Measuring Poverty Using Fuzzy Approach in Turkey

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Abstract

Fuzzy index of poverty in Turkey is calculated, using data from the State Institute of Statistic (SIS) Household Income and Expenditure Survey 2003. Poverty is a composite measure which can be calculated based on many quantitative and qualitative data. Despite its multidimensionality, only a single indicator generally represents this complexity, which is the most used indicator called poverty line. Although it is the most used indicator, it draws criticism. One of the main reasons is that two different individuals are separated based on the poverty line even if the income difference between them is tiny. Therefore, fuzzy nature of poverty and finding a more intuitive indicator are the motives behind the fuzzy index of poverty. The indicators of index are disposable income, food expenditure, clothing and footwear expenditures and habitable area per person. After calculating this index, we decompose it by employment status and education profile of the household's head.

Key Words: Poverty, fuzzy set, fuzzy membership function, decomposition.

1. Introduction

In the past few decades the measurement of poverty traditionally took place by determining whether an individual or 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. Contrary to these classical approaches, there is a

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considerable and growing literature, 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 and Zani [2] critized 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 and Lemmi [3] enhanced the fuzzy concept method, called Totally Fuzzy and Relative (TFR), by deriving deprivation indices directly from the distribution function. According to Bantilan, Bantilan and Castro [1], the theory of the 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 [4] assess living conditions in Switzerland following Cerioli and Zani [2] multi dimensional fuzzy measure of poverty. In the literature, single fuzzy index of poverty consists of both continuous and categorical variables. This kind of index causes calculation problems in the case of combining fuzzy membership function and characteristic function for continuous and categorical variable respectively.. Also in the calculation process, that some continuous variables are not fuzzified makes calculation more troublesome in the combining process. However, this paper only takes into accounts fuzzified continuous variables. This kind of approach makes calculation and interpretation relatively easy. This new proposed fuzzy index of poverty represents relative poverty phenomena better. Calculations are based on the data gathered for Turkey from the household survey conducted by SIS in 2003 [5].

2. Background

Fuzzy set theory first was introduced by Zadeh [7]. 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

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

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:

$$A = \{u, \mu(u)\} \qquad (2)$$

where u is a generic element of U and $\mu(u)$ is called the degree of membership of u in the fuzzy set A. Actually fuzzy set A of set U is a function from $U \to [0,1]$. Also any fuzzy subset V is a function. In the fuzzy set terminology A 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 $A : U \to [0,1]$, 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:

$$\mu(x) = \begin{cases} 1 & \text{if } x < 25 \\ \dfrac{40 - x}{15} & \text{if } 25 \le x \le 40 \\ 0 & \text{if } 40 < x \end{cases} \qquad (3)$$

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 combining different kinds of data. These data include continuous and categorical variables, which are dichotomy and polyatomic. In searching one index measuring poverty, both categorical 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 new 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 categorical and continuous indicators, only continuous variables are selected. In fuzzy set theory, fuzzifying is very useful means that help calculations much easier for relative poverty approach. 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 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:

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

where i, j denote persons belonging to poor set $(i = 1, 2, ..., n)$ and indicators $(j = 1, ..., k)$ respectively and $u_{\max}, u_{\min}$ 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, $\mu(u_{23}) = 0.6$ 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:

$$w_j \geq 0, j = 1,2,....,k$$
$$\sum_{j=1}^{k} w_j = 1 \qquad (5)$$

To determine weights, the formula below is employed:

$$w_j = \frac{\ln(\frac{1}{\overline{\mu}_j})}{\sum_{j=1}^{k} \ln(\frac{1}{\overline{\mu}_j})} \qquad (6)$$

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

$$\mu_P(u) = \sum_{j=1}^{k} w_j \mu_j(u) \qquad (7)$$

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:

$$FIP = \frac{1}{n}\sum_{i=1}^{n} \mu_P(u) \qquad (8)$$

where $FIP \in [0,1]$.

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 Turkey in 2003. There exist issues in both calculation and interpretation when both categorical and continuous variables are taken into account in measuring poverty as 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: Indicators

Disposable Income	0.2219
Food exp.	0.2383
Cloth exp.	0.1219
Habitable area	0.1843
FIP	0.1917

Table 2: Weights

Disposable Income	0.32
Food exp.	0.35
Cloth exp.	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 person has 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 an unexpected 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.

Table-3: Sector Where Head of Household Working

Working Sector of Head of Household's	Disposal Income	Food Exp.	Cloth exp.	Habitable area
Agriculture	**0,2434692**	0,229653	**0,1236277**	**0,2037276**
Mining	0,188359	0,206398	0,1137279	0,1976179
Manufacturing	0,2171657	0,249201	0,1216864	0,1903058
Construction	**0,2461028**	**0,252267**	**0,1234045**	**0,2100571**
Whole and retail sale	0,2079655	0,235048	0,1217753	0,1962897
Transportation	0,1882201	0,229879	0,1179426	**0,2033049**
Government	0,168185	0,208449	0,1144795	0,1851995
Education	0,1594654	0,202387	0,1142952	0,176325
Health	0,1986805	0,228568	0,1109185	0,1946665
Other social services	**0,2490188**	**0,24938**	**0,1238325**	**0,21063**
Other services	**0,2475844**	**0,273764**	**0,1367218**	**0,2105347**

Based on the results from Table 3, when the sectors are examined, head of households working in the sector such as agriculture, construction, other social services and other services are more vulnerable to poverty in four indicators. The head of households working in the sectors such as education and government have relatively low poverty ratios compared to the other sectors.

Based on the results from Table 4, gaining education towards higher degrees eliminates degree of poverty in four indicators. Especially, after secondary school, this view is clearer with decreasing relative poverty. Disposable income and food expenditure indicators show evidently that education, especially after secondary school, helps people escape from poverty. But the most powerful degrees that help people escape from poverty are vocational and upper university degrees.

Table-4: Educational Profile of Head of Household

Educational Profile of Head of Household	Disposal Income	Food Exp.	Cloth exp.	Habitable area
Illiterate	**0,2761009**	**0,2607149**	**0,1287007**	**0,2088879**
Person can read and write without diploma	**0,2560648**	**0,255771**	**0,1284968**	**0,1967429**
First school	**0,2323265**	**0,24409**	**0,1240875**	**0,1939589**
Secondary school	0,2072661	**0,235999**	**0,1200188**	0,183391
High school	0,1840072	**0,230429**	0,1161076	0,1694628
Vocational school	0,1265128	0,205227	0,1074913	0,1623312
University	0,1287265	0,193179	0,113012	0,1502269
Post Graduate	0,1047604	0,166928	0,1091699	0,1475044

References

[1] Bantilan, M.C.S, Bantilan F. T. and de Castro M. M., (1992), "Fuzzy Subset Theory in the Measurement of Poverty", Journal of Philippine Development, Num: 34, Vol. XIX, pp 97-127.

[2] Cerioli A., Zani S. (1990), "A Fuzzy Approach to the Measurement of Poverty", Income and Wealth Distribution, Inequality and Poverty, in Dangum, C. and Zenga, M. (eds)

[3] Cheli, B., Lemmi, A. (1995), "A Totally Fuzzy and Relative Approach to the Multi Dimensional analysis of Poverty", Economic Notes, vol 24, pp115-134.

[4] Miceli, D., (1998) "Measuring Poverty Using Fuzzy Sets", Discussion Paper no.38, NATSEM, University of Canberra.

[5] The State Institute of Statistic of The Republic of Turkey, Households Survey 2003.

[6] World Bank, "Development Reports", Attacking poverty, World Bank 2000/2001 Washington, D.C.

[7] Zadeh A, Fuzzy sets, Information and Control 8 (1965) 338-353.