# Comparison Study of Approaches to Measuring Poverty Implementing Fuzzy Set and Classic Set Using The Household Data of Turkey

Alparslan Abdurrahman Basaran1, Murat Alper Basaran2

*1Hacettepe University, Faculty of Economics and Administrative Sciences, Department of Public Finance, 06800, Ankara, Turkey*

*2Akdeniz University, Faculty of Engineering, Management Engineering Department, 07425,Alanya, Turkey*

E-mails: *aab@hacettepe.edu.tr, muratalper@yahoo.com*

## Abstract

Poverty is one of the issues several industrialized and developing countries encounter in the world. No country is exempt from this problem and its consequences. The top list item of the agendas of both countries and international agencies is related to diminishing poverty. Before taking action against it, countries and agencies need to measure poverty based on collected data. It is a sophisticated issue having several dimensions. So far measuring it with available data has resulted with indicators which show some deficiencies. When poverty is considered, it is a linguistic term and has a vague concept as mentioned in the theory of fuzzy set. Therefore, a new approach is proposed in the literature to examine it in order to overcome those deficiencies mentioned when classic tools are employed. On the other hand, fuzzy set

theory is a mathematical tool used for linguistic calculations. For example, when said that income level is low. Actually everybody knows what it means. But what it means changes depending upon the perception of the person. Therefore, measuring low income is a problematic area. Fuzzy set theory enables practitioners to calculate those linguistic terms. In this study, the household data of Turkey of the year 2003 collected annually based on almost 25000 is used to calculate both classic poverty indicator(s) and fuzzy poverty indicator in order to compare those measures. In the end we will show that fuzzy poverty indicator can be comprehensive in some comparisons. Also, it provides more information in terms of understanding the concept of poverty

***Keywords:*** Poverty, fuzzy set, fuzzy index, Sustainable development

## 1. INTRODUCTION

In the past few decades the measurement of poverty traditionally took place by determining whether an individual or a household could be classified as poor depending on whether their income or expenditure was above or below a specific value, the poverty line. In the measurement of poverty, after determining concrete poverty line the next step is to select available indices which shows the fraction in the total population, the intensity of poverty and the degree of inequality among the poor called such as respectively the head count, poverty gap and the severity of poverty index. Contrary to these classical approaches, there is a considerable and growing both theoretical and empirical, on the multi-dimensional measures of poverty. According to this approach poverty is a complex and vague phenomenon to separate the population poor and non poor. (Cerioli & Zani, 1990) criticized the vagueness concept of income and proposed a multi dimensional measure of poverty using fuzzy set theory to evaluate living conditions in Italian county. (Cheli & Lemmi, 1995) enhanced the fuzzy concept method, called Totally Fuzzy and Relative (TFR), by deriving deprivation indices directly from the distribution function. According to (Bantilan, Bantilan & Castro, 1992) the theory of fuzzy set provides a new approach to the use of traditional economic variables such as income or expenditure to derive new measures of poverty. Moreover the approach can readily make use of the extensive information contained in the set of standard of living indicators. (Miceli, 1998) assess living conditions in Switzerland following (Cerioli & Zani, 1990) multi dimensional fuzzy measure of poverty. In this paper, in the light of technique suggested by (Cerioli & Zani, 1990) and (Miceli, 1998), fuzzy index poverty is calculated for Turkey from the household survey conducted in 2003 (The State Institute of Statistic of The Republic of Turkey, Households Survey, 2003). Also, classic set theory, which is used in the calculation of regular poverty measures, is employed to calculate classic poverty measure to compare the fuzzy one with classic poverty measure.

## 2. Background

Fuzzy set theory first was introduced by (Zadeh, 1965). Since then it has been widely employed in many disciplines where the data are imprecise. In the classic set theory, an

object is either a member of a set which is defined by sharp boundaries or not. This implies a certain membership. However, in the fuzzy set theory, an object is a member of a set with a degree of membership taking values from the interval [0 1]. In the classic set theory, an ordinary subset A of a set U is determined by its indicator function, or characteristic function $\chi_A(x)$ defined by

$$\chi_A = \begin{cases} 1, \text{if } x \in A \\ 0, \text{if } x \notin A \end{cases} \quad (1)$$

The indicator function of a subset A of a set U specifies whether or not an element is in A. There are only two possible values the indicator function can take. However, in fuzzy set theory, any element belonging to a given fuzzy subset A of set U takes a value between 0 and 1 depending on its compatibility with this set. A fuzzy set A of set U is a set whose elements are ordered pairs which are shown as follows:

$$A = \{x, \mu(x)\} \quad (2)$$

where x is a generic element of U and μ (x) is called the degree of membership of x in the fuzzy set A. Actually fuzzy set A of set U is a function from U → [0,1]. Also any fuzzy subset V is a function. In the fuzzy set terminology μ is called membership function with the defined domain which means that the function which will be defined according to some data or some linguistic term, for example poverty, is specified by the experts. For a fuzzy set $\mu_A$ : U → [0,1], the function A is called membership function. Instead of A, μ is used as a membership function throughout the paper. For a fuzzy concept, different functions A can be considered. The choice of the function A is subjective and context dependent. For example, "young" is a fuzzy concept and can be defined as follows:

$$\mu_{YOUNG}(X) = \begin{cases} 1, & \text{if } x < 25 \\ \frac{40-x}{15}, & \text{if } 25 \leq x \leq 40 \\ 0, & \text{if } x > 40 \end{cases} \quad (3)$$

where 40 and 25 are upper bound and lower bound respectively and x is generic term for the fuzzy set "young". It is easily verified that this membership function can take various values between [0,1]depending on values of x . With this background information, poverty which is a fuzzy term can be modeled by fuzzy set theory. The classic approach draws a line called poverty line separating poor and non-poor. But this is not really helpful in differentiating the difference between a person or a household just above the poverty line and other person or household just below the poverty line in terms of understanding who is in fact poor or non-poor. We are not saying that classic approaches are useless but they have deficiencies and fuzzy set theory might provide remedies for them. Instead of classic approaches, in this paper fuzzy index of poverty is employed for the data which are gathered by the Survey of Households conducted by The State Institute of Statistics of The Republic of Turkey in 2003.

As mentioned in the related literature, poverty is a multidimensional structure and requires to combine different kinds of data. These data include continuous and categorical variables, which are dichotomic and polytomic. In searching one index measuring poverty, both categoric and continuous variables are generally employed and incorporated. This causes problems both in interpretation and calculation.

## 3. Fuzzy Index of Poverty

Instead of classic approaches, in this paper fuzzy index of poverty is employed for the data which are gathered by the Survey of Households conducted by The State Institute of Statistics of The Republic of Turkey in 2003. Instead of making composite index which consists of both categoric and continuous indicators, only continuous variables are selected. In fuzzy set theory, fuzzifying is very useful means that help calculations much easier. The four variables, which are annual disposable income, food expenditures, cloth and footwear expenditures, and habitable area of the apartment, in this study are continuous. To calculate fuzzy index of poverty, the first step is to fuzzify variables. Half of the median of the distribution is set to minimum and twice the median of the distribution is set to maximum [4]. Half of the median as a minimum is used to calculate the relative poverty of income by World Bank [6]. Twice of median as maximum is used in the paper written by [4]. These lower and upper bounds are adopted for all the four fuzzy indicators due to the fact that 25000 households have many outlier cases and median is a robust statistic. The membership function used in calculating degree of poverty of households is given as follows:

$$\mu(u_{ij})=\begin{cases} 0, & \text{if } u_{ij} \geq u_{max} \\ 1, & \text{if } u_{ij} \leq u_{min} \\ \frac{u_{max}-u_{ij}}{u_{max}-u_{min}}, & \text{if } u_{min} \leq u_{ij} \leq u_{max} \end{cases} \quad (4)$$

where i, j denote persons belonging to poor set (i= 1, 2,...,n) and indicators (j=1,...,k) respectively and max min u ,u denote twice median and half median values of the distribution respectively. In our study there are 25000 households and 4 indicators. Based on the membership function above, the persons between lower bound and upper bound are thought to be poor with different fuzzy grades in terms of four indicators. First indicator is calculated based on income variable, second one is for food expenditure variable; third one is for clothing and footwear expenditure variable and the final one is for habitable area variable. For example, $\mu(u_{23}) = 0.6$ which is that the subscript of 23 denotes second person in the third indicator which means food expenditures with fuzzy grade 0.6. After calculating indicators, it is crucial to combine these indicators in a sensible way to obtain a single indicator that provides information about the deprivation of the households. In the literature, there are many proposed ways of combining indicators to obtain a single indicator measuring deprivation of households, for example, weights can be given by experts or some calculations are made based on the proportion of poor in the population in terms of the given indicator. Here the method used in [4] is employed to calculate the weights. The weights have to satisfy some conditions:

$w_j > 0, j = 1, \dots, k$ and $\sum_1^k w_j = 1$

(5)

In order to find the weights used in the calculation of fuzzy poverty index, the formula below is employed.

$$w_j = \frac{\ln(\frac{1}{\bar{\mu}})}{\sum_1^k \ln(\frac{1}{\bar{\mu}})}$$

(6)

where $\bar{\mu_j} = \frac{1}{n}\sum_1^n \mu_j(i)$ denotes the fuzzy proportion of the poor persons according to indicator $\mu_j$ Weights related to indicators are given in Table 2. Then the indicator that measures poverty can be calculated as follows:

$$\mu_p(u) = \sum_1^n w_j \mu_j(u) \quad (7)$$

The last step to obtain fuzzy index of poverty is to find a way of incorporating indicators. In the literature, fuzzy index of poverty is derived as follows:

$$FIP = \frac{1}{n}\sum_1^n \mu_p(u) \quad (8)$$

However, this is the case when the samples for all indicators are equal. In our calculations samples are not equal size so each corresponding mean for the indicator is calculated then mean of the means are derived based on the formula in (8).

## 4. EMPIRICAL STUDY AND CONCLUSION

In this paper fuzzy index of poverty is calculated for the data which are gathered by the Survey of Households conducted by The State Institute of Statistics of The Republic of Tukey in 2003. There exist issues in both calculation and interpretation when both categoric and continuous variables are taken into account in measuring poverty in a single indicator. Therefore only continuous variables are employed when calculating fuzzy index of poverty. Based on the calculations, all information is summarized in Table 1.

Table 1

| | |
|---|---|
| Disposable Income | 0.2219 |
| Food Expenditure | 0.2383 |
| Clothe Expenditure | 0.1219 |
| Habitable Area | 0.1843 |
| FIP | 0.1917 |

Table 2 Weights

| | |
|---|---|
| Disposable Income | 0.32 |
| Food Expenditure | 0.35 |
| Clothe Expenditure | 0.14 |
| Habitable Area | 0.19 |

As seen from the membership function in (4), when the values get close to zero, it means that the personhas a membership grade close to zero is not considered poor in terms of the indicator. In this study the composite single index shows 0.1917 membership grade. If we examine each indicator carefully, food expenditure and disposable income indicators show relatively high membership grades, which denote deprivation of the households, when compared to cloth-footwear and habitable area indicators; especially cloth-footwear indicator is a surprising result. This can be explained by the fact that textile industry is the one of the most developed industry in Turkey and there is always excess supply which reduces prices. Also habitable area shows that despite of relatively poor conditions in poor houses; square meter area per person is wide. Although 25000 households are surveyed, available data for disposable income are 8421 households. This makes FPI reduce for disposable income. This might increase FIP.

Also, we summarize the results obtained from the classic measure in Table 3. This work is the extension of the study conducted and presented in EUSFLAT-LFA 2005 in Barcelona-Spain.

Table 3 Classic Poverty Measure

| | |
|---|---|
| Food Expenditure | 0.1290 |
| Poverty except food | 0.2812 |
| Relative Poverty | 0.1551 |

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