Economics Bulletin

Volume 35, Issue 3

A Multidimensional Analysis of Poverty using the Fuzzy Set Approach. Evidence from Cameroonian data

Joseph Siani
Department of Economics, University of Caen Basse-Normandie

Abstract

In economics poverty has most often been assessed by resorting to monetary variables, and its manifestation perceived as dichotomous. This analysis is based upon the splitting of the population into poor and non-poor according to a poverty line. However, since the seminal works of Townsend (1979) and Sen (1985), the concept of poverty has evolved to incorporate aspects of well-being not captured by income measures alone. Moreover, dividing the population by means of an arbitrary poverty line is seen as unrealistic (Cerioli and Zani, 1990). The totally fuzzy approach of Cerioli and Zani (1990) is discussed and applied to Cameroon using data from the ECAM3 survey (2007). Monetary and non-monetary indicators are combined to estimate the fuzzy index of poverty (FIP). Furthermore, the paper contrasts the income headcount ratio with the fuzzy poverty estimates. The results reveal that poverty was higher in 2007, contrary to the country's official report of a lower poverty index for the same year, indicating that the traditional money metric approach does not accurately identify the most deprived in society.

Citation: Joseph Siani, (2015) "A Multidimensional Analysis of Poverty using the Fuzzy Set Approach. Evidence from Cameroonian data", *Economics Bulletin*, Volume 35, Issue 3, pages 2012-2025
Contact: Joseph Siani - sianijosephr@yahoo.fr.
Submitted: November 26, 2014. **Published:** September 22, 2015.

1 Introduction

Despite unprecedented growth of the world economy, poverty remains a crucial issue in many countries, but accurate information about the dimensions of poverty and a suitable measurement are essential in crafting efficient public policy. Poverty studies have most often suffered from two limitations: the exclusive focus on income or consumption expenditure as a proxy of well-being[1] and the application of an arbitrary poverty threshold to partition the population into poor and non-poor.[2] While these limitations simplify the analysis[3], they obscure the extent and causes of hardships, thereby hampering the development of well-targeted and effective programs to curb poverty in the long-run.[4]

Income alone does not tell us much about how people fare in terms of well-being. It is certainly true that with a higher income or consumption expenditure a person may be better-off.[5] However, a relatively high income can go hand in hand with being deprived in other dimensions which are essential components of the quality of life.[6] Therefore, income as the sole indicator of well-being is inappropriate to determine who is poor and who is not poor, and should be supplemented by non-monetary indicators. Furthermore, setting a poverty line to identify the poor from the non-poor is unrealistic (Cerioli and Zani 1990; Cheli and al. 1994) because it is not certain where the boundary between poor and non-poor can be drawn.[7] To overcome these limitations, the theory of fuzzy sets offers a suitable mathematical tool.

The contribution of this paper is that it offers an illustration of the fuzzy set approach to poverty measurement using the database coming from the third round of the Cameroon Living Conditions Survey ECAM3. It contrasts the income headcount ratio with the multi-dimensional fuzzy estimates. The results will enable us to identify the dominant dimensions of poverty as well as the poorest regions and thereby serve as a basis for a better targeting as far as policies for poverty reduction are concerned. This paper is structured as follows. Section 2 describes the fuzzy set approach to multidimensional poverty measurement as proposed by Cerioli and Zani (1990). Section 3 describes the data and the attributes used. Section 4 discusses the main empirical findings while a final section concludes and gives some policy recommendations.

---

[1] Using the Alkire-Foster counting approach to estimate the evolution of poverty in Cameroon between 2001 and 2007, Siani (2013) shows that there is considerable difference between the picture of poverty that emerges from examining income or expenditure alone to that which emerges from the use of income supplemented with non-monetary attributes.

[2] Cheli and Lemmi (1995) pointed out that poverty is not a simple attribute that characterizes and individual in terms of its presence or absence. The relative hardship or well-being, they continue, is clearly a matter of degree.

[3] Using income as a measure of welfare provides decision makers with an easy-to-understand description of welfare. For example, the headcount ratio can be interpreted as the number of poor people. Along the same line, the poverty gap can be easily understood as the total amount of money needed to make every poor person's income equal to a poverty line.

[4] Following Dagum (2002), we argue that unidimensional measures of poverty only plead for transfer policies that alleviate poverty in the short-term, whereas multidimensional measures permit us to recommend structural socioeconomic policies that could break the intergenerational reproduction mechanism of poverty in the long-term.

[5] For Sen, that concentration on the monetary aspect of poverty is natural because there is no doubt, given other things, that an increase in income must make a contribution to the living conditions of people in question (Sen, 1988:12).

[6] Similarly, someone who has low consumption expenditures is not necessarily poor as it can be the result of a choice consisting in selecting cheaper goods and services.

[7] People in similar circumstances can happen to lie on opposite sides of a poverty line (Makdissi and Wodon 2004).

2 Methodology

The fuzzy set theory was developed by Zadeh (1965) in a seminal article entitled "Fuzzy sets"[8] and developed by Dubois and Prade (1980). This allows for the treatment of vague concepts such as poverty.[9]
According to the traditional approach, the population is divided between poor and non-poor by means of a poverty line, i.e. you either belong to the set of the poor, or not. There are no "partially poor people". The fuzzy approach, on the other hand, allows people some degree of belonging to the set of the poor. This approach has two critical levels: a minimum level, below which a person can be regarded as definitely poor, and a maximum level, above which a person absolutely does not belong to the set of poor people. If a person were to fall between these two levels, he or she then would belong to the set of poor people *to some degree*.[10]

Formally, let n be a population of individuals - actually households - and m a finite list of attributes or dimensions of poverty. Each individual i is identified by a vector $\mathbf{x}_i := (x_i^1, \ldots, x_i^m) \in \mathscr{X} := \mathscr{X}^1 \times \ldots \times \mathscr{X}^m$, where $x_i^j \in \mathscr{X}^j$ is the situation of individual $i \in \{1, 2, \ldots, n\}$ with respect to attribute $j \in \{1, 2, \ldots, m\}$, and $\mathscr{X}^j$ is the set of values that the attribute j can take. The attributes are of three different types: cardinal, ordinal and bi-categorical. We have $\mathscr{X}^j \subset \mathbb{R}_+$ if attribute j is cardinal (income), $\mathscr{X}^j = \left\{c_1^j, c_2^j, \ldots, c_{q^j}^j\right\}$, where $c_1^j < c_2^j < \ldots < c_{q^j}^j$, if it is ordinal (education), and $\mathscr{X}^j = \{0, 1\}$, if it is bi-categorical (television). In the standard approach, one assumes a poverty line $z^j \in \mathscr{X}^j$ for each attribute j and individual i is said to be poor in attribute j if $x_i^j < z^j$.[11] According to the fuzzy approach to poverty, we are sure that i is poor in attribute j if $x_i^j < z_-^j$ and equally sure that she is non-poor if $z_+^j < x_i^j$, where $z_-^j, z_+^j \in \mathscr{X}^j$ and $z_-^j < z_+^j$.[12] If $x_i^j \in [z_-^j, z_+^j]$, then we are not certain that i is poor in attribute j but we assume that the likelihood of i to be poor in j decreases as x_i^j increases. This basic idea is captured by the membership function $\delta^j : \mathscr{X}^j \to [0, 1]$ for attribute j defined by

$$\delta^j(s) = \begin{cases} 1, & \text{if } s \leq z_-^j, \\ f^j(s), & \text{if } z_-^j < s < z_+^j, \\ 0, & \text{if } z_+^j \leq s, \end{cases} \tag{1}$$

where $f^j(z_-^j) = 1$, $f^j(z_+^j) = 0$ and $f^j(s)$ is decreasing over $[z_-^j, z_+^j] \cap \mathscr{X}^j$. This leaves open a lot of possibilities regarding the choice of the function f^j that can be linear as in the paper, or convex, or concave. Zhen (2013) provide arguments for choosing a s-shaped membership function. Then, the overall poverty membership function $\delta : \mathscr{X} \to [0, 1]$ is defined by:

[8] Zadeh (1965) defined fuzzy sets as "a class of objects that do not have precisely defined criteria of membership, but rather can be characterized by a continuum of grades of memberships".

[9] Sen (1989:317-318) suggests that fuzzy set theory is a useful technique for approaching inexactness or vagueness.

[10] Cerioli and Zani (1990) developed the first fuzzy poverty measures. However, Kundu and Smith (1983) discussed the possibility of using the concepts of fuzzy set theory in the poverty measurement study ahead of Cerioli and Zani (1990), though they did not provide a concrete method.

[11] For binary variables, the logic of traditional set theory is directly applied. So if household i owns attribute j, then it is natural to conclude that that household does not belong to the subset of poor with respect to the attribute j. However, if household i does not own the attribute j, then that household completely belongs to the subset of poor with respect to j.

[12] For example, for a five-step ordinal variable like health condition, 1 being the poorest health, 1 is z_-^j. By the same logic 5 being the most healthy, z_+^j is 5.

$$\delta(s^1, \ldots, s^m) := \sum_{j=1}^{m} \alpha_j \delta^j(s^j), \tag{2}$$

where $\alpha_j \geq 0$ for all j, and $\sum_{j=1}^{m} \alpha_j = 1$
The poverty ratio of the i^{th} household $\delta_P(x_i)$, i.e., the degree of membership of the i^{th} household to the fuzzy set P is defined as the weighted average of x_i^j as follows:

$$\delta_P(x_i) = \frac{\sum_{j=1}^{m} w_j \delta^j(x_i^j)}{\sum_{j=1}^{m} w_j} \tag{3}$$

where w_j is the weight attached to the j^{th} attribute.

The poverty ratio $\delta_P(x_i)$ measures the degree of poverty of the i^{th} household as a weighting function of the m attributes. Hence, it measures the relative deprivation of the i^{th} household to reach a living standard of the society to which it belongs.

The weight w_j attached to the j^{th} attribute stands for the intensity of deprivation of x^j. It is an inverse function of the degree of deprivation in this attribute that is experienced by the population of households. The smaller the number of households and the amount of their deprivation of x^j , the greater the weight w_j. This essentially implies that the more an attribute is present in the population, the fewer the number of households deprived and the more important it becomes. Consequently, such an attribute is likely to attract a greater weight among the attributes included in $\mathscr{X}^j$. In order to reduce the arbitrariness involved in the estimation of the weight, Cerioli and Zani (1990)[13] propose a logarithimic function, which they define as follows:

$$w_j = log\left(\frac{1}{\bar{\delta}(x^j)}\right) \tag{4}$$

where

$$\bar{\delta}(x^j) = \frac{1}{n} \sum_{i=1}^{n} \delta^j(x_i^j)$$

$\bar{\delta}(x^j)$ is the average deprivation experienced in dimension x^j.

To get an overall picture of poverty in a geographical area or some subset of the population, the fuzzy approach allows for the creation of a fuzzy poverty index (FIP) by simply calculating the mean poverty for that area or subset:

$$FIP = \frac{1}{n} \sum_{i=1}^{n} \delta_P(x_i) \tag{5}$$

[13]Further interesting proposals on the weighting structure are developed, among the others, by Cheli and Lemmi (1995) and Betti and Verma (1999).

3 Choosing indicators of deprivation

The methodology described above will now be applied to the data obtained from the third round of the Cameroon Living Conditions Survey ECAM3. This survey was conducted nationwide in 2007 by the Cameroon National Institute of Statistics. The data were collected from households across the country in both rural and urban areas. The total number of households surveyed is 5026 and 6365 for rural and urban areas respectively. Twelve regions were created for the sample: the two biggest cities, Douala, Yaounde[14] and the 10 administrative regions of the country.

To estimate fuzzy poverty measures, we first need to select the indicators of deprivation. The selection can be constrained by the availability of data or dependent on the purpose of the study. However, whatever the selection, indicators must be faithful, and reflect clearly the real state of the population. In other words, the indicators must be faithful to what is perceived by just observing reality. Here, we select $k = 10$ variables relative to the household expenditure, educational achievement, ownership of durable goods, housing characteristics, and quality of the housing. The different attributes or indicators of poverty used in the analysis are presented in table 1.

Table 1: Indicators of deprivation

Indicator	Description of the indicator
Income (X_1)	Household per capita expenditure
Education (X_2)	Educational achievement of the household head
Health (X_3)	Use of health facilities during illness
Refrigerator (X_4)	Possession of a refrigerator
Television (X_5)	Possession of a television
Housing (X_6)	Housing characteristic
Electricity (X_7)	Type of electricity access
Water (X_8)	Type of water access
Sanitation (X_9)	Type of sanitation facilities
Occupancy status (X_{10})	Housing occupancy status

We now have to specify the form of the membership function - the degree to which a household belongs to the set of poor people - for each indicator. Our indicators are of three types: continuous (income); binary (refrigerator and television) and the remaining ones are ordinal. For the dichotomic indicators, the membership function is obvious. An individual belongs to the subset of deprived people according to each dichotomic indicator, unless he is equipped with the good in question. For the continuous and ordinal variables, we use the membership function proposed by Cerioli and Zani (1990) in Equation 1.

1. Income: This is the market value of all goods and services including food, clothing, and housing, purchased by the household. z^j_- is set at 60 per cent of sample median per capita expenditure, which is considered as the relative poverty line in traditional welfare economic approach (Atkinson, Cantillon, Marlier and Nolan, 2002; Bradshaw and Finch, 2003), while z^j_+ is 150 per cent of sample median per capita expenditure. The latter value is determined by the previous research, specifically by Brandolini and D'Alessio (1988) and Miceli (1998). We judge that households with per capita expenditure per year less than 266314 Cfa francs[15]

[14] Douala (2446945 inhabitants) and Yaounde (2440462 inhabitants) are the 2 biggest cities of the country. While Yaounde is the seat of the institutions, Douala is the economic capital.

[15] The Cfa franc is the currency used in Cameroon as well as in fourteen African countries. 1€ = 655.957 Cfa franc. The Cameroon's official income poverty line for the year 2007 is 269448 Cfa francs (411 euros).

(406 euros) belong entirely to the fuzzy subset of deprived people, while those with more than 665787 Cfa francs (1015 euros) per year may be considered as completely out of poverty.

2. Education: Education has a potential to enable individuals to participate in the social, economic and political spheres of their lives. It is therefore pertinent to include education as an indicator for multidimensional poverty measurement. z_-^j is set at 1, which means that the household head never attended school (totally deprived) and z_+^j is 8, which means that the household head attended university or equivalent (totally non-deprived). Likewise, a household whose head attended high school is partially deprived.

3. Health: Consultation acts as a proxy for the health status.[16] Indeed, in Cameroon, people sometimes cannot afford to go to hospital when they are ill.[17] Yet, it is crucial to consult a doctor or a chemist to recover from disease. This dimension identifies the health personnel the household consulted when they were ill. z_-^j is set at 1, if the household members consulted a drug hawker during illness and z_+^j is 6 if they consulted a doctor.

4. Sanitation: Access to proper sanitation facilities can prevent the spread of diseases like diarrhea and malaria. It is therefore an important dimension of the well-being of households. This dimension identifies the type of sanitation facility the household has. z_-^j is set at 1, in case the household has no sanitation facilities and z_+^j is 4, in case the household has flush toilet inside.

5. Water: Diarrhea, often due to unsafe drinking water, is one of the leading causes of childhood deaths in Cameroon. Several communicable diseases, such as Hepatitis are spread through unsafe drinking water. Moreover, Since Cameroon is continually riddled with water shortages, access to drinking water cannot be taken for granted. This dimension identifies the main source of water of the household. z_-^j is set at 1, which means that the household has river, stream, well, standing water or backwater as main source of water and z_+^j is 5, which means that the household has piped water inside house or uses bolted water.

6. Electricity: Electricity allows lighting, which in turn allows people to be independent during the night time. It also enables a wide range of work and leisure activities ranging from refrigeration, sewing, and so forth. Increasing the access to electricity (especially in rural areas) will not only improve the living conditions of the rural population but it will also reduce the proportion of the population using solid fuels improving the quality of the air. z_-^j is set at 1, which means that the household steals electricity or uses oil lamp as lighting equipment and z_+^j is 4, which means that the household has light with an individual electric meter.

7. Housing: The material used to build the house is an important indicator of living standard. Forty per cent of the urban population and sixty per cent of rural population in Cameroon live in slums with poor housing conditions. We focus on the quality of house material that is assessed by asking whether the household lives in carabot house (made of old plank), terra cotta house (made of mud), or more conventional houses (made of perpends or concrete). z_-^j is set at 1 if the household lives in house made of old plank, mud, leaves or straw and z_+^j is 4, if the household lives in a house made with concrete or perpend.

8. Occupancy status: Over forty per cent of Cameroonian households don't own their house and ten per cent are housed by friends. z_-^j is set at 1, which means that the household is housed by friends and z_+^j is 4, which means that the household live in a house with land title.

[16] In our survey, there we no viable information on the health status. Therefore, we we forced to approximate health with the persons consulted during illness.

[17] One person in four still has recourse to traditional medicine or to drug hawkers for consultation.

9. Television: Television is used for entertainment, but it can also serve as a vector for conveying information, for example, for health, training, and job opportunities. Moreover, television gives people an opportunity to be connected to the world and to discover the world. $z^j_-$is set at 1 if the household does not own a television and z^j_+ is 0 if the household owns a television.

10. Refrigerator: Even though possessing a refrigerator is not essential for people, it can be play an important role, in particular for the preservation of food and medicine. z^j_- is set at 1 if the household does not possess a refrigerator and z^j_+ is 0 if the household possesses a refrigerator.

4 Results

4.1 Fuzzy poverty by attribute

Table 2 presents membership functions which identify the average deprivations experienced in each attribute. It also shows the contribution of each dimension to global poverty. The membership functions can also be interpreted as the probability - in a fuzzy sense - of being poor in different attributes. For instance, among the 10 attributes, the probability of being - or the percentage of households - poor in the possession of refrigerator (0.8999) is the highest. The second most important cause of poverty is water (0.6175), followed by possession of a television (0.6094) and education (0.5695). The lowest membership function is 0.1278 reflecting the weak state of deprivation with respect to health. The average degree of deprivation is greater than 50 per cent for seven attributes out of 10. It is therefore no surprise that the FIP for Cameroon in 2007 is 0.5531. Considering the fact that the measure ranges from zero (definitely non-poor) to one (definitely poor), we can say that the incidence of multidimensional poverty in Cameroon according to the fuzzy set approach is high.
Before interpreting the results in table 2, we have to remind that the membership function does not have the same meaning for all types of variable. For dichotomic variable, the household either belong to the subset of poor (they don't possess the item) or they don't belong to the subset of poor (they possess the item). However, for continuous and ordinal variables, the membership function gives as the average relative position of households in relation to two extreme situations: that of the most deprived and that of the best-off. Keeping this interpretation in mind, we note that the degree of belonging to poverty is very high for the possession of durable goods. Indeed, ninety per cent of Cameroonian households don't possess a refrigerator and 61 per cent don't have a television. These high deprivation measures reflect the fact that these items are still very expensive and therefore not so widespread in Cameroon.
Concerning living conditions it appears that electricity remains an issue in Cameroon as households are on average closer to the top of the distribution (0.5286). Likewise, sanitation still poses problems since the degree of belonging to poverty is significant (0.5176). Table 2 also reveals a rather low membership function for health (0.1278). This is not a surprise, given that more than 80 per cent of the sampled households consulted a doctor, a chemist or a nurse during illness. Along the same line, the degree of belonging to poverty is relatively low for the quality of housing, which shows that Cameroonians, on average built houses with solid material (concrete, perpend).
Turning now to education, we note a very high degree of deprivation (0.5965). This means that household heads, on average are at the top of the distribution with regard to education. In other words, household heads in Cameroon are not so educated. Finally, a look at the income dimension shows that are on average, households are in the middle the distribution

(0.5071).[18]
Table 2 also presents the contribution of each dimension to the global poverty. Refrigerator has the highest contribution (21.46 per cent), followed by television (14 per cent) and water (12.6 per cent), while health has a negligible contribution (1.3 per cent).

Table 2: Fuzzy poverty by attribute and rel. contributions to $\delta(x_{ij})$

Attributes	$\delta^j(x_i^j)$	**Rel. contrib.**
Income (X_1)	0.5071	10.2768
Education (X_2)	0.5965	12.1585
Health (X_3)	0.1278	1.3027
Refrigerator (X_4)	0.8999	21.4583
Television (X_5)	0.6094	13.9135
Housing (X_6)	0.3511	1.8817
Electricity (X_7)	0.5286	11.4529
Water (X_8)	0.6175	12.6108
Sanitation (X_9)	0.5176	8.8113
Occupancy status (X_{10})	0.3267	6.1335
Total	55.31%	100%

4.2 Decomposition of fuzzy poverty by region

In order to capture differences in fuzzy poverty measures, we now turn to their breakdown at the regional level (Table 3). The regions can be shared out in three groups. The first group includes the poorest ones in which the FIP exceeds 60 per cent. Except the East (60.5 per cent), the other regions in this group are all located in the Northern part of the country: the Adamawa (62 per cent), the Far North (71 per cent) and the North (69 per cent). The remoteness of these regions as well as the lack of basic infrastructures (paved roads, safe water, electricity), inadequate public services, underdeveloped market, may explain this high multidimensional poverty prevalence. The second group is composed by the regions whose FIP is between 45 and 60 per cent. Those are the Centre (58 per cent), the Littoral (55 per cent), the Northwest (60 per cent), the West (58.5 per cent), the South (47.3 per cent) and the Southwest (50.5 per cent). The remaining group is made up by the two relatively richest cities of the country, Douala (35.3 per cent), Yaounde (31.5 percent) whose ratios lie below 40 per cent.
Table 3 also presents the attribute-specific changes driving the variations in FIP. The rows break the regional poverty level down by attribute. The first row gives the decomposition for Douala, with column 3 reporting that 11 per cent of the multidimensionally poor households in Douala don't possess a refrigerator. This shows that multidimensionally poor households face various deprivations in various attributes. In the same table, we can notice that for people of Douala, the contributions from refrigerator(0.28) and water (0.15) are extremely high, whereas the contribution of health (0.01) and housing(0.008) are very low. Likewise, the contribution of income for the Souhtwest region is relatively low. The example shows how the FIP can be broken down by population subgroup and dimension to help explain its aggregate level[19].

[18]This is the fuzzy income poverty. We can say the incidence of income poverty in Cameroon according to the fuzzy set approach is 51 per cent. This means that more that half of the Cameroonian households are monetary poor.

[19]A government which targets education, for example, would be able to see this directly reflected in the

It can extremely useful to compare the results obtained with the FIP with those obtained using single (unique) indicators. The main difference we observe, when we use a unique indicator of deprivation, is the change in the relative position of some regions with respect to some attributes. For example, while the FN region has the highest FIP, they display the least deprivation with respect to possession of a refrigerator. Likewise, the North, which is the second poorest region appears to be less deprived than the two richest cities of the country with respect to water. These results show that some regions or households can be multidimensionally poor and perform relatively well in some attributes.

Table 3: Fuzzy poverty by region

Regions	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)	(X_9)	(X_{10})	FIP
DLA	0.07	0.11	0.01	0.28	0.10	0.008	0.08	0.15	0.09	0.08	0.3534
YDE	0.07	0.09	0.01	0.3	0.09	0.02	0.1	0.14	0.10	0.07	0.315
ADM	0.10	0.13	0.03	0.20	0.13	0.02	0.11	0.13	0.07	0.06	0.6169
CTR	0.12	0.10	0.008	0.21	0.14	0.02	0.11	0.13	0.08	0.07	0.5809
East	0.10	0.11	0.008	0.20	0.14	0.02	0.11	0.14	0.09	0.06	0.6052
FN	0.10	0.13	0.01	0.18	0.15	0.02	0.13	0.12	0.1	0.06	0.710
LT	0.12	0.12	0.01	0.21	0.15	0.01	0.1	0.12	0.08	0.06	0.5474
North	0.10	0.12	0.01	0.18	0.15	0.02	0.12	0.12	0.09	0.06	0.6888
NW	0.11	0.13	0.008	0.21	0.15	0.02	0.12	0.11	0.08	0.06	0.6022
West	0.10	0.12	0.02	0.21	0.14	0.02	0.10	0.13	0.09	0.06	0.5846
South	0.11	0.10	0.01	0.25	0.12	0.01	0.09	0.15	0.09	0.05	0.4728
SW	0.09	0.12	0.006	0.23	0.15	0.013	0.12	0.12	0.09	0.04	0.5051
Total	0.12	0.14	0.01	0.25	0.16	0.02	0.13	0.14	0.10	0.07	0.5531

4.3 Monetary poverty and Multidimensional poverty

Table 4 presents the traditional income poverty headcount P_0[20] and the fuzzy index of poverty FIP. Column 3 gives the population share in each group while Column 5 presents the share of all income poor people found in each group. Comparing these two columns, we see that the incidence of income poverty is disproportionately high for the regions of the North, the Far North and the Adamawa. Indeed, while having only 24.89 per cent of the population, the income poor in these regions generate 40.2 per cent of the total income poverty. Contrariwise, the regions of the Southwest, the West and the cities of Douala and Yaounde which account for 40 per cent of the population only generates 15 per cent of the total income poverty. Moving now to fuzzy multidimensional poverty FIP, column 6 gives the percentage of all multidimensionally poor people who fall within each group. The percentage of the multidimensionally poor in the regions of the North, the Far North and the Adamawa (30.7 per cent) is much lower than the respective figure in column 5, while the percentage of those who are multidimensionally poor in the regions of the Southwest, the West and the cities of Douala and Yaounde (26.8 per cent) is significantly higher. These results reflect the fact that people who are income-poor are not always the same as those who lack access to education, health, water, electricity. We also notice that in 2007, our FIP(55.31 per cent) is much higher than the country's official income head count ratio for the same year. Therefore, monetary poverty appears to significantly misidentify deprivations in

overall level of poverty (rather than having to wait until the effects show up much later in income) and could break the total down to understand the relationship between dimensional policies and overall poverty impacts.

[20]The income poverty headcounts are the official ones estimated in 2007 by the Cameroon's National Statistics Institute.

other dimensions. In terms of policy implication, these findings suggest that by only focusing on income poverty, people who are deprived in other dimensions may be excluded.

Table 4: Income poverty and fuzzy poverty by region

Regions	Population	% contrib.	P_0	% contrib.	FIP	% contrib.
Douala	1049	9.21	0.055	1.21	0.3534	5.4
Yaounde	1022	8.97	0.059	1.3	0.315	4.8
Adamawa	579	5.08	0.529	11.7	0.6169	9.4
Centre	796	6.99	0.412	9	0.5809	8.8
East	587	5.15	0.504	11.1	0.6052	9.2
Far North	1483	13.02	0.659	14.5	0.710	10.8
Littoral	637	5.59	0.308	6.8	0.5474	8.4
North	773	6.79	0.637	14	0.6888	10.5
Northwest	1482	13.01	0.510	11.2	0.6022	9.2
West	1294	11.36	0.289	6.4	0.5846	8.9
South	535	4.70	0.293	6.5	0.4727	7.2
Southwest	1154	10.13	0.275	6	0.5051	7.7
Total	11391	100	0.399	100	0.5531	100

5 Conclusion and Policy Recommendation

5.1 Conclusion

The traditional approach, by only focusing on income or expenditure, and by applying a poverty line to divide the poor from the non-poor, does not address the multidimensionality and vagueness of poverty. To overcome this limitation, this paper proposed to complement income with other attributes and to use the fuzzy set approach as proposed by Cerioli and Zani (1990) to derive fuzzy index of poverty.

The main result shows that more than half of the Cameroonian population is structurally poor (55.3 per cent). The results further reveal high deprivation degrees for durable household items (televisions and refrigerators), water and education. A regional decomposition show that the Far North, the North and the Adamawa face the highest levels of deprivation while Douala and Yaounde display the lowest deprivation levels.

We could also identify the dimension-specific changes driving the variations of the FIP. We found that 11 per cent of the households in the Douala are both multidimensionally poor and deprived in refrigerator. Moreover, the Far North which is the poorest region, displays the lowest deprivation level with respect to possession of refrigerator.

Our analysis also looked at a comparison between the traditional approach and the multidimensional fuzzy approach by comparing poverty rates calculated by the two methods. It was found that the poorest of the poor are often missed by the traditional money metric approach.

5.2 Policy Recommendation

The paper is innovative not only in that it changes the focus from the traditional unidimensional perspective of poverty, centred on income, to a broader multidimensional one, but it also provides with a methodology that is potentially useful for policy consideration. The fundamental policy orientation arising from this work is that it provides the opportunity of allocating the budget among the regions and within them and among the different

dimensions. Consequently, anti-poverty policies must be implemented in areas of extreme multidimensional poverty on the basis of shortages on those dimensions.
On the basis of the findings of this paper, we propose four policy recommendations for tackling poverty: **First**, improve access to safe drinking water. To address this critical challenge, policy makers should seek to enhance access to drinking water for all regions. In particular, policy should seek to increase the present drinking water coverage by rehabilitating and extending water supply plants including the construction of boreholes and water wells in rural areas and most especially in the northern regions of the country. **Second**, secure coverage in electricity power to urban areas and extend it to rural regions and zones: Steps need to be taken to improve the country's capacity to generate electricity through a variety of appropriate means which include hydroelectric power plants, thermal stations, solar power plants and windmill plants. **Third**, strengthen human capacity: We have concluded from the findings of this study that education constitutes a major poverty predictor in Cameroon. A social strategy of capacity building and enhancing human resources is strongly recommended. Such a strategy should aim to promote basic education for all by broadening educational access and improving the quality of education. The literacy rate must be improved in the northern regions by building more schools. **Fourth**, facilitate access to television. The government should reduce taxes on imported televisions, which will in turn make them more affordable. Indeed, television can achieve some of the steps towards eradication of poverty: it can increase literacy and provide jobs opportunities; it can spread information so that people have access to information on issues that affect their lives. Finally, television makes it possible for people to know what happens in other part of the world.

Appendix

Table 1: Household per capita expenditure

	Degree of membership
$y_i < 0.6 * y_{med}$	1
$0.6 * y_{med} \leq y_i \leq 1.5 * y_{med}$	$\frac{1.5*y_{med}-y_i}{1.5*y_{med}-0.6*y_{med}}$
$y_i > 1.5 * y_{med}$	0

Table 2: Educational achievement of household head

	Degree of membership
None	1
Primary school	0.86
Post primary school	0.86
General secondary 1st cycle	0.29
Technical secondary 1st cycle	0.29
General secondary 2nd cycle	0.14
Technical secondary 2nd cycle	0.14
University degree	0

Table 3: Health

	Degree of membership
None	1
Drug hawker	0.8
Traditional healer	0.6
Health worker (nurse, midwife)	0.4
Pharmacy	0.2
Doctor	0

Table 4: Sanitation

	Degree of membership
No toilet	1
Latrine	0.66
Imp. latrine	0.33
Flush toilet inside	0

Table 5: Water

	Degree of membership
river, standing water, backwater, well	1
Protected spring, well, borehole	0.75
Public standpipe	0.5
Piped water on premises	0.25
Piped water inside house	0

Table 6: Electricity

	Degree of membership
Steal electricity (direct access), oil lamp	1
Col. electric meter (neighborhood)	0.66
Col. electric meter (main user)	0.33
Ind. electric meter	0

Table 7: Housing

	Degree of membership
Old plank, mud, leaf, straw	1
Plank	0.71
Clay, baked brick	0.57
Cement bricks, concrete	0

Table 8: Occupancy status

	Degree of membership
Housed by friends	1
Office housing	0.75
Rent	0.5
Owner	0

References

Alkire, S.; Foster, J. (2011) "Counting and multidimensional poverty measurement". *Journal of Public Economics* **95**, 476-487.

Anand, S.; Sen, A. (1997) "Concepts of Human Development and Poverty: A Multidimensional Perspective". *Human Development Papers*, 1-19.

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

Atkinson, A. B.; Cantillon, B.; Marlier, E.; Nolan, B. (2002) *Social Indicators : the EU and Social Inclusion.* New York, NY: Oxford University Press.

Basu et al., (1987) "The growth and decay of custom: The role of the new institutional economics in economic history," *Explorations in Economic History* **24**, pages 1-21.

Basu, K.; Foster, J. (1998) "On Measuring Literacy". *The Economic Journal* **108**, 1733-1749.

Basu, K. (1998) "Axioms for a Fuzzy Measure of Inequality". *Mathematical Social Sciences* **14**, 275-288.

Betti, G.; Cheli, B.; Cambini, R. (2004) "A Statistical Model for the Dynamics Between Two Fuzzy States: Theory and An Application to Poverty Analysis". *Metron*, LXII **3**, 391-411.

Betti, G.; Verna, V. (1999) "Measuring the degree of poverty in a dynamic and comparative context: a multidimensional approach using fuzzy set theory", *Proceedings ICCS-VI*, Lahore, Pakistan, **11**, 289-301.

Betti, G.; Cheli, B.; Lemmi, A.; Verma, V. (2006) "On the Construction of Fuzzy Measures for the Analysis of Poverty and Social Exclusion". *Statistica & Applicazioni*, IV (Special Issue 1), 77-97.

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

Bradshaw, J.; Finch, N. (2003) "Overlaps in Dimensions of Poverty". *Journal of Social Policy*, **4**, 513-525.

Brandolini, A.; D'Alessio, G. (1998) *Measuring Well-being in the Functioning Space.* Mimeo. Banca d'Italia.

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. Studies in Contemporary Economics. Springer Verlag, Berlin, 272-284.

Chakravarty, SR. et al., (1998) "On the family of subgroup and factor decomposable measures of multidimensional poverty." *Research on Economic Inequality* **8**, 175-194.

Chakravarty, S.R., Deutsch, J., Silber, J., (2008) "On the Watts multidimensional poverty index and its decomposition." *World Development* **36**, 1067-1077.

Cheli, B.; Ghellini G.; Lemmi A.; Pannuzi N. (1994) "Measuring Poverty in the Countries in Transition via TFR Method: The Case of Poland in 1990-1991". *Statistics in Transition* **1**, 585-636.

Cheli, B.; Lemmi A. (1995) "A totally Fuzzy and Relative Approach to the Multidimensional Analysis of Poverty". *Economics Notes* **24**, 115-134.

Dagum, C. (2002) "Analysis and measurement of poverty and social exclusion using fuzzy set theory. Application and policy implication". University of Bologna.

Deutsch, J.; Silber, J. (2005) "Measuring Multidimensional Poverty: An Empirical Comparison of Various Approaches". *Review of Income and Wealth*, **1**, 145-174.

Dubois, D.; Prade, H. (1980). *Fuzzy Sets and Systems*. Boston: Academic Press.

Foster , J.; Greer, J.; Thorbecke , E. (1984) "A class of decomposable poverty Measures". *Econometrica* **388**, 215-51.

Kakwani, N.; Silber, J. (2008a) "The Many Dimensions of Poverty." Basingstoke: Palgrave MacMillan.

-, (2008b) "Quantitative Approaches to Multidimensional Poverty Measurement." Basingstoke: Palgrave Macmillan

Laderchi, C.; Saith, R.; Stewart, F. (2003) "Does it Matter That We Don't Agree on the Definition of the Poverty? A comparison of Four Approaches" *Oxford Development Studies* **31**, 243-274.

Lelli, S., (2008), "Operationalising Sen's capability approach: The influence of the selected technique", págs. 310-361, en Flavio Comim, Mozaffar Qizilbash y Sabine Alkire (2008), The Capability Approach, Concepts, Measures and Applications, Cambridge: Cambridge University Press.

Lemmi, A.; Betti, G. (2006) *Fuzzy Set Approach to Multidimensional Poverty Measurement*. New York, NY: Springer.

Maasoumi, E., Lugo, M.A., (2008) "The Information Basis of Multivariate Poverty Assessments." In N. Kakwani and Jacques Silber (Eds), Quantitative Approaches to"Multidimensional Poverty Measurement. Palgrave Macmillan, 1-29.

Miceli, D. (1998) *Measuring Poverty Using Fuzzy Sets* (No. DP38). National Centre for Social and Economic Modeling (NATSEM), University of Canberra.

Qizilbash, M.; Clark, D. A. (2005) "The Capability Approach and Fuzzy Poverty Measures: An Application to the South African Context". *Social Indicators Research*, **1**, 103-139.

Sen, A.K. (1980a) "Equality of What?", in McMurrin (ed.), *Tanner Lecture on Human Values*, Cambridge : Cambridge University Press, 26 p.

-, (1984) "The Living Standard", *Oxford Economic Papers* **36**, 74-90.

-, (1985), *Commodities and Capabilities*, Amsterdam : Elsevier, 142b p.

-, (1989), "Development as Capabilities Expansion". *Journal of Development Planning*, **19**, 41 - 58.

-, (1993a), "Capability and Well-being", in Nussbaum M. and Sen A., (ed.), *The Quality of Life*, Oxford: Clarendon Press, p. 30-53.

-, (1999), *Development as Freedom*. Oxford University Press.

Siani, J. (2013) "Has poverty decreased in Cameroon between 2001 and 2007? An analysis based on multidimensional poverty measures". *Economics Bulletin*, Vol. 33, **4**, 3059-3069.

Thorbecke, E., (2008) "Multidimensional Poverty: Conceptual and Measurement Issues," in The Many Dimensions of Poverty ed. by N. Kakwani, and J. Silber. New York: Palgrave MacMillan.

Townsend, P. (1979) *Poverty in the United Kingdom*. Penguin Books, Middlesex.

Tsui, K.Y., (2002) "Multidimensional poverty indices." *Social Choice and Welfare* **19**, 69-93.

Zadeh, L.A. (1965) "Fuzzy Sets". *Information and Control* **8**, 338-353.

Zheng, B. (2015) "Poverty: Fuzzy measurement and crisp ordering." *Social Choice and Welfare* **45**, 203-229.