households were selected in each rural area and twelve in each urban area. Twenty-one strata were constructed, one for each urban/rural sample of the 11 provinces of Mozambique (the province of Maputo City does not have a rural area). The IOF08 has a sample size of 51,177 individuals in 10,832 households, divided into 5,223 urban households and 5,609 rural households. It is representative at the national, regional (North, Centre, South), provincial and urban/rural level. Sampling weights are provided in the survey dataset.

The survey includes information on general characteristics of the individuals and of the households, on daily, monthly and durable goods final consumption expenditures, own consumption, transfers and gifts. A community survey is also available, but only for rural areas, containing information on community characteristics. Supplementary information for the IOF08 can be found in (INE, 2010; MPD-DNEAP, 2010).

For what concerns socioeconomic status, we use data on (real) per capita daily consumption, available from the IOF08. This is the variable that is used by the Government for official analyses of poverty, so that our results are immediately comparable with the existing ones. Such indicator takes into account daily and monthly expenditures, durable goods use and rent, self-consumption, in kind earnings. All different sources of consumption are averaged out on a daily basis, providing a good measure of economic status for Mozambican households. This measure of income also considers the inflation occurred during the implementation of the surveys, the different values of the *Metical* -the

Mozambican currency- in different periods of the year, and spatial differences in price levels among different provinces and areas (rural/urban). Thirteen relatively homogeneous regions and poverty lines have been identified for Mozambique, so as to take into account the differences in price levels in the various provinces and rural/urban areas.

In order to compute a measure for non-monetary poverty we use information on ownership of durable goods, housing quality, health status and education level. In particular, we consider ownership of bikes, motorbikes, radios, watches, beds, TVs, computers, printers, sewing machines, fans or air conditioners, telephones or mobiles, new or used cars, irons, other tools, fridges or freezers.

Concerning housing quality, we use information on whether the house where the household lives is a proper house or a thatched hut; whether walls, roof or floor are made of high-quality materials; information on access to safe water, on sanitation quality, on the most used source of energy for cooking or lighting purposes; on the number of rooms per (squared) household member.

We also consider as important dimensions for a non-monetary poverty measure both the highest education level attained in the household and whether someone in the household can read or write. Two other health-related indicators like having a household member affected by chronic illnesses or having a chronically malnourished (stunted) child are also added. Finally, other household characteristics as having a bank account or having someone in the house with a formal or informal job are included, together with the average number of daily meals the household members can afford.

4.1 Problems with the data

The IOF08 is a very rich and detailed dataset. It has been carefully designed and implemented, so that it can provide reliable information and statistical results. Nonetheless, a few problems with the data were encountered while conducting our analysis on multidimensional poverty. In particular, we found that sampling weights were not calibrated at the household level following non-response or other problems occurred in the surveying process. Moreover, such weights range from 54.6 to 93,452.2; as a result, a few households with very high weights significantly influence statistical results.

Concerning household real consumption -the variable used to assess socioeconomic status-, we conformed to official analyses that divide it by the number of household members, and on the basis of such variable we estimate poverty rates. However, this leaves aside all considerations about intra-household allocation of resources and economies of scale, which might considerably matter when dealing with poverty estimates in a country with an average household size of about six members.

Indeed, the Head Count Ratio computed dividing household consumption per adult equivalent produces very different poverty estimates -the percentage of poor being only 36.8% instead of 54.69%-.

5. Empirical analysis and results

In this section we describe the steps involved in the measurement of multidimensional poverty in Mozambique at national, provincial and urban/rural level, as it has been outlined in previous sections. This is followed by an analysis of the results for Mozambique concerning monetary poverty and the different dimensions of non-monetary deprivation.

As introduced in Section 4, the Fuzzy Monetary measures, FM, are based on household real consumption divided by household size. Real consumption is obtained by taking into account regional differences in price levels, inflation and seasonal fluctuations. In order to obtain FM, we need to take into account both the proportion of households richer than each particular household and the cumulative share of consumption such richer households receive. Finally, the resulting distribution is transformed such that its mean is equal to the Head Count Ratio: this ensures comparability between the two measures and the two approaches, the traditional and the multidimensional one.

Concerning the Fuzzy Supplementary measures, we use information about thirty-two basic items, as described in Section 4. The deprivation dimensions are initially determined using an exploratory factor analysis: this procedure permits to describe the variability among observed variables -our basic items- in terms of a lower number of unobserved, uncorrelated variables, which are called factors. In the exploratory factor analysis the observed variables are expressed as a linear combination of the underlying factors, without any a priori assumption about the factor structure.

The results of the exploratory factor analysis are then calibrated according to the literature and to the experience acquired during the fieldwork in Mozambique. For example, owning a mobile was moved to the dimension of more widespread durable goods, while the number of rooms per household member was included in the housing conditions dimension, even though they were more correlated with other variables or factors. The results of the exploratory factor analysis and the subsequent reorganisation and calibration are found in Appendix A.1.

Finally, a confirmatory factor analysis was performed: in doing this procedure we impose a priori assumptions about the underlying factor structure. This allows us to test whether the proposed calibration of initial items into a lower number of dimensions makes statistical sense (Table 5.2).

After these preliminary steps, thirty-two basic indicators were grouped into six dimensions, roughly

corresponding to: i) housing conditions; ii) more widespread and affordable durable goods; iii) less common, more expensive durable goods; iv) housing quality; v) income-related deprivation; vi) health and education. The complete list of the selected indicators and the resulting dimensions are reported in Table 5.1, while the results of the confirmatory factor analysis are summarised in Table 5.2.

For what concerns the aggregation of different indicators in each single dimension, a weighting procedure was carried out, as described in Section 3. Depending on the distribution of each indicator in the population and its correlation with other indicators in the same dimension, we constructed item-specific composite weights with equal value for all households in the population. The item-specific weights, W_j, are composed of two parts: Wa_j, that is an inverse function of the percentage of people deprived in item j, and Wb_j, an inverse function of the correlation between item j and all the other items in the same dimension. For each dimension we have that $W_j = Wa_j \cdot Wb_j$.

Intuitively, the first component of the weights, Wa_j, takes into account that if a high percentage of people possess j, then the few who do not possess j are very deprived; the second component, Wb_j, tries to achieve some parsimony assigning a lower weight to items that are highly correlated in the same dimension (e.g. high-quality walls and high-quality roof in the 'housing conditions' dimension).

The result is the identification of six different fuzzy supplementary measures, one for each dimension: FS1, FS2, FS3, FS4, FS5, FS6. Subsequently, we aggregate the different non-monetary dimensions into a single composite Fuzzy Supplementary poverty indicator, FS. This is done by assigning equal weights to each supplementary dimension, based on the assumption that all dimensions are equally important in determining supplementary deprivation. The resulting FS distribution is also scaled so that its mean is equal to the Head Count Ratio, as we did for the monetary poverty indicator, FM. The rescaling ensures that the traditional and the fuzzy indicators are comparable.

The results for the Fuzzy Monetary (FM), the composite Fuzzy Supplementary (FS) measure, and for the individual Fuzzy Supplementary dimensions (FS1-FS6) at national level are outlined in Subsection 5.1, while those relative to the provincial and urban/rural level are presented in Subsection 5.2 and Subsection 5.3, respectively. A detailed description of the technique used for the computation of the standard errors and relative advantages compared to other methods is found in Appendix B.

1An enumeration area (EA) represents the area assigned to each enumerator for distributing questionnaires to households and it is the smallest building block of the geographical frame for the Mozambican Household Budget Surveys.

Table 5.1 – Dimensions and indicators of non-monetary deprivation

1	Housing conditions	2	More widespread durable goods	3	Less common, expensive durable goods	4	Housing quality	5	Income-related deprivation	6	Health and education
d1	Bed	d8	Telephone or mobile phone	d14	Tools	d21	Energy source for cooking	d26	A bank account	d29	Ability to read and write
d2	Proper house	d9	TV	d15	Electric or coal iron	d22	Energy source for in-house lighting	d27	A formal or informal job	d30	Education level
d3	High-quality walls	d10	Bike	d16	Fridge or freezer	d23	Hotplate or gas ring	d28	More than two meals per day	d31	Chronic illness
d4	High-quality roof	d11	Radio	d17	New or second-hand car	d24	Has access to safe water			d32	Child malnutrition
d5	High-quality floor	d12	Watch	d18	Computer	d25	Fan or air conditioner				
d6	Has WC or latrine	d13	Motorbike	d19	Printer						
d7	Number of rooms/(household members)^2			d20	Sewing machines						

Table 5.2 – Confirmatory factor analysis results

Goodness of fit (GFI)[a]	0.834
Adjusted GFI[b]	0.8086
Parsimonious GFI[c]	0.77
Root Mean Square Residual[d]	0.0807
RMSEA[e]	0.0748

Notes:
[a] It is based on the ratio of the sum of squared discrepancies to the observed variances; it ranges from 0 to 1 with higher values indicating a good fit.
[b] It is the GFI adjusted for degrees of freedom of the model, that is the number of the fixed parameters. It can be interpreted in the same manner.
[c] It adjusts GFI for the number of estimated parameters in the model and the number of data points.
[d] The fit is considered really good if RMR is equal or below 0.06.
[e] The Root Mean Squared Error of Approximation (RMSEA) is based on the analysis of residuals, with small values indicating a good fit.

5.1 Poverty estimates at national level

As outlined before, the overall Fuzzy Monetary (FM) and Fuzzy Supplementary (FS) dimensions are constructed such that their mean is equal to the official Head Count Ratio, so they do not convey additional information to our analysis at national level (Head Count Ratio = FM = FS = 54.69%). Hence, in this subsection we only focus on the values of the supplementary dimensions FS1-FS6.

From Table 5.3, it is possible to notice that the factor whose level of deprivation is highest is FS3: this corresponds to less common, expensive durable goods. Most Mozambicans do not possess any of the items included in this dimension, and a level of deprivation of about 0.75 is thus reasonable. Conversely, the deprivation value for less expensive durable goods (FS2) is lower, showing that some durable goods -especially mobile phones and bikes- are becoming more common in the country.

The level of deprivation for housing conditions (FS1) is also very high (0.53), and reflects the fact that many households lack basic facilities in their dwellings. Even so, the proportion of households lacking

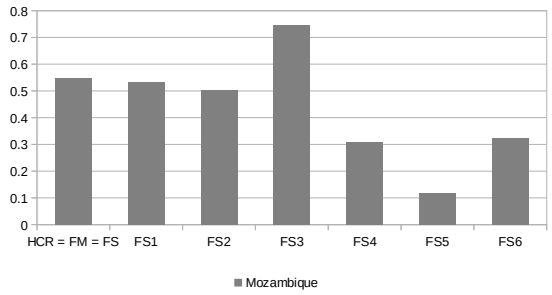
decent household quality (FS4) is significantly lower (0.31). Income-related deprivation (FS5) appears to be relatively low: this result is probably influenced by the inclusion of a dummy for whether someone in the household had a job (formal or informal) or not. Since most of the households interviewed (about 98%) had a member with a formal or informal job, this pushes the entire dimension towards low levels of deprivation (0.12). When this variable is taken out of the FS5 dimension, then the average deprivation becomes much higher (0.64). This is taken into account in the following analyses, while other sensitivity checks have been undertaken and are presented in Appendix A.2.

Finally, the result for health and education (FS6) shows that education and health conditions in Mozambique are improving. However, one needs to be warned that the relatively low average value of deprivation for this dimension (0.32) is likely to be affected by the low level of deprivation concerning chronic illnesses and ability to read and write. Indeed, the level of child malnutrition in Mozambique is still among the highest in the world (WHO, 2011).

Table 5.3 – Deprivation by dimension, national level

	Mozambique (n = 10831)								
	HCR	**FM**	**FS**	**FS1**	**FS2**	**FS3**	**FS4**	**FS5**	**FS6**
Mean	0.5469	0.5469	0.5469	0.5345	0.5043	0.7457	0.3079	0.1158	0.3224
SE	0.0119	0.0078	0.0056	0.0065	0.0070	0.0076	0.0103	0.0020	0.0063

Figure 5.1 – Deprivation by dimension, national level



5.2 Poverty estimates at provincial level

When fuzzy set poverty analysis is carried out at sub-national level then it becomes evident how the inclusion of multiple dimensions substantially increases the amount of available information.

Mozambique is divided into eleven provinces[1]. These territories are quite heterogeneous with regard to economic development, culture, ethnic and linguistic composition. Consequently, huge differences in

poverty rates exist among different zones and provinces in Mozambique. Even though some insights emerged from the official Head Count reports, the multidimensional analysis of poverty we undertook using Fuzzy Set Theory allows us to highlight important characteristics that would otherwise go unnoticed in a traditional poverty assessment.

In particular, looking at the Fuzzy Monetary (FM) and Fuzzy Supplementary (FS) statistics presented in Table 5.4 it strikes that some of the provinces with low rates of monetary poverty are also much more deprived in other dimensions, and vice-versa. The Northern provinces (Niassa, Cabo Delgado, Nampula) and the Central province of Tete, all have much higher Fuzzy Supplementary (FS) averages with respect to their Fuzzy Monetary (FM) ones. The other Central provinces (Zambezia, Manica and Sofala) have similar statistics in both the FM and FS dimension, while the Southern provinces show FS averages that are lower than their respective FM averages. The estimated averages for the Head Count Ratio, the Fuzzy Monetary and Fuzzy Supplementary dimensions together with their standard errors are presented in the first rows of Table 5.4 and in Figure 5.2.

The analysis of Fuzzy Supplementary dimensions evidences that the South is generally more developed than the Centre and the North, with Maputo City being much less deprived than all other provinces. These characteristics remained hidden using the standard poverty Head Count analysis. This is probably due to various causes: first, consumption is highly dependent on temporary and/or seasonal fluctuations -e.g. a bad harvest in 2008-, while other dimensions as those included in the computation of the Fuzzy Supplementary statistics are more robust to such changes. Buying an asset, a durable good or investing in education requires an evaluation of household's economic status that is only partially related to the level of income/consumption in a given year. Moreover, a large part of the Mozambican population has consumption levels that are close to the poverty line, hence even small fluctuations can alter the poverty Head Count statistics in a substantial way. This is one of the main drawbacks of using a dichotomous index like the Head Count Ratio for the analysis of a complex phenomenon such as poverty. As a matter of fact, poverty Head Count analyses based on Mozambican Budget Surveys generally retrieved strange or non-robust results, with huge jumps up and down in the Head Count Ratio and re-ranking of poor and rich provinces (Van den Boom, 2011; pp. 7-8).

Going deeper into the analysis of supplementary factors, other interesting results emerge (Table 5.4). Concerning housing conditions (FS1), we can identify three distinct groups of provinces on the basis of their FS1 averages: the Central provinces (Zambezia, Tete, Manica and Sofala) and the province of Nampula are the most deprived in this dimension (with an average of about 0.60 for Nampula, Manica

and Sofala; about 0.70 for Zambezia and Tete). In the second group, with an average deprivation of about 0.40, we find two Northern provinces (Niassa and Cabo Delgado) and two Southern provinces (Gaza and Inhambane). The least deprived provinces are again Maputo Province and Maputo City, the latter one with an average of 0.03.

In the FS2 dimension we put together some durable goods that are more widespread than others, like mobile phones, bikes and motorbikes, radios, watches and TVs. Indeed, most provinces show similar average levels of deprivation in this dimension -ranging in the 0.44-0.55 interval-, with Nampula being the most deprived (0.60) and Niassa and Manica the least deprived (0.36 and 0.33, respectively).

Conversely, the FS3 dimension consists of those durable goods that are less affordable and thus less common among Mozambicans, like cars, fridges or freezers, irons, computers, printers, other tools and sewing machines. As evidenced in the analysis at national level, this is the factor for which average levels of deprivation are highest. Especially in the North and in the Centre, where five provinces (Niassa, Cabo Delgado, Nampula, Zambezia and Tete) have average values that exceed 0.80; the other Central provinces (Manica and Sofala) perform a little better, with values around 0.75. Once again, the Southern provinces of Gaza, Maputo Province and Maputo City have much lower deprivation levels (0.52, 0.43 and 0.28, respectively). This confirms that Southern provinces are less deprived than Northern and Central provinces in various dimensions.

Concerning access to safe water, energy sources for cooking, in-house lighting and similar -included in the FS4 dimension-, we find that the average level of deprivation is relatively low. For Northern and Central provinces, it ranges between 0.28 (Sofala) and 0.41 (Niassa), while all Southern provinces perform comparatively better.

As emerged in Subsection 5.1, the FS5 dimension (income-related deprivation) is the one for which average levels of deprivation are lowest. In this case, there are no noticeable differences between provinces. However, when the variable “formal or informal job” is taken out, then it emerges that there is a group of provinces with average deprivation values between 0.40 and 0.50 (Manica, Sofala, Maputo Province, Maputo City) and all other provinces that perform comparatively worse (with values around 0.65-0.75).

Finally, the last supplementary dimension (FS6) takes into account education (education level and ability to read and write) and health (child malnutrition and chronic illnesses). In this case, Maputo Province and Maputo City record an average level of 0.12-0.15, while the estimated values for other provinces range between 0.28 (Sofala) and 0.38 (Zambezia); namely, more than twice the level of

deprivation of the two most Southern provinces.

As it clearly emerged from this subsection, the analysis of dimensions other than consumption substantially improves the mapping of provincial differences regarding poverty. In particular, the higher level of development of the Southern provinces distinctly came out in more than one dimension (FS, and particularly FS1, FS3, FS4, FS6). At the same time, understanding which factors most influence deprivation, yields a deeper insight about which characteristics are more unequally distributed throughout the country.

The estimated averages and standard errors for the supplementary dimensions are found in Table 5.4, while a graphical analysis of the results is shown in Figure 5.2, 5.3, 5.4 and 5.5. In Figure 5.2 we present the Head Count Ratio, Fuzzy Monetary and Fuzzy Supplementary averages for all provinces, and it permits to highlight the differences that exist between monetary and overall non-monetary deprivation. Instead, in Figure 5.3 all the different supplementary dimensions are shown, divided by region and province. In Figure 5.4 both the monetary and individual non-monetary dimensions are shown for each region and province on a net graph. This kind of graph provides additional information on the overall condition of each province compared with other provinces in the same region. Figure 5.5 is particularly informative since it allows to compare all provinces in all dimensions; here the gap between the Centre-North and the South for supplementary dimensions of deprivation is clearly evident.

In Table 5.5 we present the ranking of each province in all dimensions of deprivation. While being very similar for the Head Count Ratio and the Fuzzy Monetary (FM) measure, it greatly differs when it comes to supplementary dimensions.

1The eleven provinces of Mozambique are grouped into three bigger zones: the North, which includes the provinces of Niassa, Cabo Delgado and Nampula; the Centre, with the provinces of Zambezia, Tete, Manica and Sofala; the South, containing the provinces of Gaza, Inhambane, Maputo Province and Maputo City.

Table 5.4 – Deprivation by dimension, provincial level

	Niassa	Cabo Delgado	Nampula	Zambezia	Tete	Manica	Sofala	Gaza	Inhambane	Maputo Pr.	Maputo Cid.
Head Count Ratio	0.3194	0.3740	0.5468	0.7054	0.4203	0.5509	0.5803	0.5795	0.6254	0.6746	0.3615
SE	0.0322	0.0353	0.0291	0.0339	0.0444	0.0427	0.0484	0.0475	0.0320	0.0245	0.0239
mean FM	0.4068	0.4386	0.5459	0.6423	0.4903	0.5605	0.5690	0.5504	0.6132	0.6134	0.4054
SE	0.0237	0.0217	0.0186	0.0218	0.0273	0.0249	0.0377	0.0329	0.0233	0.0165	0.0182
mean FS	0.5649	0.5829	0.6431	0.6406	0.6615	0.5313	0.5265	0.4603	0.4385	0.2970	0.1672
SE	0.0244	0.0171	0.0143	0.0123	0.0192	0.0208	0.0255	0.0225	0.0249	0.0159	0.0066
mean FS1	0.4941	0.4229	0.6353	0.7319	0.7200	0.6101	0.6179	0.4021	0.3076	0.1233	0.0323
SE	0.0284	0.0190	0.0148	0.0150	0.0273	0.0284	0.0231	0.0290	0.0298	0.0159	0.0029
mean FS2	0.3615	0.5175	0.5969	0.4948	0.5132	0.3345	0.4360	0.5578	0.5554	0.5305	0.5031
SE	0.0213	0.0211	0.0171	0.0141	0.0285	0.0190	0.0408	0.0236	0.0222	0.0231	0.0137
mean FS3	0.8316	0.8319	0.8710	0.8349	0.8796	0.7410	0.7511	0.5181	0.6439	0.4253	0.2768
SE	0.0200	0.0209	0.0139	0.0280	0.0179	0.0245	0.0236	0.0291	0.0288	0.0240	0.0159
mean FS4	0.4084	0.3763	0.3269	0.3471	0.3945	0.3545	0.2756	0.2048	0.2187	0.2355	0.0327
SE	0.0396	0.0342	0.0285	0.0245	0.0358	0.0395	0.0367	0.0278	0.0438	0.0368	0.0042
mean FS5	0.1186	0.1131	0.1293	0.1172	0.1150	0.0910	0.0957	0.1316	0.1355	0.1060	0.0979
SE	0.0065	0.0057	0.0042	0.0064	0.0067	0.0057	0.0075	0.0043	0.0044	0.0073	0.0069
mean FS6	0.3489	0.3755	0.3652	0.3843	0.3445	0.3017	0.2775	0.3272	0.2936	0.1517	0.1234
SE	0.0146	0.0168	0.0125	0.0228	0.0147	0.0157	0.0242	0.0305	0.0162	0.0156	0.0087
n	814	780	1575	1523	768	804	851	803	814	900	1199

Table 5.5 - Relative ranking according to the different dimensions of deprivation (1: lowest deprivation; 10: highest deprivation)

	HCR	FM	FS	FS1	FS2	FS3	FS4	FS5	FS6
Niassa	1	2	7	6	2	7	11	8	8
Cabo Delgado	3	3	8	5	7	8	9	5	10
Nampula	5	5	10	9	11	10	6	9	9
Zambezia	11	11	9	11	4	9	7	7	11
Tete	4	4	11	10	6	11	10	6	7
Manica	6	7	6	7	1	5	8	1	5
Sofala	8	8	5	8	3	6	5	2	3
Inhambane	7	6	4	4	10	3	2	10	6
Gaza	9	9	3	3	9	4	3	11	4
Maputo Pr.	10	10	2	2	8	2	4	4	2
Maputo Cid.	2	1	1	1	5	1	1	3	1

Figure 5.2 – Head Count Ratio (HCR), Fuzzy Monetary (FM) and Fuzzy Supplementary (FS), by province

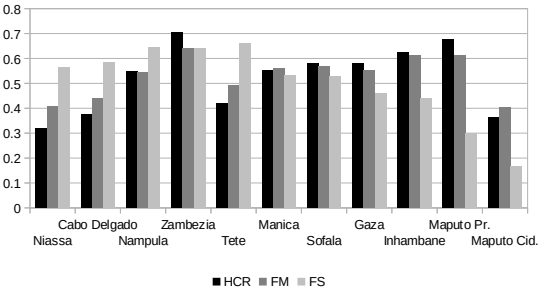


Figure 5.3 – Fuzzy Supplementary dimensions (FS1-FS6), by region and province

North *Centre* *South*

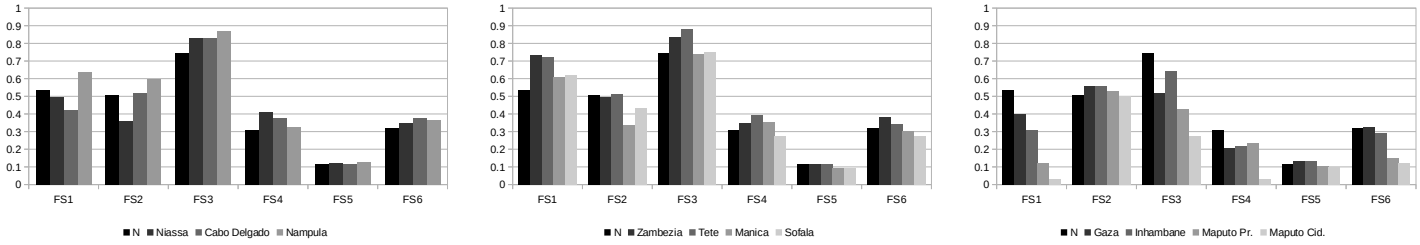


Figure 5.4 – Deprivation by dimension and province

North *Centre* *South*

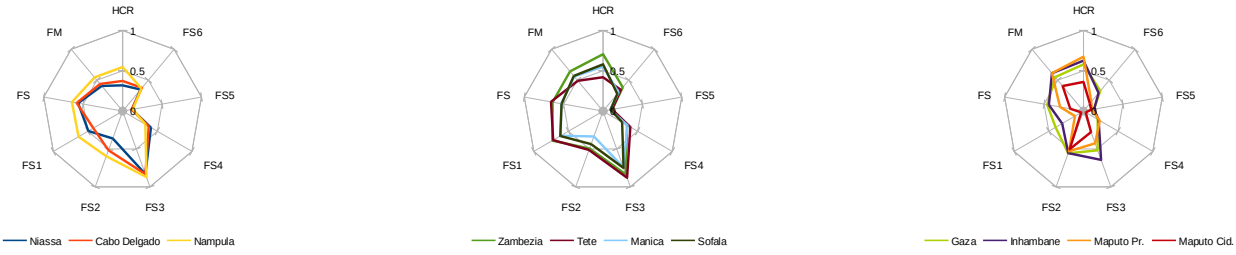
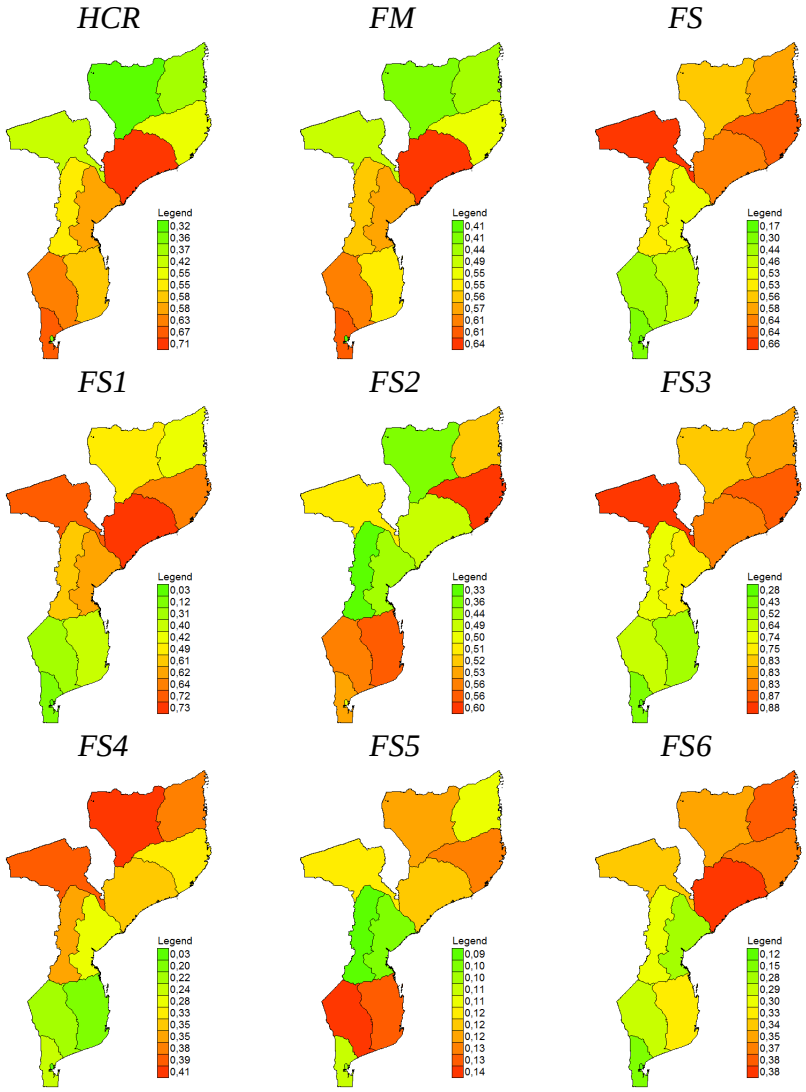


Figure 5.5 – Maps of deprivation, by dimension



5.3 Multidimensional poverty estimates by province and area of residence (urban/rural)

In what follows, we present multidimensional deprivation as estimated by province and by area of residence (urban/rural). The huge differences in poverty estimates that exist between urban and rural areas at both national and sub-national level in Mozambique were already introduced in Section 2. Nonetheless, unexpected results emerge from the analysis of supplementary dimensions of deprivation (Table 5.6): when these are introduced, the urban/rural deprivation gap widens substantially, contrasting with the official analyses based on consumption that estimate a differential of about seven percentage points. Indeed, at national level the Head Count Ratio of rural and urban areas for 2008-09 is about 56.9% and 49.6%, respectively (MPD-DNEAP, 2010). Such gap is very small when compared with

urban/rural poverty gaps in other Sub-Saharan countries (Van den Boom, 2011; World Bank, 2011): for example, while 50% of rural people in Kenya has an income that falls below the poverty line, only 32% of the urban population is considered poor. An even wider gap is found in Uganda, where the rural Head Count Ratio is 34%, as opposed to 14% in urban areas. In Ghana the percentage of poor people in rural areas is more than three times that of poor people in urban areas (39% and 11%, respectively).

However, when supplementary dimensions of deprivation are considered, a different story emerges for Mozambique, too. The aggregated Fuzzy Supplementary (FS) deprivation level for urban areas is 0.34, whereas the one for rural areas exceeds 0.63. Such difference is due to the urban/rural gap found in the underlying supplementary dimensions. In particular, housing conditions (FS1), possession of less common, more expensive durable goods (FS3), housing quality (FS4) and -to a lesser extent- health and education (FS6) all show very different deprivation levels for urban and rural areas (Figure 5.6).

For housing conditions (FS1) the urban deprivation level is 0.26, the rural one as high as 0.65. For more expensive durable goods (FS3) they are equal to 0.52 and 0.84, respectively. The values for the housing quality dimension (FS4) are 0.13 for urban areas and 0.38 for rural areas, while those for the health and education dimension (FS6) are 0.21 (urban) and 0.37 (rural). Much smaller differences exist in the more widespread durable goods (FS2) and income-related (FS5) deprivation dimensions[1].

Such wide deprivation gap between urban and rural areas that exists in most supplementary dimensions at national level is also reflected at the provincial level. Point estimates and standard errors are found in Table 5.6 divided by province and area of residence.

The central regions of Manica and Sofala exhibit the greatest difference between supplementary deprivation values in urban and rural areas. In the supplementary dimensions FS1 (housing conditions), FS3 (more expensive, less affordable durable goods) and FS4 (housing quality) such difference is extraordinarily wide, between 30 and 60 percentage points. While the urban areas of these two provinces are among the less deprived areas of Mozambique in all dimensions, the opposite is true for their rural counterparts. The urban/rural deprivation gap for the three above mentioned supplementary dimensions is huge also for other provinces: Niassa, Cabo Delgado and especially Nampula, Zambezia, Tete. Moreover, the Southern provinces of Gaza and Maputo Province also show significant differences between rural and urban areas.

Conversely, and in line with results at national level, urban and rural deprivation levels are comparable for more widespread durable goods (FS2) and income-related (FS5) supplementary dimensions. Some of the rural areas score even better than their relative urban areas in FS2 (Tete, Manica). As pointed out

in previous paragraphs, excluding the variable “formal or informal job” from the FS5 dimension modifies the results for this dimension substantially. When this variable is not considered the difference between urban and rural areas largely increases for Niassa, Nampula, Tete, Sofala, Gaza and Inhambane. Both figures, with and without the variable “formal or informal job”, are presented in Figure 5.6.

Also for what concerns FS6 (health- and education-related indicators), rural areas are systematically more deprived than urban areas. This is plausible, as healthcare facilities and schools are more widespread in urban areas. The average gap between areas of residence amounts to more than ten percentage points, notwithstanding the commitment of the Mozambican government to increase the availability of health and education facilities in rural areas (Chao and Kostermans, 2002; Government of Mozambique, 2005; Republic of Mozambique, 2006).

As introduced at the beginning of this section, both the monetary deprivation dimensions -Head Count and Fuzzy Monetary- analysed at national level provide a totally different information from non-monetary dimensions. This holds also for the analysis at provincial and urban/rural level. From Head Count Ratio and Fuzzy Monetary estimates it comes out that the poorest region in Mozambique is the rural area of Maputo Province, while the rural areas of Niassa, Cabo Delgado and Tete are richer than their urban counterparts and present the same (low) deprivation levels of Maputo City, the capital. In these monetary dimensions the urban/rural deprivation gap of Manica and Sofala is not as wide as it appeared in the supplementary dimensions, while the urban/rural Head Count Ratio gap of Gaza and Inhambane is significantly wider.

Therefore, introducing supplementary dimensions to the analysis of poverty in Mozambique substantially increases the amount and quality of available information, providing figures that often contrast with the ones derived solely from monetary poverty estimates.

In Figure 5.6 we present the average deprivation levels for each dimension and for all provinces divided by area of residence. The province of Maputo City only exhibits one bar as it does not have a rural area.

In Table 5.7 we show the ranking of each urban/rural area for all provinces in all dimensions of deprivation. As happened for provincial analysis, the Head Count Ratio and the Fuzzy Monetary (FM) measure retrieve very similar rankings, while those produced by supplementary dimensions differ both among them and with respect to monetary measures. On average, it appears that the ranking of some rural area sensibly worsens. This is the case for Cabo Delgado, Tete, Niassa. Instead, it improves for

other provinces, like Zambezia or Maputo Province.

1Again, the urban/rural difference increases for dimension FS5 when the variable "formal or informal job" is not considered: in this case the average urban deprivation becomes 0.51, while the rural one 0.70.

Table 5.6 – Deprivation by dimension, provincial and urban/rural level

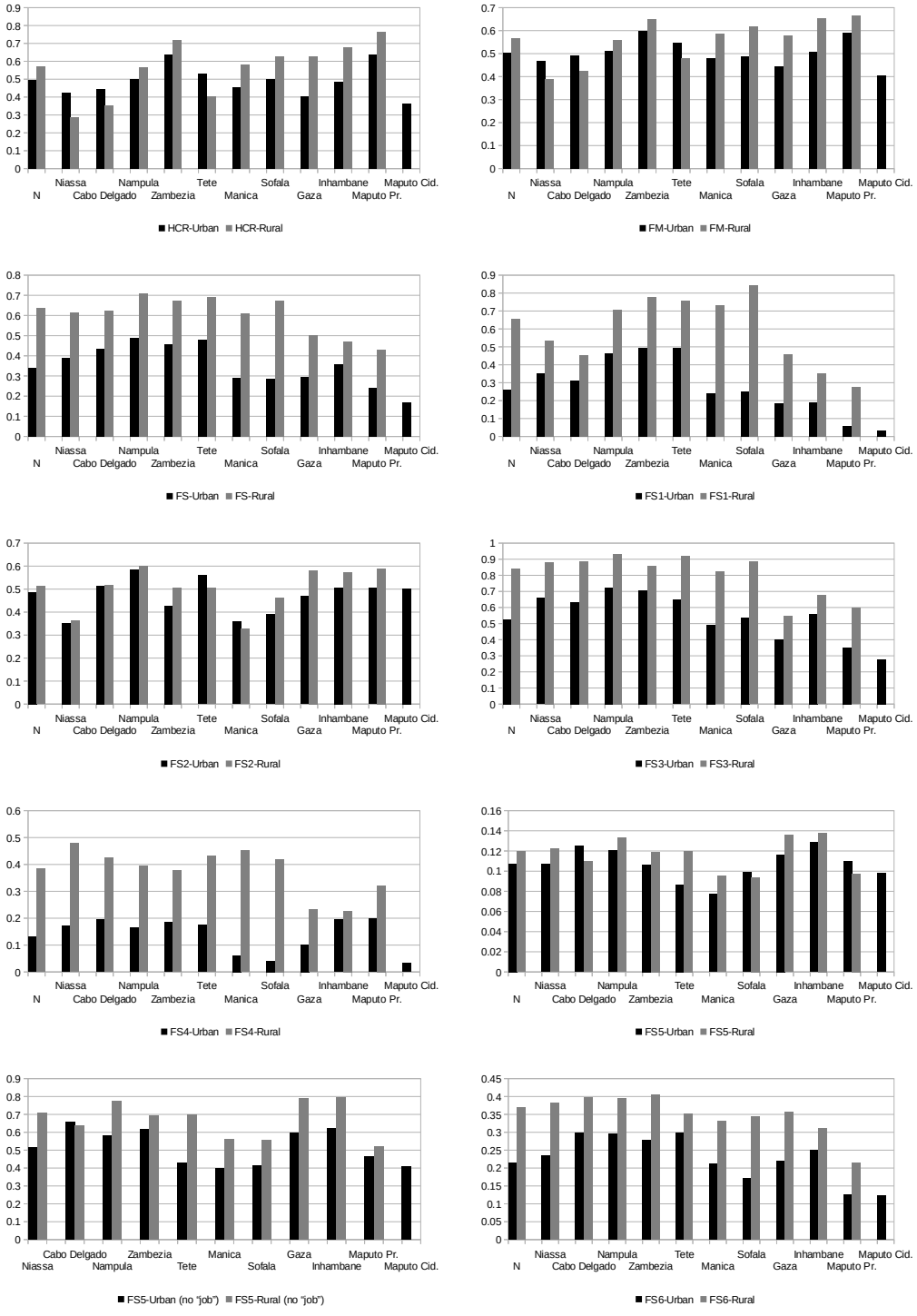
	Mozambique		Niassa		Cabo Delgado		Nampula		Zambezia		Tete	
	urban	rural	urban	rural	urban	rural	urban	rural	urban	rural	urban	rural
Head Count Ratio	0.4962	0.5691	0.4224	0.2892	0.4429	0.3552	0.499	0.5667	0.6362	0.718	0.5302	0.4015
SE	0.0164	0.0170	0.0512	0.0388	0.0866	0.0382	0.0548	0.0343	0.0680	0.0381	0.0798	0.0502
mean FM	0.5042	0.5656	0.4664	0.3893	0.4922	0.4239	0.5105	0.5607	0.5985	0.6503	0.5462	0.4808
SE	0.0114	0.0108	0.0221	0.0300	0.0588	0.0226	0.0400	0.0204	0.0485	0.0243	0.0478	0.0309
mean FS	0.339	0.6378	0.3887	0.6165	0.4358	0.623	0.4901	0.7072	0.4557	0.6743	0.479	0.6926
SE	0.0103	0.0067	0.0313	0.0301	0.0387	0.0191	0.0312	0.0155	0.0457	0.0119	0.0709	0.0190
mean FS1	0.2596	0.6545	0.3521	0.5357	0.3099	0.4538	0.4646	0.7068	0.4923	0.7756	0.4927	0.7588
SE	0.0113	0.0094	0.0269	0.0359	0.0232	0.0233	0.0325	0.0160	0.0543	0.0147	0.0958	0.0274
mean FS2	0.487	0.5119	0.3531	0.3639	0.5145	0.5183	0.5847	0.602	0.4285	0.5068	0.5599	0.5053
SE	0.0117	0.0087	0.0232	0.0267	0.0527	0.0227	0.0437	0.0159	0.0278	0.0159	0.0497	0.0323
mean FS3	0.5248	0.8421	0.6586	0.8822	0.6328	0.8862	0.7224	0.9333	0.7072	0.8581	0.6481	0.9191
SE	0.0133	0.0095	0.0334	0.0240	0.0675	0.0192	0.0385	0.0113	0.0484	0.0319	0.0779	0.0161
mean FS4	0.1317	0.3848	0.1711	0.4779	0.1951	0.4258	0.1637	0.3953	0.184	0.3768	0.1743	0.432
SE	0.0119	0.0136	0.0475	0.0493	0.0434	0.0418	0.0454	0.0357	0.0401	0.0280	0.0500	0.0410
mean FS5	0.1075	0.1195	0.1069	0.1221	0.1251	0.1099	0.1205	0.133	0.1064	0.1191	0.0866	0.1199
SE	0.0033	0.0024	0.0103	0.0079	0.0127	0.0064	0.0092	0.0046	0.0127	0.0072	0.0136	0.0075
mean FS6	0.2135	0.3699	0.2355	0.3821	0.2972	0.3969	0.2951	0.3945	0.2769	0.4039	0.2978	0.3525
SE	0.2135	0.3699	0.0221	0.0178	0.0232	0.0204	0.0161	0.0164	0.0349	0.0262	0.0371	0.0160
n	5222	5609	384	430	240	540	570	1005	336	1187	192	576

	Manica		Sofala		Gaza		Inhambane		Maputo Pr.		Maputo Cid.
	urban	rural	urban	rural	urban	rural	urban	rural	urban	rural	urban
Head Count Ratio	0.4537	0.5828	0.5005	0.6293	0.4049	0.6267	0.4836	0.6784	0.6366	0.7633	0.3615
SE	0.0505	0.0543	0.0721	0.0643	0.0429	0.0592	0.0612	0.0376	0.0276	0.0502	0.0239
mean FM	0.4818	0.5864	0.4865	0.6197	0.4459	0.5786	0.5059	0.6533	0.5914	0.6649	0.4054
SE	0.0322	0.0314	0.0474	0.0535	0.0268	0.0412	0.0427	0.0277	0.0195	0.0308	0.0182
mean FS	0.2888	0.6111	0.2849	0.6751	0.2969	0.5045	0.3566	0.469	0.2401	0.43	0.1672
SE	0.0255	0.0264	0.0318	0.0362	0.0269	0.0276	0.0545	0.0275	0.0134	0.0427	0.0066
mean FS1	0.2387	0.7322	0.2507	0.8436	0.185	0.4609	0.1875	0.3525	0.0584	0.2748	0.0323
SE	0.0314	0.0363	0.0404	0.0279	0.0276	0.0361	0.0534	0.0357	0.0058	0.0514	0.0029
mean FS2	0.3591	0.3263	0.3906	0.4639	0.4695	0.5817	0.5061	0.5738	0.5049	0.5902	0.5031
SE	0.0320	0.0230	0.0334	0.0626	0.0325	0.0287	0.0271	0.0288	0.0244	0.0520	0.0137
mean FS3	0.4919	0.823	0.5364	0.8831	0.4025	0.5494	0.56	0.6752	0.3523	0.5958	0.2768
SE	0.0350	0.0305	0.0488	0.0235	0.0363	0.0357	0.0466	0.0355	0.0219	0.0616	0.0159
mean FS4	0.0615	0.4509	0.0414	0.4196	0.1017	0.2327	0.1958	0.2272	0.1987	0.3213	0.0327
SE	0.0234	0.0519	0.0109	0.0588	0.0220	0.0348	0.0908	0.0496	0.0268	0.1058	0.0042
mean FS5	0.0775	0.0955	0.0989	0.0937	0.1164	0.1357	0.1285	0.1381	0.1096	0.0976	0.0979
SE	0.0069	0.0072	0.0147	0.0080	0.0076	0.0050	0.0089	0.0050	0.0082	0.0151	0.0069
mean FS6	0.2123	0.3311	0.1703	0.3435	0.2185	0.3567	0.2499	0.3099	0.1248	0.2145	0.1234
SE	0.0228	0.0195	0.0216	0.0367	0.0263	0.0382	0.0260	0.0200	0.0151	0.0380	0.0087
n	336	468	527	324	336	467	382	432	720	180	1199

Table 5.7 - Relative ranking according to the different dimensions of deprivation (1: lowest deprivation; 10: highest deprivation)

	HCR	FM	FS	FS1	FS2	FS3	FS4	FS5	FS6
Niassa urban	6	5	7	9	2	11	6	9	7
Niassa rural	1	1	16	16	4	17	21	16	18
Cabo Delgado urban	7	9	9	8	14	9	9	17	11
Cabo Delgado rural	2	3	17	11	15	19	18	11	20
Nampula urban	10	11	13	13	19	14	5	15	10
Nampula rural	13	13	21	17	21	21	16	19	19
Zambezia urban	17	17	10	14	6	13	8	8	9
Zambezia rural	20	19	18	20	13	16	15	13	21
Tete urban	12	12	12	15	16	10	7	2	12
Tete rural	4	6	20	19	11	20	19	14	16
Manica urban	8	7	4	5	3	4	3	1	4
Manica rural	14	15	15	18	1	15	20	4	14
Sofala urban	11	8	3	6	5	5	2	7	3
Sofala rural	16	18	19	21	7	18	17	3	15
Gaza urban	5	4	5	3	8	3	4	12	6
Gaza rural	15	14	14	12	18	6	13	20	17
Inhambane urban	9	10	6	4	12	7	10	18	8
Inhambane rural	19	20	11	10	17	12	12	21	13
Maputo Pr. urban	18	16	2	2	10	2	11	10	2
Maputo Pr. rural	21	21	5	7	20	8	14	5	5
Maputo Cid. urban	3	2	1	1	9	1	1	6	1

Figure 5.6 – Deprivation by dimension, provincial and urban/rural level



Note: The province of Maputo City does not have a rural area.

6. Conclusions

In this study we have shown how it is possible to construct poverty measures relative to monetary and non-monetary dimensions using Fuzzy Set Theory. We applied this technique to the Mozambican Household Budget Survey 2008-09 (IOF08) dataset, the most recent budget survey available for Mozambique.

Our main contribution to the analysis and measurement of poverty in Mozambique is twofold. On the one hand, we estimate a concept of poverty wider than monetary poverty, and therefore involving supplementary dimensions. At the same time, we have obtained reliable estimates of poverty rates at sub-national and urban/rural level, by using the Jackknife Repeated Replications method to compute standard errors.

To our knowledge, this is the first study that applies Fuzzy Set Theory to the measurement of poverty in Mozambique. As a result, the figures provided in the study substantially increase the amount and quality of available information about Mozambican households' deprivation. Our estimates -especially those obtained for non-monetary dimensions- complement the ones derived solely from the Head Count Ratio. They also provide new evidence with respect to provincial and urban/rural deprivation levels.

Concerning monetary poverty, the Fuzzy Monetary estimates essentially confirm the official results obtained using the Head Count Ratio. In particular, the ranking of poorer and richer provinces remains unchanged, also when the analysis is carried out at the urban/rural level. This is due to both measures - the Head Count and Fuzzy Monetary- being based on consumption data.

Conversely, innovative results come from the inclusion of supplementary dimensions of deprivation in the analysis of poverty: housing conditions; more widespread and affordable durable goods; less common, more expensive durable goods; housing quality; income-related deprivation; health and education. When such dimensions are considered, then some of the provinces with relatively low Head Count Ratios result among the most deprived with respect to supplementary dimensions of deprivation, and vice-versa. In particular, the Northern provinces and the Central province of Tete, all have much higher Fuzzy Supplementary (FS) averages with respect to their Fuzzy Monetary (FM) averages. The other Central provinces have similar statistics in both the FM and FS dimension, while the Southern provinces show FS averages that are lower than their respective FM averages (especially Maputo Province and Maputo City). Concerning individual supplementary dimensions, the higher level of development of the Southern provinces distinctly comes out in more than one dimension: housing

conditions (FS1); less common, more expensive durable goods (FS3); housing quality (FS4); and, to a lesser extent, health and education (FS6).

Furthermore, in our analysis we point out that deprivation values found in urban and rural areas are very different. When we consider non-monetary dimensions of deprivation it emerges that the urban/rural gap is much wider than it appears from Head Count Ratio or Fuzzy Monetary statistics. The aggregated Fuzzy Supplementary deprivation level for urban areas is estimated to be 0.34, whereas the one for rural areas exceeds 0.63. Moreover, the ranking of some rural area (Cabo Delgado, Niassa, Tete) sensibly worsens, while it improves for other provinces (Zambezia, Maputo Province).

A possible explanation of such difference between monetary and non-monetary poverty results is that some of the items included in the supplementary analysis are non-essential items, like fridge, car or PC. These items are not present in many areas of Mozambique and it can be objected that they tell very little about poverty status in such areas. Consequently, the highest average level of deprivation is found for FS3 (less common, expensive durable goods), as most Mozambicans do not possess any of the items included in this dimension, especially in the North and in the Centre. However, contrasting results with monetary poverty estimates also emerge for supplementary dimensions that are indeed important to denote a situation of deprivation, like housing conditions, housing quality, or health and education.

Analyses of poverty carried on in other Sub-Saharan countries also retrieved contrasting results when they focused on both monetary and non-monetary deprivation: for example Bradshaw and Steyn (2001) and Ngwane et al. (2001) study multidimensional poverty with various methods and find different rankings among South African regions. The same is true for Ghana (Appiah-Kubi et al., 2007) and for a group of other Sub-Saharan countries (Batana, 2008). However, from our study it appears that the extent to which Mozambican results differ is greater.

Our results are particularly relevant since Mozambique is among the poorest countries in the world, with a per capita income level of about $428 (World Bank, 2010), and several donor countries and international agencies involved in poverty reduction plans. A detailed information and definition of poorer provinces and areas is thus required and might orientate funds in different ways. Considering dimensions other than consumption substantially helps mapping the existing geographical differences regarding poverty. Particularly in a country like Mozambique, where monetary and non-monetary deprivation seem to have very different distribution patterns, especially at the provincial level and considering the area of residence.

Notes

[1] A possible alternative definition of the overall Fuzzy Supplementary indicator could be the simple average of the corresponding indicators; the advantage would be that the overall indicators would fulfill consistency properties with respect to decomposition (Chakravarty *et al.*, 1998; among others); the drawback would be that the weighted mean of the individual would not be equal to the Fuzzy Monetary and the Head Count Ratio indicators.

[2] An enumeration area (EA) represents the area assigned to each enumerator for distributing questionnaires to households and it is the smallest building block of the geographical frame for the Mozambican Household Budget Surveys.

[3] The eleven provinces of Mozambique are grouped into three bigger zones: the North, which includes the provinces of Niassa, Cabo Delgado and Nampula; the Centre, with the provinces of Zambezia, Tete, Manica and Sofala; the South, containing the provinces of Gaza, Inhambane, Maputo Province and Maputo City.

[4] Again, the urban/rural difference increases for dimension FS5 when the variable “formal or informal job” is not considered: in this case the average urban deprivation becomes 0.51, while the rural one 0.70.

References

Anand, S., Sen, A. (1997), *Concepts of human development and poverty: a multidimensional perspective*. UNDP New York.

Atkinson, A. (2002), *Social indicators: The EU and social inclusion*. Oxford University Press, USA.

Atkinson, A. (2003), Multidimensional deprivation: contrasting social welfare and counting approaches. *Journal of Economic Inequality*, **1(1)**, pp. 51-65.

Atkinson, A., Bourguignon, F. (1982), The comparison of multi-dimensioned distributions of economic status. *The Review of Economic Studies*, **49(2)**, pp. 183-201.

Betti, G., Cheli, B., Lemmi, A., Verma, V. (2006), Multidimensional and longitudinal poverty: an integrated fuzzy approach. In: Lemmi, A., Betti, G. (Eds.), *Fuzzy set approach to multidimensional poverty measurement*, Springer, pp. 115-137.

Betti, G., Ferretti, C., Gagliardi, F., Lemmi, A., Verma, V. (2009), Proposal for new multidimensional and fuzzy measures of poverty and inequality at national and regional level. Working Paper n. 83, Dipartimento di Metodi Quantitativi, Università di Siena.

Betti, G., Verma, V. (1999), Measuring the degree of poverty in a dynamic and comparative context: a multi-dimensional approach using fuzzy set theory. Proceedings, ICCS-VI, Vol. 11, pp. 289-301, Lahore, Pakistan, August 27-31, 1999.

Bourguignon, F., Chakravarty, S. (2003), The measurement of multidimensional poverty. *Journal of Economic inequality*, **1(1)**, pp. 25-49.

Castel-Branco, M. (2010), Intervention at the launch of the book “Economia extractiva e desafios de industrializacao em Mocambique". Instituto de Estudos Sociais e Economicos, 21/10/10, Maputo.

Cerioli, A., Zani, S. (1990), A fuzzy approach to the measurement of poverty. In: Dagum, C., Zenga, M. (Eds.), *Income and wealth Distribution, Inequality and Poverty*, Springer Verlag Berlin, pp. 272-284.

Chakravarty, S., Mukherjee, D., Ranade, R. (1998), On the family of subgroup and factor decomposable measures of multidimensional poverty. *Research on Economic Inequality*, **8**, pp. 175-194.

Chao, S., Kostermans, K. (2002), Improving health for the poor in Mozambique. The fight continues. Health, Nutrition and Population Discussion Paper. World Bank, Washington DC.

Cheli, B. (1995), Totally fuzzy and relative measures of poverty in dynamic context. *Metron*, **53**, pp. 183-205.

Cheli, B., Betti, G. (1999), Fuzzy analysis of poverty dynamics on an Italian pseudo panel, 1985-1994. *Metron*, **57**, pp. 83-104.

Cheli, B., Lemmi, A. (1995), A" Totally" fuzzy and relative approach to the multidimensional analysis of poverty. *Economic Notes*, **24**, pp. 115-134.

Chiappero Martinetti, E. (1994), A new approach to evaluation of well-being and poverty by fuzzy set theory. *Giornale degli Economisti e Annali di Economia*, **53**, pp. 367-388.

Chiappero Martinetti, E. (2006), Capability approach and fuzzy set theory: description, aggregation and inference issues. In: Lemmi, A., Betti, G. (Eds.), *Fuzzy Set Approach to Multidimensional Poverty Measurement*, Springer, pp. 93-113.

Duclos, J., Sahn, D., Younger, S. (2006), Robust Multidimensional Poverty Comparisons. *The Economic Journal*, **116(514)**, pp. 943-968.

Durbin, J. (1959), A note on the application of Quenouille's method of bias reduction to the estimation of ratios. *Biometrika*, **46(3/4)**, pp. 477-480.

Efron, B., Stein, C. (1981), The jackknife estimate of variance. *Annals of Statistics*, **9**, pp. 586-596.

Eurostat (2002), *Income, Poverty and Social Exclusion: 2nd Report*. Luxembourg: Office for Official Publications of the European Communities.

Eurostat (2009), *Description of SILC user database variables: cross-sectional and longitudinal*. Version 2007. Luxembourg: Office for Official Publications of the European Communities.

Filippone, A., Cheli, B., D'Agostino, A. (2001), Addressing the interpretation and the aggregation problems in totally fuzzy and relative poverty measures. ISER Working Paper n. 2001-22 University of Essex.

Government of Mozambique (2005), Education sector strategy plan II 2005-2009.

Hanlon, J. (2007), Is poverty decreasing in Mozambique?. IESE Conference Paper n.14.

INE (2004) Inquérito Nacional aos Agregados Familiares Sobre Orçamento Familiar 2002/3, http://www.ine.gov.mz/inqueritos_dir/iaf/

INE (2010) Inquérito Sobre Orçamento Familiar, 2008/09 – Quadros Básicos, http://www.ine.gov.mz/inqueritos_dir/iaf/

Kish, L., Frankel, M. (1974), Inference from complex samples. Journal of the Royal Statistical Society B(36), 1-37.

Klasen, S., 2000. Measuring poverty and deprivation in South Africa. *Review of Income and Wealth*, **46(1)**, pp. 33-58.

Kolm, S. (1977), Multidimensional egalitarianisms. *The Quarterly Journal of Economics*, **91**, pp. 1-13.

Maasoumi, E. (1986), The measurement and decomposition of multi-dimensional inequality. *Econometrica*, **54**, pp. 771-779.

MPF (2004), Poverty and Well-Being in Mozambique: The Second National Assessment (2002-2003). National Directorate of Planning and Budget, Ministry of Planning and Finance, Economic Research Bureau, Ministry of Planning and Finance, International Food Policy Research Institute, Purdue University.

MPD-DNEAP (2010), Poverty and wellbeing in Mozambique: third national poverty assessment. Maputo: Ministério da Planificação e Desenvolvimento - Direcção Nacional de Estudos e Análise de Políticas.

MPF (1998), Poverty and Well-Being in Mozambique: The First National Assessment (1996-1997). Ministry of Planning and Finance, Universidade Eduardo Mondlane, International Food Policy Research Institute.

Ossemane, R. (2010), O dilema do crescimento empobrecedor. 26/10/10, Tete, Mozambique.

Republic of Mozambique (2006), Action plan for the reduction of absolute poverty 2006-2009.

Sen, A. (1999), *Development as freedom*. Oxford University Press, Oxford.

Shao, J., Tu, D. (1995), *The Jackknife and Bootstrap*. Springer-Verlag, Inc.

Smeeding, T., Saunders, P., Coder, J., Jenkins, S., Fritzell, J., Hagenaars, A., Hauser, R., Wolfson, M. (1993), Poverty, inequality and family living standards impacts across seven nations: The effect of non-cash subsidies for health, education and housing. *Review of Income and Wealth*, **39**, pp. 229-256.

Townsend, P. (1979), *Poverty in the United Kingdom*. Allen Lane, Harmondsworth.

Tsui, K. (1995), Multidimensional generalizations of the relative and absolute inequality indices: the Atkinson-Kolm-Sen approach. *Journal of Economic Theory*, **67(1)**, pp. 251-265.

Van den Boom, B. (2011), Analysis of poverty in Mozambique. Available at:
http://undp.org.mz/en/Publications/Other-Publications/Analysis-of-poverty-in-Mozambique

Verma, V. (Ed., 1993), Sampling Errors in Household Surveys: A Technical Study. New York: United Nations Department for Economic and Social Information and Policy Analysis, Statistical Division, INT-92-P80-15E.

Verma, V., Betti, G. (2011), Taylor linearization sampling errors and design effects for poverty measures and other complex statistics. *Journal of Applied Statistics*, **38(8)**, pp. 1549-1576.

Vero, J., Werquin, P. (1997), Reexamining the Measurement of Poverty: How Do Young People in the Stage of Being Integrated in the Labor Force Manage. *Economie et Statistique*, **8(10)**, pp. 143-156.

Whelan, C., Layte, R., Maitre, B., Nolan, B. (2001), Income, deprivation, and economic strain. An analysis of the European Community Household Panel. *European Sociological Review*, **17(4)**, pp. 357-372.

WHO (2011), Nutritional status. Available at:
http://www.childinfo.org/undernutrition_nutritional_status.php

World Bank (2008), Beating the odds: sustaining inclusion in Mozambique's growing economy. Washington D.C.: The World Bank.

World Bank (2010), World Development Report 2010: Development and Climate Change. Washington D.C.: The World Bank.

World Bank (2011), World Development Indicators 2010. Washington D.C.: The World Bank.

Zadeh, L. (1965), Fuzzy sets. *Information and control*, **8(3)**, pp. 338-353.

Appendix A.1 - Exploratory Factor Analysis results and subsequent calibration

Exploratory Factor Analysis results	Calibration results
Factor 1 ***(became dimension 1)***	**1. Housing conditions**
d1. Bed	d1. Bed
d2. Proper house	d2. Proper house
d3. High-quality walls	d3. High-quality walls
d4. High-quality roof	d4. High-quality roof
d5. High-quality floor	d5. High-quality floor
d6. Has WC or latrine	d6. Has WC or latrine
d8. Telephone or mobile phone *(moved to dimension 2)*	d7. Number of rooms/(household members)^2
Factor 2 ***(became dimension 4)***	**2. More widespread durable goods**
d21. Energy source for cooking	d8. Telephone or mobile phone
d22. Energy source for in-house lighting	d9. TV
Factor 3	d10. Bike
d9. TV *(moved to dimension 2)*	d11. Radio
d14. Tools	d12. Watch
d15. Electric or coal iron	d13. Motorbike
d16. Fridge or freezer	**3. Less common, expensive durable goods**
d23. Hotplate or gas ring *(moved to dimension 4)*	d14. Tools
d25. Fan or air conditioner *(moved to dimension 4)*	d15. Electric or coal iron
d26. A bank account *(moved to dimension 5)*	d16. Fridge or freezer
Factor 4 ***(became dimension 2)***	d17. New or second-hand car
d10. Bike	d18. Computer
d11. Radio	d19. Printer
d12. Watch	d20. Sewing machines
Factor 5 ***(became dimension 6)***	**4. Housing quality**
d7. Number of rooms/(household members)^2 *(moved to dimension 1)*	d21. Energy source for cooking
d29. Ability to read and write	d22. Energy source for in-house lighting
d30. Education level	d23. Hotplate or gas ring
Factor 6 ***(became dimension 3)***	d24. Has access to safe water
d17. New or second-hand car	d25. Fan or air conditioner
d18. Computer	**5. Income-related deprivation**
d19. Printer	d26. A bank account
d20. Sewing machines	d27. A formal or informal job
Factor 7	d28. More than two meals per day
d27. A formal or informal job *(moved to dimension 5)*	**6. Health and education**
Factor 8	d29. Ability to read and write
d13. Motorbike *(moved to dimension 2)*	d30. Education level
d28. More than two meals per day *(moved to dimension 5)*	d31. Chronic illness
Factor 9	d32. Child malnutrition
d24. Has access to safe water *(moved to dimension 4)*	

Appendix A.2 - Sensitivity Analysis

Here we present the results of a sensitivity analysis that is performed to assess the robustness of the selection of the items for the subsequent Fuzzy Set poverty analysis. This is done by implementing a leave-one-out process in which one item at the time is excluded from the analysis. After the exclusion, an Exploratory Factor Analysis is run and we check for the number of changes that occur with respect to the baseline analysis. In particular, we check whether the number of dimensions (factors) varies, and how many items pass from a factor to another (Column 1 and 2 of Table A.2.1).

Afterwards, the same calibration process shown in Appendix A.1 is applied, and we report the summary statistics that describe the goodness of fit of such calibration: Goodness of Fit (GFI), GFI adjusted for degrees of freedom (AGFI), Root Mean Square Residual (RMR), Parsimonious GFI, and Root Mean Squared Error of Approximation (RMSEA).

Finally, at the bottom of Table A.2.1 the average values of deprivation for each supplementary dimension are presented.

From the results of the sensitivity analysis it is possible to notice that for most of the items the procedure is quite robust. The number of dimensions remains fairly stable: for 19 items it does not change at all compared with the baseline, while for the remaining 13 items it decreases at most by one dimension, from 8 to 7. Concerning the number of items that change their position from one dimension to another in each run, we have that for 13 items no change is observed. For other 16 items this number is comprised between 1 and 3 changes, while only the exclusion of “proper house”, “high-quality roof” and “child malnutrition” generates more sensible modifications (respectively 11, 8 and 4 changes).

All the goodness of fit statistics derived from the calibration procedure and the Confirmatory Factor Analyses retrieve satisfactory results, in line with the baseline analysis presented in the study.

The average values of deprivation for supplementary dimensions are also shown to be robust to the exclusion of most items. For FS1 (housing conditions), only the exclusion of improved sanitation related variables provokes a significant increase in its average, while for FS2 (more widespread durable goods) the biggest change comes from the exclusion of “owning a radio”. When we do not consider the possession of an electric or coal iron, then the FS3 dimension (less common, expensive durable goods) increases its average deprivation value by more than ten percentage points. For the dimension FS4 (housing quality) the items that cause greater modifications are “access to safe water” and “energy source for in-house lighting”: the former makes deprivation increase by 13 percentage points, while the

latter makes it decrease from 0.31 to 0.21. The most relevant changes, however, occur in the dimension FS5 (income-related deprivation). Here, the exclusion of certain items -the ones related to health and education- brings about a decrease in deprivation of about nine percentage point. Furthermore, when the variable “formal or informal job” is excluded from the analysis, the deprivation value for this dimension increases from 0.12 to 0.64. Even though it leaves unaltered the values of all the other dimensions, this represents a very big change, and for this reason we analysed it in greater detail throughout the study. The dimension FS6, instead, appears to be more robust to the exclusion of items. The most significant changes for all dimensions and summary statistics are marked in bold in Table A.2.1.

Table A.2.1 – Sensitivity Analysis

Excluded item	Number of dimensions	Number of items changing dimension	GFI	AGFI	RMR	Parsimonious GFI	RMSEA
-	8	-	0.834	0.8086	0.0807	0.77	0.0748
Has access to safe water	**7**	2	0.831	0.8042	0.0828	0.7649	0.077
New or second-hand car	8	-	0.8365	0.8105	0.0806	0.7699	0.0759
Has WC or latrine	8	-	0.837	0.8112	0.0816	0.7704	0.0758
Bike	8	2	0.842	0.8168	0.08	0.775	0.0744
Proper house	**7**	**11**	0.8389	0.8138	**0.0987**	0.774	0.0799
Tools	8	-	0.8326	0.806	0.0802	0.7663	0.0764
Telephone or mobile phone	8	-	0.8428	0.8179	0.0805	0.7758	0.0747
Computer	**7**	3	0.8488	0.8248	0.078	0.7813	0.0712
A bank account	8	-	0.8399	0.8144	0.0786	0.773	0.075
Energy source for cooking	8	-	0.8385	0.8128	0.0804	0.7718	0.0752
Sewing machines	**7**	3	0.8308	0.8039	0.0829	0.7647	0.0771
Electric or coal iron	8	-	0.8438	0.819	0.0785	0.7767	0.0746
Hotplate or gas ring	8	-	0.844	0.8192	0.0777	0.7769	0.074
Fridge or freezer	8	-	0.8416	0.8165	0.0764	0.7747	0.0736
Energy source for in-house lighting	**7**	3	0.8366	0.8107	0.0811	0.7701	0.0758
A formal or informal job	**7**	2	0.8314	0.8046	0.0826	0.7652	0.0769
Ability to read and write	**7**	3	0.8466	0.8223	**0.064**	0.7793	0.0719
Bed	8	1	0.84	0.8146	0.0802	0.7731	0.075
Chronic illness	**7**	-	0.8298	0.8028	0.0832	0.7638	0.0773
Motorbike	8	-	0.8316	0.8048	0.0827	0.7654	0.0769
High-quality walls	**7**	3	0.8423	0.8173	0.0819	0.7753	0.0746
Watch	8	1	0.8359	0.8098	0.0816	0.7694	0.0761
More than two meals per day	8	-	0.8335	0.8071	0.0824	0.7672	0.0766
High-quality floor	8	2	0.8457	0.8212	0.0818	0.7784	0.074
Radio	8	1	0.841	0.8158	0.0805	0.7741	0.0749
Printer	**7**	3	0.8459	0.8214	0.0791	0.7786	0.0721
Number of rooms/(household members)^2	**7**	3	0.8362	0.8102	0.0814	0.7697	0.0756
Education level	**7**	3	0.8511	0.8274	**0.0639**	0.7833	0.071
High-quality roof	**7**	**8**	0.8557	0.8328	0.0736	0.7876	0.0701
TV	8	-	0.8431	0.8181	0.0787	0.776	0.0744
Fan or air conditioner	8	1	0.842	0.8168	0.078	0.775	0.0743
Child malnutrition	8	**4**	0.8328	0.8063	0.0821	0.7666	0.0766

Excluded item	FS1	FS2	FS3	FS4	FS5	FS6
-	0.5345	0.5043	0.7457	0.3079	0.1158	0.3224
Has access to safe water	0.5302	0.5002	0.7419	**0.4396**	0.1119	0.318
New or second-hand car	0.5343	0.5041	0.7445	0.3077	0.1156	0.3221
Has WC or latrine	**0.6039**	0.5042	0.7456	0.3077	0.1157	0.3222
Bike	0.533	0.5277	0.7451	0.3065	0.1145	0.3208
Proper house	0.5339	0.5043	0.7457	0.3079	0.1158	0.3224
Tools	0.5343	0.5041	0.7356	0.3077	0.1156	0.3221
Telephone or mobile phone	0.5349	0.5142	0.7458	0.3082	0.1162	0.3228
Computer	0.5343	0.5042	0.7455	0.3077	0.1157	0.3222
A bank account	0.5342	0.5041	0.7434	0.3067	0.1027	0.3221
Energy source for cooking	0.5343	0.5041	0.7435	0.2929	0.1157	0.3222
Sewing machines	0.534	0.5039	0.7433	0.3075	0.1154	0.3219
Electric or coal iron	0.536	0.5058	**0.8861**	0.3092	0.1172	0.3239
Hotplate or gas ring	0.534	0.5039	0.7433	0.3095	0.1154	0.3219
Fridge or freezer	0.5343	0.5041	0.7356	0.3077	0.1157	0.3222
Energy source for in-house lighting	0.5347	0.5046	0.7436	**0.2125**	0.1161	0.3226
A formal or informal job	0.5226	0.493	0.7391	0.2966	**0.6386**	0.3102
Ability to read and write	0.5344	0.5043	0.7435	0.3069	**0.0309**	0.3295
Bed	0.5414	0.5044	0.7457	0.308	0.1159	0.3225
Chronic illness	0.5315	0.5014	0.7424	0.3043	**0.0298**	**0.3496**
Motorbike	0.5344	0.5033	0.7456	0.3078	0.1158	0.3223
High-quality walls	0.5296	0.5042	0.7456	0.3078	0.1157	0.3222
Watch	0.5345	0.4994	0.7457	0.3079	0.1159	0.3224
More than two meals per day	0.5344	0.5043	0.7435	0.3069	**0.031**	0.3223
High-quality floor	0.5294	0.5043	0.7457	0.3078	0.1158	0.3223
Radio	0.5343	**0.5377**	0.7456	0.3077	0.1157	0.3222
Printer	0.5343	0.5042	0.7457	0.3077	0.1157	0.3222
Number of rooms/(household members)^2	0.5488	0.5023	0.7449	0.306	0.1139	0.3202
Education level	0.5342	0.5041	0.7434	0.3067	**0.0308**	**0.2946**
High-quality roof	0.5319	0.5043	0.7457	0.3079	0.1158	0.3224
TV	0.5344	0.5006	0.7456	0.3078	0.1157	0.3222
Fan or air conditioner	0.5341	0.5039	0.7434	0.3071	0.1155	0.3219
Child malnutrition	0.534	0.5039	0.7433	0.3065	**0.0307**	0.3247

Appendix B - Jackknife Repeated Replication (JRR) for variance estimation

The Jackknife Repeated Replication (JRR) is one of a class of methods for estimating sampling errors from comparisons among sample replications which are generated through repeated resampling of the same parent sample.

We prefer to use the JRR instead of other methods like bootstrapping as it is less computer-intensive, in that the JRR only provides estimates of the variance of the point estimator, while bootstrapping estimates its whole distribution. Moreover, the bootstrap may be seen as a random approximation of the general version of the JRR we chose, and while it gives different results when repeated on the same data, the Jackknife gives exactly the same result each time (Shao and Tu, 1995).

In the JRR procedure each replication needs to be a representative sample in itself and to reflect the full complexity of the parent sample. However, in so far as the replications are not independent, special procedures are required in constructing them so as to avoid bias in the resulting variance estimates. We prefer the JRR to similar methods such as the Balanced Repeated Replication because the JRR is generally simpler and more flexible.

Originally introduced as a technique of bias reduction, the Jackknife method has by now been widely tested and used for variance estimation (Durbin, 1959). Efron and Stein (1981) provide a discussion of the Jackknife methodology. As a landmark empirical study of such applications, see Kish and Frankel (1974). For a general description of JRR and other practical variance estimation methods in large-scale surveys, see Verma (1993). For a comparative analysis between JRR and Taylor linearisation methods see Verma and Betti (2011).

The JRR variance estimates take into account the effect on the variance of aspects of the estimation process which are allowed to vary from one replication to another. In principle this can include complex effects such as those of imputation and weighting. But it has to be noted that often in practice it is not possible to repeat such operations entirely fresh at each replication.

The basic model of the JRR for application in the context described above may be summarised as follows. Consider a design in which two or more primary units have been selected independently from each stratum in the population. Within each primary sampling unit (PSU), subsampling of any complexity may be involved, including weighting of the ultimate units.

In the ‘standard’ version, each JRR replication can be formed by eliminating one sample PSU from a particular stratum at a time, and increasing the weight of the remaining sample PSU's in that stratum

appropriately so as to obtain an alternative but equally valid estimate to that obtained from the full sample.

The above procedure involves creating as many replications as the number of primary units in the sample. The computational work involved is sometimes reduced by reducing the number of replications required. For instance, the PSUs may be grouped within strata, and JRR replications formed by eliminating a whole group of PSUs at a time. This is possible only when the stratum contains several units. Alternatively, or in addition, the groupings of units may cut across strata. It is also possible to define the replications in the standard way ('delete one-PSU at a time Jackknife'), but actually construct and use only a subsample of them.

In the kind of multistage samples encountered in most national household surveys, it is possible to apply the standard JRR method without such grouping of units. However, one common situation in which grouping of units is unavoidable is when the sample or a part of it is a direct sample of ultimate units or of small clusters, so that the number of replications under 'standard' JRR is too large to be practical. Normally, the appropriate procedure to reduce this number would be to form new computational units by forming random groupings of the units within strata. The presence of small and variable-sized PSUs may also require some grouping in the practical application of the procedure.

Briefly, the standard JRR involves the following.

Let u be a full-sample estimate of any complexity, and $u_{(hi)}$ be the estimate produced using the same procedure after eliminating primary unit i in stratum h and increasing the weight of the remaining (a_h-1) units in the stratum by an appropriate factor g_h (see below). Let $u_{(h)}$ be the simple average of the $u_{(hi)}$ over the a_h values of i in h. The variance of u is then estimated as:

$$\mathrm{var}(u) = \Sigma_h \left[(1 - f_h) . \frac{a_h - 1}{a_h} . \Sigma_i \left(u_{(hi)} - u_{(h)} \right)^2 \right]. \qquad (5)$$

A major advantage of a procedure like the JRR is that, under quite general conditions for the application of the procedure, the same and relatively simple variance estimation formula (5) holds for u of any complexity.

A possible variation which may be mentioned is to replace $u_{(h)}$, the simple average of the $u_{(hi)}$ over the a_h replications created from h, by the *full-sample* estimate u:

$$\mathrm{var}(u) = \Sigma_h \left[(1 - f_h) . \frac{a_h - 1}{a_h} . \Sigma_i \left(u_{(hi)} - u \right)^2 \right]. \qquad (5')$$

This version tends to provide a 'conservative' estimate of variance, but normally the difference with (5)

is small. We have used form (5) in the empirical analysis for Mozambique.

Concerning the re-weighting of units retained in a stratum after dropping one unit, normally the factor g_h is taken as (6.a), but for reasons noted below, we propose the form in (6.w):

$$g_h = a_h / (a_h - 1), \qquad (6.a)$$

$$g_h = w_h / (w_h - w_{hi}) \qquad (6.w)$$

where $w_h = \Sigma_i w_{hi}$, $w_{hi} = \Sigma_j w_{hij}$, the sum of sample weights of ultimate units *j* in primary selection *i*.

Note that (6.a) gives the variance of a simple aggregate, while (6.w) gives the corresponding (lower) variance of a mean, or of total as a ratio estimate.

Form (6.w) is used throughout in our empirical analysis here. This form retains the total weight of the included sample cases unchanged across the replications created -the same total as that for the full sample-. With the sample weights scaled such that their sum is equal (or proportional) to some external more reliable population total, population aggregates from the sample can be estimated more efficiently, often with the same precision as proportions or means.